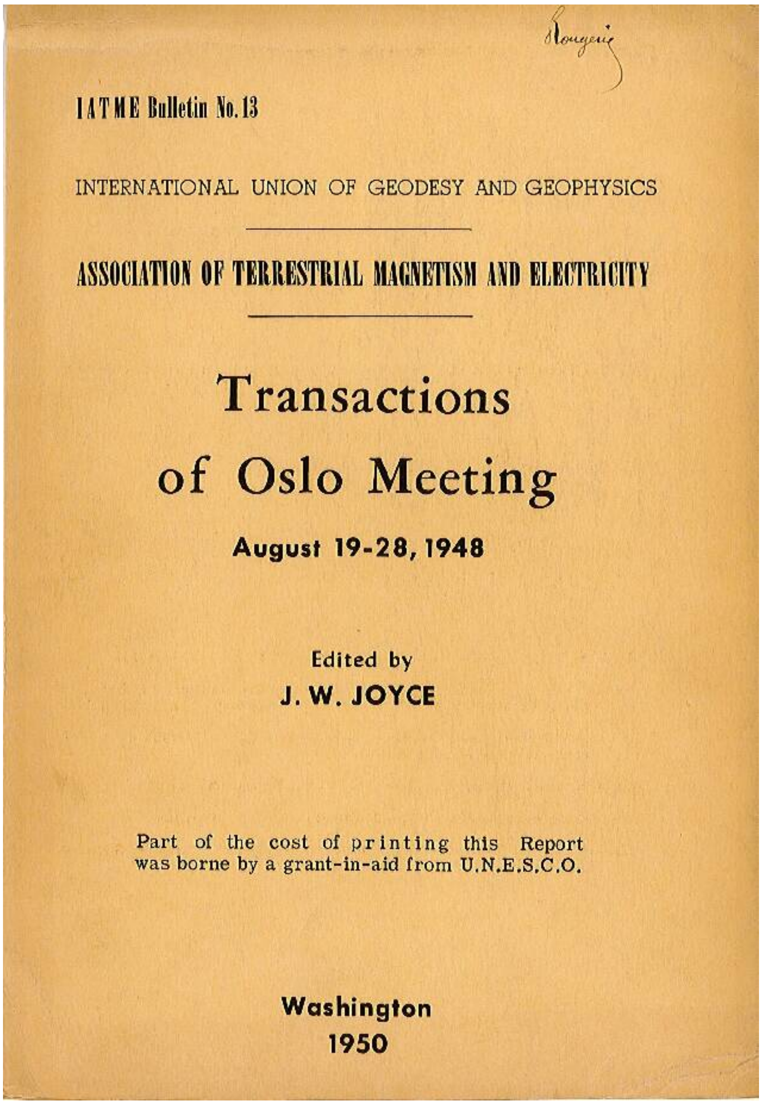


IATME Bulletin No. 13

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY

Transactions of Oslo Meeting

August 19-28, 1948

Edited by
J. W. JOYCE

Part of the cost of printing this Report was borne by a grant-in-aid from U.N.E.S.C.O.

Washington
1950

Rougerie

IATME Bulletin No. 13

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY

Transactions of Oslo Meeting

August 19-28, 1948

Edited by
J. W. JOYCE

Part of the cost of printing this Report was borne by a grant-in-aid from U.N.E.S.C.O.

Washington
1950

With the Compliments of:

The CENTRAL BUREAU

of the

INTERNATIONAL ASSOCIATION of TERRESTRIAL MAGNETISM

and ELECTRICITY

IATME Bulletin No. 13

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY

Transactions of Oslo Meeting

August 19-28, 1948

Edited by
J. W. JOYCE

Part of the cost of printing this Report was borne by a grant-in-aid from U.N.E.S.C.O.

Washington
1950


UNDERWOOD & UNDERWOOD
WASHINGTON

DR. JOHN A. FLEMING

Dr. John A. Fleming, whose portrait faces this page, was the fourth President of our Association (formerly the Section) of Terrestrial Magnetism and Electricity. He was elected to the office at Stockholm in 1930, in succession to Dr. L. A. Bauer, whose period as President was cut short by illness. Dr. Fleming presided over our meetings at the Assemblies of Lisbon (1933), Edinburgh (1936), and Washington (1939). At the latter, held just after the outbreak of the recent war, the Union and its Associations decided to retain their officers in service until the first post-war ordinary General Assembly. Hence, Dr. Fleming remained our President until that Assembly, held at Oslo in 1948, when he notified his resignation, after a record length of service of 18 years. Greatly to our regret, he was unable to be present at Oslo, owing to the illness of Mrs. Fleming. Besides presiding most acceptably over our Assemblies, he was very active on our behalf in the intervening periods, and conducted an extensive correspondence with institutions and workers throughout the world in support of the Association and its committees and projects. His ability and administrative gifts aroused our admiration, and his kindness and modesty won our affection. Our hope is that he will long be spared to serve the Association and our science in his retirement, and that at the next and many later Assemblies we may be favored with his presence and aid.

ACKNOWLEDGMENT

The Editor acknowledges the very helpful assistance and advice of Dr. John A. Fleming in the preparation of these Transactions.

CONTENTS

PART I

AGENDA AND MINUTES

INTERNATIONAL
UNION OF GEODESY AND GEOPHYSICS

Oslo Meeting, August 19-28, 1948

ASSOCIATION OF TERRESTRIAL MAGNETISM
AND ELECTRICITY

AGENDA

I. Address of President: "Some needs and challenges of geomagnetism" (Friday, August 20, at 11:30). (pp. 37-48)

II. Report of Secretary and Director of Central Bureau. (pp. 49-52)

III. Finances. Report of Director of Central Bureau. (pp. 52-55)

IV. Election of Officers of the Association.

V. Statutes. (pp. 59-64)

VI. National Reports. (pp. 65-247)

VII. (A) Reports of Committees and Reporters appointed at the Washington Assembly.

Committees:

1. On the selection of sites of new observatories for terrestrial magnetism and electricity: John A. Fleming, Chairman. (pp. 249-252)
2. On Aurora: C. Stormer, Chairman. (pp. 253-296)
3. On the study of the relationship between solar activity and terrestrial magnetism: Jno. A. Fleming, Chairman. (pp. 296-297)
4. On magnetic secular-variation stations: E. H. Vestine, Acting Chairman. (pp. 298-306)
5. On ionic equilibrium: O. H. Gish, Chairman.
6. On magnetic charts:
   (a) Organization of the work: Sir Harold Spencer Jones, Chairman. (pp. 313-316)
   (b) Methodology: E. H. Vestine, Acting Chairman. (pp. 316-317)
7. On registration in Iceland of giant pulsations: J. Olsen, Acting Chairman. (pp. 318-319)

8. On methods of observatory publication: Ch. Maurain, Chairman (E. B. Roberts, Acting Chairman). (pp. 319-321)
9. On classification of magnetic literature: H. D. Harradon, Chairman. (pp. 321-334)
10. To promote international comparisons of magnetic standards: J. Keränen, Acting Chairman. (p. 335)
11. On observational technique: H. E. McComb, Chairman. (pp. 336-338)
12. On three-hour-range indices for magnetic characterization: A. G. McNish, Acting Chairman. (pp. 339-341)

Joint Committees:

13. Of the Association and of the Commission on Terrestrial Magnetism and Atmospheric Electricity on methods and codes to adequately describe magnetic disturbances and perturbations: Jno. A. Fleming, Chairman. (pp. 341-342)
14. Of the Association and of the International Scientific Radio Union: Sir E. V. Appleton, Chairman. (p. 343)

Reporter:

15. Prof. Chapman on international collaboration for promoting the study of the influence of the moon on geophysical phenomena. (pp. 343-345)

VII. (B) Remarks to be submitted to existing Committees and Reporters.

Committee No. 6--By Sir Harold Spencer Jones: That the two Committees on magnetic charts (a) Organization of the work, and (b) Methodology, be combined into a single committee.

Committee No. 10--By J. W. Joyce: That the Committee formulate a list of world geomagnetic observatories between which a regularly scheduled series of intercomparison observations should be established.

Committee No. 12--By A. G. McNish: Since there is now a sufficient overlap of magnetic character figures (C) and three-hour-range indices (K) to establish the interrelation of the two measures, and since K is a more satisfactory measure of magnetic activity, it is recommended:

1. That C figures be discontinued after December 31, 1948.
2. That observatories, as far as they are able, continue to supply K figures.
3. That an International magnetic activity figure be determined by an average obtained from K figures from a limited number of strategically located observatories (approximately 16).

VIII. Polar Year 1932-33.

1. Report of the Temporary Commission on Liquidation of the Polar Year 1932-33: Jno. A. Fleming, Chairman. (pp. 346-347)
2. Report on the establishment in Copenhagen of a Central Bureau for the liquidation of the Polar Year 1932-33. (pp. 348-349)

IX. Communications.

(A) Discussion on physical aspects of the influence of solar activity on terrestrial magnetism: L. Vegard, Discussion Leader.

1. L. Vegard: Opening remarks. (351-355)

5. B. Trumpy: A magnetic survey of Norway. (p. 397)
6. H. F. Baird: Magnetic resurvey of New Zealand. (pp. 397-399)
7. E. H. Vestine: Completion of magnetic and electric survey of the earth. (pp. 400-401)
8. Edmond Hoge: Essai d'interprétation géologique des anomalies magnétiques décelées dans l'Est de la Belgique. (pp. 402-403)
9. José G. Siñeríz: Las variaciones de la componente vertical del campo magnético terrestre aplicadas a la prospeccion de minerales. (pp. 403-408)
10. J. Bertrand and Edmond Lahaye: Sur la réalisation d'appareils de mesures magnétiques absolues. (p. 408)
11. Edouard Selzer: "Multiplicateur" de champ magnétique terrestre pour magnetrons et magnetophones enregistreurs. (pp. 408-410)
12. H. Nagaoka and T. Ikebe: Induction magnetograph for recording sudden changes of terrestrial magnetic field. (p. 411)
13. Y. Kato and S. Utashiro: A new method of measuring the intensity of the earth's magnetic field. (p. 411)
14. H. Nagaoka, T. Ikebe, and S. Imamiti: Comparison of induction magnetograph with induction loop at Kakioka Magnetic Observatory. (p. 411)
15. J. R. Balsley: Techniques and results of aeromagnetic surveying. (pp. 413-418)
16. L. H. Rumbaugh and L. R. Alldredge: Airborne equipment for geomagnetic measurements. (pp. 418-419)
17. E. A. Johnson, T. Murphy, and O. W. Torreson: Pre-history of the earth's magnetic field. (pp. 421-422)
18. E. Thellier and Mme. O. Thellier: Recherches sur l'intensité du champe magnétique terrestre ancien. (pp. 422-425)
19. J. Barnóthy: The origin of the earth's magnetic field. (p. 425)
20. E. H. Vestine: Description of the geomagnetic variations. (p. 426)
21. L. Slaucitajs: Some notes on secular variation. (p. 426)
22. M. Hasegawa and M. Ota: On the magnetic field of Sq in the middle and lower latitudes during the II Polar Year. (pp. 426-430)
23. J. Egedal: The magnetic diurnal variation of the horizontal force near the magnetic equator. (p. 431)
24. M. Hasegawa and M. Ota: The representation for magnetic field of Sq with potential calculated through a method of graphical integration. (pp. 431-434)
25. H. Hatakeyama: Investigations on the bay-disturbance and the pulsation of the terrestrial magnetic field and the earth current. (p. 435)
26. Y. Kato: On a new theory of the magnetic storm. (p. 435)
27. T. Rikitake: The electrical state of the earth's interior as inferred from variations in the earth's magnetic field. (pp. 435-438)
28. M. Ota: The position and motion of the focus of the electric current-vortex equivalent to the variation-field of terrestrial magnetism. (pp. 438-442)
29. H. Nagaoka: Sudden commencement of magnetic storms and its probable cause. (p. 442)
30. H. H. Howe: Computing magnetic observatory results with punched cards. (pp. 443-450)
31. A. Romañá et C. Gaibar: Contribution à l'étude de la variation séculaire de la constante magnétique locale G. (p. 451)
32. Edmond Lahaye: Rapport sur la réalisation d'un centre d'études géophysiques en Belgique. (p. 451)
33. Edmond Hoge and Edmond Lahaye: Sur la caractérisation magnétique des jours. (pp. 451-452)

34. H. F. Johnston, W. E. Scott, and Ella Balsam: Geomagnetic indices, C and K, 1940-47. (p. 452)
35. T. Nagata: Local geomagnetic anomalies in volcanic regions and their interpretation. (pp. 452-458)
36. H. Nagaoka and T. Ikebe: Sudden magnetic variation during the volcanic activity of Asamayama. (p. 458)
37. H. Nagaoka and T. Ikebe: Magnetic variation during an explosion of Asamayama and its mechanism. (p. 458)

(D) The aurora.
1. C. Störmer: Some results from the observations and measurements of polar aurora in Southern Norway (an illustrated lecture).
2. F. T. Davies: Visual auroral observations in Canada, 1943-47. (p. 464)
3. E. H. Vestine: Analyses of visual observations of aurora. (p. 465)
4. M. Nicolet and R. Dogniaux: Nouvelles suggestions au sujet de l'interprétation du spectre des aurores. (pp. 465-466)
5. B. W. Currie and W. D. Penn: A recording meter for auroral radiations. (p. 466)
6. W. Petrie: Remarks on the excitation of certain oxygen and hydrogen lines appearing in the auroral spectrum. (pp. 466-470)
7. K. G. Malmfors: Model experiment on the aurora. (pp. 470-471)
8. B. W. Currie: Report on auroral investigations at the University of Saskatchewan, Canada. (pp. 471-473)

(E) Physics of the upper atmosphere and the ionosphere (Joint Meeting with the Association of Meteorology).
1. J. Kaplan: Laboratory studies related to the physics of the upper atmosphere. (pp. 474-479)
2. L. Vegard: Properties of the upper atmosphere revealed through spectral analysis of aurorae and twilight. (pp. 479-490)
3. C. W. Gartlein: Aurora spectra showing broad hydrogen lines. (pp. 491-492)
4. K. R. Ramanathan and R. V. Karandikar: Recent work on the measurement of atmospheric ozone and its vertical distribution in India. (pp. 492-494)
5. C. D. Ellyett and A. C. B. Lovell: Radio studies of meteoric ionization. (p. 494)
6. P. M. Millman and D. W. R. McKinley: The correlation of visual meteor data with the character of meteor radar echoes. (pp. 494-495)
7. H. Nagaoka: Luminescence and ionization of meteors. (p. 496)
8. F. Link: Exploration meteorique de la haute atmosphere. (pp. 496-499)
9. L. V. Berkner and E. H. Vestine: Measurement of the geomagnetic field in the ionosphere. (pp. 499-500)
10. H. E. Newell: Upper atmosphere research with V-2 rockets. (p. 500)
11. E. H. Vestine: Rocket measurements of the geomagnetic field and heights of electric current systems in the atmosphere. (pp. 500-501)
12. R. C. Langille: The scattering of ten-centimeter radio waves by rain. (p. 501)
13. F. Link: Sondages optiques de la haute atmosphere a l'aide des eclipses de lune. (pp. 502-503)
14. F. Link: Sur la possibilite des sondages optiques de la haute atmosphere a l'aide des phenomenas crepusculaires. (pp. 504-506)
15. H. Nagaoka: Sudden fade-out of high-frequency electric waves caused by alpha particles formed in the uppermost atmosphere. (p. 507)

16. M. Hasegawa: A suggestion for the electric conductivity of the upper atmosphere from an analysis of the diurnal variations of terrestrial magnetism. (pp. 507-509)

(F) Atmospheric and terrestrial electricity, cosmic rays, etc.

1. J. Bertrand and Edmond Lahaye: Sur la réalisation de comteurs d'ions et d'enregistreurs de la conductibilité électrique de l'atmosphère. (p. 510)
2. T. Koono: Meteoric impact ionization observed on radar oscilloscopes. (p. 510)
3. E. O. Hulburt: The brightness and polarization of the daylight sky. (p. 510)
4. O. H. Gish and G. R. Wait: Electrical surveys over thunderheads. (pp. 510-511)
5. Antonio Romañá, S.J. et J. O. Cardús, S.J.: Contribution à l'étude de l'influence de la Lune sur les courants telluriques. (pp. 511-512)
6. W. Smosarski: Quelques résultats des observations simultanées due champ electrique, de la conductibilité et des phénomènes météorologiques. (p. 513)
7. Y. Sekido: An abstract of geophysical research of cosmic rays in Japan. (pp. 513-515)
8. T. Yonezawa: On the reflection of radio waves from a meteor. (pp. 516-518)
9. A. Kimpara: The wave form of atmospherics. (p. 518)
10. D. Justin Schove: The phase of the sunspot cycle through the centuries. (p. 518)
11. M. Schlumberger and G. Kunetz: Observations sur les variations rapides des courants telluriques. (pp. 518-528)
12. S. E. Forbush: Summary of cosmic-ray observations. (pp. 529-531)

X. Subjects for discussion.

1. Proposal by Jno. A. Fleming: "Because of the great need of continuing the operation conducted for a quarter century by the Carnegie Institution of Washington and because of the Institution's decision not to replace the Carnegie, the British Admiralty has designed and has completed, except for the non-magnetic power plant, a special vessel R.R.S. Research. Already there are marked uncertainties in present isomagnetic charts because of uncertainties of secular variation and its changes in certain regions of the oceans. It is, therefore, urged that cruises by the R.R.S. Research be undertaken at the earliest possible moment even if, because of incompletion of the power plant equipment, the vessel must be for the first few years operated under sail."

2. Proposal by Jno. A. Fleming: "The task of the geophysical surface survey is so great that the hydrographic services of other nations in addition to the British Admiralty should provide additional non-magnetic vessels with equipment and personnel to take appropriate share in the execution and coordination of such surveys."

3. Proposal by Jno. A. Fleming and J. W. Joyce: "While prospects of the early realization of airborne magnetic surveys over land and ocean areas appear promising, the surface magnetic surveys over land and sea areas remain of paramount importance as (1) control observations for airborne surveys and (2) as a means of continuing the series of secular-variation observations so necessary to the proper maintenance of worldwide magnetic surveys. Hence, such surface observations must be continued as in the past."

4. Proposal by Jno. A. Fleming and J. W. Joyce: "It is recommended that the Committee on Methods of Observatory Publication be continued and that it be instructed to accomplish the objectives of the recommendations in its report to the Oslo Assembly regarding selection of key observatories and the establishment of two Central Bureaus, one in the United States and one in Europe."

5. Proposal by Jno. A. Fleming: "In view of the discontinuance of the Commission on Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization, it is recommended that a Committee be appointed under the Association of Terrestrial Magnetism and Electricity to implement methods and codes to adequately describe magnetic disturbances and perturbations to replace the now discontinued Joint Committee appointed at the Washington Assembly."

6. Proposal by Jno. A. Fleming: "In view of the establishment by the International Council of Scientific Unions of Joint Commissions on the Ionosphere and on Radio Meteorology, it is recommended that the Joint Committee of the Association and the International Scientific Radio Union be discontinued since the new Joint Commissions are represented by members of the Associations of Terrestrial Magnetism and Electricity and Meteorology and the International Scientific Radio Union."

7. Proposal by J. Olsen: "The Association urges the importance to studies of giant pulsations of operating continuous quick-run magnetographs at Tromsö, Abisko, and Sodankylä."

8. Proposal by J. Egedal and E. Sucksdorff: "The Association, regarding a better utilization of quick-run records as desirable, recommends the appointment of a Committee to organize and support such investigations. This Committee should find out whether it would perhaps be to the point to establish an International Bureau to take care of the processing of all quick-run recording material which has been collected so far, including the material from the Polar Year 1932-33."

9. Proposal by J. Egedal and A. G. McNish: "In order to aid in obtaining a better understanding of diurnal variation, the Association urges that additional emphasis be placed on the prosecution of more studies of magnetic diurnal variation, especially in horizontal intensity, and on ionic characteristics in the vicinity of the magnetic equator." [Editor's Note: During the morning session of August 25, 1948, this proposal was restated (p. 26.)]

10. Proposal by G. Fanselau: "The Association recommends the publication of the geomagnetic writings of Prof. Adolf Schmidt, completely revised and re-edited."
[In October 1944 Professor Adolf Schmidt died in Gotha. His numerous important works on the subject of geomagnetism are widely known. Nevertheless, the danger exists that with the lapse of time many of his valuable contributions will be ignored, because some of his most important works have appeared in places where they are not always easily accessible. Therefore, it is my intention to collect and revise the most important theoretical and experimental works of Professor Adolf Schmidt and to republish them in this new form. In this way Dr. Schmidt's ideas, which will still continue to be extremely valuable and inspiring in the future, will be made much more accessible to all scientists. Uniform revision, eliminating many difficulties of presentation, is very important in order to make it easier to understand Adolf Schmidt's work.]

11. Proposal by G. Fanselau: "The Association urges the selection on an international scale of particularly clear cases of typical geomagnetic variations for further careful study."
[The phenomena of geomagnetic variations in general may be described as an extremely heterogeneous mixture of the various time-changes of the outer part of the earth's magnetic field. Only by correct statistical treatment is it possible to get a clear picture of these complex phenomena. However, geomagnetic variations include some especially clear typical cases with very characteristic peculiarities observable under very quiet conditions. These are mainly the geomagnetic effects of solar eruptions (Dellinger effects), also the sudden fluctuations, the elementary wave pulsations of larger amplitude and finally the typical bay disturbances. Here it is possible, by careful selection of such variations, to compile observational data, which, even without any great statistical preparations, to a certain extent can be directly applied to physical investigations. Even though critical selection (clear observation of the effect) makes the number of cases rather limited, on the other hand, the value of this material is especially high, if all observatories publish accurately coordinated data relating to cases considered valuable from an international point of view.]

12. Proposal by F. Bahnemann: "In view of the importance pertaining to all questions connected with the problem of the magnetization of matter, especially the matter of the magnetization of ferromagnetic materials, the Association urges the appointment of a Committee to study and report on the following points:
   (a) Progress in the study of the magnetization of ferromagnetic materials. Theoretical and experimental work should be co-ordinated with the vast amount of field work carried out in the course of geophysical prospecting.
   (b) Devising of high pressure and high temperature experiments along the lines indicated by geophysical experience with special reference to geomagnetic problems.
   (c) Devising of and reporting on experiments regarding the magnetic state of magnetic rocks in situ."

13. Proposal by A. Tanakadate: "It is proposed that the Journal of Terrestrial Magnetism and Electricity be designated the official organ of the Association, and that it be supported by an appropriate annual subsidy."

14. Proposal by Jno. A. Fleming: "The great advance, during the years of the war, of recognition by the general public of the immense benefits of scientific results to human welfare presents an opportunity which should be utilized to improve future service of the Association and to promote firmer foundations of international relations.

"It is therefore proposed that the Secretary and Director of the Central Bureau be instructed, when publishing the Transactions of the Oslo Assembly, to include lists of persons and organizations (with their addresses) in all parts of the world, known to be actively interested in the various aspects of geomagnetism and electricity. This list should be of such a nature as to make possible a more general and effective distribution of reports and Transactions of the Association and its Committees with informative material on objectives and achievements of the Association."

15. Proposal by L. Koenigsfeld: "The Association recommends that the international program of geomagnetic observatory intercomparison observations originally conceived by Dr. la Cour be reactivated and extended to embrace a regular schedule of such intercomparisons between representative magnetic observatories of the world."

16. Proposal by the British National Committee: "The Association of Terrestrial Magnetism and Electricity would recommend to all magnetic observatories that their publications should include a list of times of their recorded crochets and sudden commencements of magnetic disturbances and of similar changes not followed by magnetic disturbances, together with the amount of movement in each magnetic element recorded."

XI. Appointment of Committees and Reporters.

[Editor's Note: The appointments of committees and reporters were made concurrently with the consideration of the reports of the Special Committees and Reporter appointed at Washington and as discussions during the course of the meetings indicated need for new committees and reporters.]

XII. Resolutions.

SUPPLEMENTARY AGENDA

IX. Communications.

(C) Terrestrial Magnetism.

38. P. L. Mercanton and E. Wanner: Die magnetische Anomalie im Jorat. (p. 464)
39. M. R. Madwar: Secular changes of terrestrial magnetic field at Helwan, Egypt, 1908-1944. (pp. 411-413)
40. P. Rougerie: L'Evolution diurne lunaire de la déclinaison magnétique au Val-Joyeux. (pp. 459-463)
41. S. Chapman: Abnormal daily variations of horizontal force at Huancayo and Uganda.
42. M. A. Dauvillier: Sur la variation séculaire du magnétisme terrestre. (p. 463)

(F) Atmospheric and terrestrial electricity, cosmic rays, etc.

13. J. A. Van Allen: The use of rockets in upper atmospheric research. (pp. 531-536)
14. J. Bricard: L'Equilibre ionique de la basse atmosphère. (p. 536)

STATEMENT SUMMARIZING TRANSACTIONS OF THE OSLO MEETING OF THE INTERNATIONAL ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY

By S. Chapman

(Presented at the final General Assembly of the International Union of Geodesy and Geophysics, August 28, 1948.)

The International Association of Terrestrial Magnetism and Electricity has held a very successful Assembly under the excellent arrangements made by our Norwegian hosts for our meeting place and office accommodation. We have all deeply regretted the absence of our President, Dr. J. A. Fleming, who is so much honored and beloved by all who know him and his work. In his absence the meetings have been presided over by the two Vice-Presidents, namely, Professor Coulomb, who succeeded Dr. Maurain, whose absence from us was likewise a great loss to us, and myself. We have held 10 sessions, at which the attendance was rarely below 50 and often above 100; we are an active Association and have considered reports from 14 committees, some of them joint committees with other Associations or other Unions. We have held one joint meeting with the Association of Meteorology. We have instituted and continued 15 committees, which we expect to work during the interval before our next Assembly.

Our branch of geophysics is very extensive, and has links with meteorology, radio science, and astronomy, as well as with the general physics of the solid earth. For our own use and our associated sciences we have had a scheme for assigning a world magnetic character-figure to each day, and even for each period of three hours; this scheme has been disorganized by the war, and we have taken steps to renew it on a stable basis. Since our last Assembly there has developed the possibility of making the magnetic survey of the world by air, and this has been one subject of our discussions; there is still need, however, to renew the world survey by ships on the oceans, a work long overdue since the loss of the non-magnetic ship Carnegie in 1929. Since then the continual slow change of the earth's magnetism has not been adequately followed. Since our last Assembly another important discovery which we have discussed is the influence of solar flares and magnetic storms on cosmic rays, a matter that leads our thoughts far beyond the earth and even beyond the solar system and our own galaxy of stars.

We have also discussed new information bearing on the magnetic variations from the radio investigation of the ionosphere, from meteorological studies, and from studies of the aurora and the light of the night sky.

I will mention, finally, we have discussed the past magnetic history of the earth revealed by ancient breccia and pottery, volcanic lavas, glacial varves, and from matter brought from the ocean bed.

In all these subjects we have every expectation of many new discoveries to report at our next Assembly.

PARTICIPATION IN THE OSLO ASSEMBLY OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY, AUGUST 19-28, 1948

The presence in the various sessions is indicated by "p".

Name	Country	Meeting of August											
		19 p.m.	20 a.m.	20 p.m.	21 a.m.	23 a.m.	23 p.m.	24 a.m.	24 p.m.	25 a.m.	25 p.m.	26 a.m.	26 p.m.
Alfvén, H.	Sweden	..	p	p	p	p	..	p	p	..	p	..	..
Allen, C. W.	Australia	p	p	p	..	p	p	..	p	..	p	p	p
Amble, O.	Norway	..	..	..	..	..	..	..	..	..	p	..	..
Ambolt, L.	Sweden	p	p	p	p	p	p	p	p	p	p	p	p
Banerji, S. K.	India	..	p	..	..	..	..	..	..	p	p	..	..
Barber, N. F.	Great Britain	..	p	..	..	p	..	..	..	..	..	..	..
Beals, C. S.	Canada	..	p	..	p	..	..	p	..	..	p	..	..
Bossolasco, M.	Italy	..	p	p	..	p	p	p	..	..	..	..	p
Brakken, H.	Norway	..	..	..	..	..	..	..	p	p	..	..	..
Breusse, J. J.	France	..	p	..	..	..	..	..	p	..	..	..	..
Brewer, A. W.	Great Britain	..	p	..	..	..	..	..	p	..	..	p	..
Burrows, C. R.	U.S.A.	..	p	p	..	..	..	..	p	..	p	..	..
Cassinis, R.	Italy	..	p	p	..	..	..	..	p	..	..	..	..
Chapman, S.	Great Britain	p	p	p	p	p	p	p	p	p	p	p	p
Coales, J. F.	Great Britain	..	p	..	..	..	..	p	..	p	..	p	p
Coulomb, J.	France	p	p	p	p	p	p	p	p	p	p	p	p
Currie, B. W.	Canada	p	p	p	..	p	..	..	..	..	p	p	p
Dauvillier, A.	France	..	p	..	..	..	..	..	p	p	..	p	..
Davies, F. T.	Canada	p	p	..	p	p	p	..	p	p	p	p	p
Dombai, T.	Hungary	..	p	p	p	p	..	p	..	..	..	..	..
Eady, E. T.	Great Britain	..	p	..	..	..	..	..	..	..	p	..	..
Egedal, J.	Denmark	p	p	p	p	p	p	p	p	p	p	p	p
Ferraro, V. C.A.	Great Britain	..	p	p	p	p	p	p	p	p	p	p	p
Genty, R. L. J.	France	p	p	p	p	p	p	p	p	p	p	p	..
Gibson, R. E.	U.S.A.	..	p	..	..	..	..	..	..	..	p	..	..
Götz, F. W. P.	Switzerland	..	..	..	..	..	..	..	..	..	p	..	..
Grenet, G.	France	p	p	..	..	..	..	p	..	..	..	..	..
Hanson, G.	Canada	..	p	..	..	..	..	..	p	..	..	p	..
Harang, L.	Norway	..	p	..	p	..	..	p	p	p	p	p	..
Hazen, N. R.	U.S.A.	..	..	..	..	..	..	..	..	..	p	..	..
Herrinck, P.	Belgian Congo	..	..	p	p	..	..	p	p	p	..	p	p
Holmboe, J.	U.S.A.	..	..	..	..	..	..	..	..	..	p	..	..
Hulburt, E. O.	U.S.A.	..	p	..	p	p	..	..	..	p	p	p	p
Ising, G.	Sweden	..	p	..	..	..	..	..	p	..	p	..	..
Jarman, C. A.	Great Britain	..	p	..	..	..	..	p	..	..	p	p	p
Johnson, Sir N.	Great Britain	..	p	..	..	..	..	..	..	..	p	..	..
Jolly, H. L. P.	Great Britain	..	p	..	..	..	..	..	p	..	..	..	..
Jones, Sir H. Spencer	Great Britain	..	p	p	p	p	p	..	p	p	p	p	p
Joyce, J. W.	U.S.A.	p	p	p	p	p	p	p	p	p	p	p	p
Kalinowska, Mlle. S.	Poland	..	p	p	p	p	p	p	p	p	..	p	..
Kaplan, J.	U.S.A.	..	p	..	..	p	p	..	p	p	p	p	p
Kent, L.	South Africa	..	..	..	..	..	..	..	p	..	..	..	..
Keränen, J.	Finland	..	p	p	p	p	p	p	p	p	p	p	p
Kjaer, R.	Norway	..	..	p	..	..	..	p	..	..	..	..	..
Koenigsfeld, L.	Belgium	p	p	p	p	p	p	p	p	p	p	p	p
Lahaye, E.	Belgium	p	p	p	p	p	p	p	p	p	p	p	p
Landsberg, H. E.	U.S.A.	..	..	..	..	..	..	..	..	..	p	..	..
Laursen, V.	Denmark	p	p	p	p	p	p	p	p	p	p	p	p
Lejay, P.	France	..	p	..	..	..	..	..	..	..	..	..	..
Link, F.	Czechoslovakia	..	..	..	p	p	p	p	p	p	p	p	p
LoSurdo, A.	Italy	..	p	p	..	p	..	..	..	p	..	..	..
Lützow-Holm, O.	Argentina	p	p	p	p	p	p	p	p	p	p	p	p
Mackintosh, N. A.	Great Britain	..	p	..	..	..	..	..	..	..	..	..	..
Madwar, M. R.	Egypt	p	p	p	..	..	..	..	..	..	..	p	..
Marsden, E.	New Zealand	..	..	..	p	..	..	..	..	..	..	..	..
Martyn, D. F.	Australia	..	p	..	p	p	p	..	..	p	..	p	p

PARTICIPATION IN THE OSLO ASSEMBLY OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY, AUGUST 19-28, 1948--Concluded

Name	Country	Meeting of August											
		19 p.m.	20 a.m.	20 p.m.	21 a.m.	23 a.m.	23 p.m.	24 a.m.	24 p.m.	25 a.m.	25 p.m.	26 a.m.	26 p.m.
Medi, E.	Italy	..	p	p	p	p	p	p	p	p	p	p	p
Mercanton, P. L.	Switzerland	..	..	..	..	..	..	..	..	..	..	..	p
Monasterio, C. N.	Argentina	..	p	..	..	..	..	..	..	..	..	..	..
Montanari, D.	Italy	..	..	..	..	..	..	..	..	..	p	..	..
Mulders, G. F. W.	U.S.A.	..	..	..	..	p	..	p	p	p	p	..	..
Nicolet, M.	Belgium	..	..	..	..	p	..	..	..	p	p	..	p
Nörgaard, G.	Sweden	..	p	..	..	..	..	..	..	..	..	..	..
Norinder, H.	Sweden	..	p	..	..	p	..	..	p	p	p	..	..
Olczak, T.	Poland	..	p	..	..	p	..	..	..	p	..	..	..
Olsen, J.	Denmark	p	p	p	p	p	p	p	p	p	p	p	p
Ore, A.	Norway	..	..	..	..	..	..	..	..	..	p	..	..
Orr, A. P.	Great Britain	..	..	..	..	..	..	p	..	..	..	..	..
Pawlowski, S.	Poland	..	p	p	..	..	..	p	..	..	..	..	..
Pawsey, J. L.	Australia	..	p	..	..	..	p	..	..	..	p	..	..
Perlat	France	..	..	..	..	..	..	..	..	..	p	..	..
Piggot, C. S.	U.S.A.	..	p	..	..	..	p	..	..	..	..	..	..
Queney, P.	France	..	..	..	..	..	..	..	..	..	p	..	..
Ramanathan, K. A.	India	..	..	..	..	..	..	..	..	..	p	..	..
Rankine, A. O.	Great Britain	..	p	..	..	..	..	p	..	..	..	p	..
Renner, J.	Hungary	p	p	p	p	p	..	p	..	p	..	..	..
Romañá, Father A.	Spain	..	..	..	p	p	p	p	p	..	..	p	p
Rosseland, S.	Norway	..	..	..	..	..	..	..	..	..	p	..	..
Rumbaugh, L. H.	U.S.A.	..	p	..	..	..	p	..	..	..	p	p	p
Runcorn, S. K.	Great Britain	..	p	..	p	p	..	..	p	p	..	p	..
Ruska, W. E. A.	U.S.A.	p	p	..	..	..	..	..	p	..	p	..	..
Rydbeck, O. E. H.	Sweden	..	p	..	..	..	p	..	p	p	p	p	..
Selzer, E.	France	p	p	p	p	p	p	p	p	p	p	p	p
Smith, W.	U.S.A.	..	..	..	..	..	..	p	..	..	..	..	..
Stephenson, E. B.	U.S.A.	..	p	..	..	..	..	..	..	..	p	..	..
Störmer, C.	Norway	..	..	p	..	p	p	..	..	p	p	p	..
Sucksdorff, E.	Finland	p	p	p	p	p	p	p	p	p	p	p	p
Sutton, O. G.	Great Britain	..	..	..	..	..	..	..	p	..	..	..	..
Thellier, E.	France	p	p	p	p	p	p	p	p	p	p	p	p
Thellier, Mme. O.	France	..	..	..	p	p	p	p	..	p	..	..	..
Thomas, A. V.	Great Britain	..	p	..	p	p	p	..	p	p	..	p	p
Thomson, A.	Canada	..	p	..	..	..	..	..	..	..	p	..	..
Thorp, J. R.	Great Britain	..	..	..	..	..	..	..	..	..	p	..	..
Tönsberg, E.	Norway		..	..	..	..	..	p	p	p	p	..	..
Tschu, K. K.	China	..	..	..	p	p	..	p	p	..	..	p	..
Tuve, M. A.	U.S.A.	..	p	..	..	p	p	..	p	p	p	p	..
Vassy, Mme. A. T.	France	..	p	p	p	p	p	..	..	p	p	p	p
Vassy, E.	France	..	p	p	..	..	p	..	..	..	p	p	p
Vegard, L.	Norway	p	p	p	p	p	p	p	p	p	p	p	p
Veldkamp, J.	Netherlands	..	..	..	p	p	..	p	p	p	p	p	p
Viglieri, A.	Italy	..	p	..	..	..	..	..	..	..	..	..	..
Wadia, D. N.	India	..	p	..	..	..	..	..	..	..	..	..	..
Wasserfall, K. F.	Norway	p	p	..	..	..	..	..	p	p	p	p	p
Werner, S.	Sweden	p	p	p	p	p	p	p	p	p	p	p	p
Whipple, F. L.	U.S.A.	..	..	..	..	..	..	..	p	..	p	..	p
Wilkes, M. V.	Great Britain	..	p	..	p	..	..	..	p	p	..	p	p
Wiseman, J. D. H.	Great Britain	..	p	..	..	..	..	..	..	..	..	..	..
Woolley, R. V. R.	Australia	..	..	..	..	..	p	..	..	p	p	..	..
Yriberry, Father A. J.	Argentina	..	p	p	..	p	p	p	p	p	p	p	p
Zátopek, A.	Czechoslovakia	..	..	..	p	..	..	..	..	..	..	..	..
Ångstrom, A.	Sweden	..	..	..	..	..	..	..	..	..	p	..	..
Åslund, S.	Sweden	p	p	p	p	p	p	p	p	p	p	p	p
Totals		25	78	39	42	49	41	44	55	52	69	52	43

MINUTES OF OSLO MEETING
AUGUST 19-26, 1948

Session of August 19, 1948

The meeting was opened at 14:45 by the Acting President, Prof. J. Coulomb.

Following some general announcements by the Secretary, the Acting President recommended that a cable be sent to Dr. Fleming, the President of the Association, expressing regret that he and Mrs. Fleming could not be in Oslo. The Association agreed to this proposal, and the Secretary was instructed to compose and forward such a cable.

The Association also authorized the Secretary to prepare a letter to Dr. A. H. R. Goldie, expressing the Association's appreciation for his services as Secretary and Director of the Central Bureau from 1936 to 1947.

The following three special committees, nominated by the Executive Committee, were appointed by the Association:

Auditing Committee
Mr. J. Egedal
Prof. E. Thellier
Dr. M. A. Tuve

Nominations Committee
Mr. J. Egedal
Prof. L. Harang
Sir Harold Spencer Jones
Prof. E. Thellier
Dr. M. A. Tuve

Resolutions Committee
Prof. S. Chapman
Prof. J. Coulomb
Dr. J. W. Joyce
Dr. J. T. Wilson

At the request of the Acting President, the Secretary read a list of names of geomagneticians who have died during the period since the Washington Assembly in 1939 (see pp. 31-36).

The Secretary and Director of the Central Bureau presented his report (item II of the Agenda). Approval of this report was deferred pending the receipt of the Auditing Committee's report. The Secretary then advised the Association that it had been impossible to circulate proposals and agenda items to the members of the General Assembly four months prior to the Oslo Assembly, as provided for under Section V of the Association's statutes. He therefore requested that the

Association permit the discussion of such proposals and questions, and proceed in accordance with Section V of the statutes. This request was granted.

National reports (item VI of the Agenda) were presented in abstract as follows:

(a) Dr. Lahaye presented the Belgian report.

(b) Mr. Egedal and Mr. Olsen discussed the Danish report, pointing out that while instrument construction was now proceeding in Denmark, the demand for QHM's and BMZ's far exceeded present production possibilities. Mr. Egedal also stated that he had information on new and improved earth inductors and would be glad to give this information to interested persons.

(c) Dr. Renner presented a brief of the Hungarian report and mentioned that this year marked the hundredth anniversary of the birth of Baron Roland von Eötvös.

(d) Prof. Vegard abstracted Norwegian work on geomagnetism and the aurora under the Norwegian Institute of Cosmical Physics. Prof. Vegard mentioned plans for a new observatory near Spitsbergen in the near future.

(e) Dr. Ambolt commented on the Swedish national report. He had with him a new instrument for better declination observations, and arrangements were made to display this instrument to interested members of the Association.

(f) Mr. Lützow-Holm gave some information on behalf of Argentina, stating that magnetic maps for 1944 are now ready for release. A plan is in existence to occupy within the next ten years approximately 1,000 magnetic stations in Argentina. Plans for the new observatories in that country include stations in Patagonia and the Antarctic.

(g) Dr. Allen presented a brief of the Australian report.

(h) Mr. Davies presented an abstract of the Canadian reports on terrestrial magnetism and atmospheric ionization.

(i) Dr. Sucksdorff presented a brief of the Finnish national report.

(j) Dr. Thellier presented an abstract of the French report.

(k) Dr. Madwar remarked that in Egypt magnetic observations in the Nile valley had started in 1910 and utilized three sets of Watson magnetometers standardized by Kew magnetometers and Dover dip circle. In 1933 there was added to the absolute instruments a Schuster-Smith magnetometer and a Dye vertical-force magnetometer.

(l) The Secretary commented briefly on the United States report consisting of contributions from the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, the Department of the Navy, the Coast and Geodetic Survey, and the American Geophysical Union.

The meeting adjourned at 16:00.

Morning Session of August 20, 1948

The meeting was opened at 11:00 by Acting President Coulomb.

In the absence of President Fleming, his Presidential Address was read by the Secretary.

The meeting adjourned at 12:15.

Afternoon Session of August 20, 1948

Acting President Coulomb called the meeting to order at 14:45.

The minutes of the last meetings were read and approved after minor corrections.

The Secretary read the message that had been forwarded to Dr. Fleming in accordance with the Association's action at its first meeting.

The following Committee was nominated by the Acting President and appointed by the Association to review the statutes of the Association to assure their conformity with those of the Union:

Prof. S. Chapman, Chairman
Mr. F. Davies
Dr. J. W. Joyce
Mr. J. Olsen
Dr. E. Sucksdorff

Reports of the various Committees appointed at the Washington Assembly were then presented as follows (item VII(A) of the Agenda):

(a) Committee on the Selection of Sites of New Observatories for Terrestrial Magnetism and Electricity: Dr. J. A. Fleming, Chairman.

The Secretary read Dr. Fleming's report. This report was discussed by Messrs. Chapman, Egedal, Ambolt, Vegard, Olsen, Lützow-Holm, and Joyce. Out of this discussion came several proposed resolutions concerning the establishment of new geophysical observatories. These were referred to the Resolutions Committee for action.

The Association accepted the report and continued the Committee with the following members:

Dr. J. A. Fleming, Chairman
Prof. S. Chapman
Prof. J. Coulomb
Mr. V. Laursen

(b) Auroral Committee: Prof. C. Störmer, Chairman.

Professor Störmer presented this report. He indicated that the supply of Auroral Atlases was now about 29. If more are reprinted before the next Assembly, the Executive Committee will have to approve reprinting of them.

The Association accepted the report and continued the Auroral Committee with the following membership:

Prof. C. Störmer, Chairman
Dr. B. W. Currie
Dr. J. Dufay
Dr. F. P. W. Götz
Dr. J. Paton
Dr. E. Sucksdorff

(c) Committee on the Study of Relationship Between Solar Activity and Terrestrial Magnetism: Dr. J. A. Fleming, Chairman.

The Secretary read the Committee's report, and it was accepted by the Association. It was decided to dissolve the Committee in accordance with the Committee's recommendation, since members of the Association are also members of the Commission for the Study of Relations between Solar and Terrestrial Phenomena of the International Council of Scientific Unions. Under these circumstances it was also decided that a reporter would not be required.

(d) Committee on Secular-Variation Stations: Dr. E. H. Vestine, Chairman. The Secretary read the report. It was discussed by Messrs. Thellier, Olsen, Ambolt, and Sir Harold Spencer Jones. In particular, Dr. Ambolt stressed the importance of the height of the instrument in observing at repeat stations.

This discussion led to consideration by the Association of proposals 1, 2, and 3 (item X of the Agenda). Sir Harold Spencer Jones read the following statement on behalf of the British Board of Admiralty regarding R.R.S. Research:

> "The question of completing R.R.S. Research has been receiving the urgent consideration of the Board of Admiralty. The board fully appreciates the high international importance of the work Research was designed to perform, and views with all possible sympathy the desire of the International Union of Geodesy and Geophysics and many other scientific interests to see the ship put into service.
>
> "There are certain considerations, financial and material, which have not yet been fully examined and they much regret, therefore, that they are not at the present moment in a position to give a final decision on this matter.
>
> "They wish, however, to reaffirm their interest in the project and their intention to do the utmost practicable to realise it."

In view of this statement, it was decided to modify proposal 1 to take account of the Admiralty's statement. Proposals 1, 2, and 3 were then referred to the Resolutions Committee for further action.

The Association accepted the report and continued the Committee on Secular-Variation Stations with the following membership:

Dr. E. H. Vestine, Chairman
Mr. J. Egedal
Dr. J. A. Fleming
Mlle. S. Kalinowska*
Mr. T. H. O'Beirne
Dr. Pushkov
Dr. J. M. Rayner

The Association further appointed a new Committee to be known as the Committee on Centralization and Standardization of Records. Membership is as follows:

Sir Harold Spencer Jones, Chairman
Dr. N. Ambolt
Dr. O. Lützow-Holm
Dr. Pushkov
Capt. E. B. Roberts*
Dr. E. H. Vestine

(e) Committee on Ionic Equilibrium: O. H. Gish, Chairman.
No report has been received from this Committee. It was decided not to reappoint the Committee.

---

*These appointments were made after the Oslo Assembly and were approved by the Executive Committee.

(f) Committee on Magnetic Charts - Organization of the Work: Sir Harold Spencer Jones, Chairman. Committee on Magnetic Charts - Methology: Dr. E. H. Vestine, Acting Chairman.

These reports were presented and then discussed together. Dr. Ambolt brought to the attention of the Association the following International Hydrographic Bureau Circular Letter No. 12-H of 1948, dated at Monte-Carlo, June 29, 1948, on the subject "Magnetic Charts" (Reference: Circular Letter No. 10-H of November 26, 1947):

> "Attention is again invited to the following resolution adopted at the IVth International Hydrographic Conference:
>
> 1. It is recommended that Hydrographic Offices which publish Magnetic Charts for the Oceans of the whole world enter into an agreement to the effect that the sequence of dates of publication be arranged so as to reduce as much as possible the interval between the various publications.
> 2. It is advisable to indicate clearly on charts the epoch to which values are referred. (Example 1935.0, 1935.5)
>
> "In reply to the Bureau's subject letter and certain additional correspondence the following determined sequence for the publication of the Isogonic Magnetic Charts of the World is acceptable to the indicated Nations:
>
> | | Epoch | Subsequent interval |
> |---|---|---|
> | U.S.A. | 1950.0 | 5 years |
> | France | 1951.0 | 5 years |
> | Great Britain | 1952.0 | 5 years |
> | Germany | 1953.0 | 5 years |
>
> "It has also been determined that the countries which publish Magnetic World Charts other than World Isogonic Charts have used for the epoch date of these Magnetic Charts the same epoch date used for their Isogonic Charts.
>
> "It is anticipated that the Nations concerned, in the interests of maintaining this predetermined sequence, will continue this practice.
>
> "It is obviously desirable that, should some other country contemplate publishing World Magnetic Charts, that country adopt as their epoch date the date 1949 or 1954 on a five-year cycle, thus permitting an Isogonic World Chart to be published for each epoch year. Should other countries at some later date publish such charts it is suggested that they adopt as an epoch date the half year period f.i. 1952.5 and notify the Bureau of their intention so that an orderly sequence can be maintained.
>
> (Signed) Vice-Admiral J. D. Nares
> President of the Directing Committee."

The reports of the Committee on Magnetic Charts were accepted. After some discussion the Association agreed with the recommendation of the Committee on Magnetic Charts - Organization of the Work that the two groups be continued into one Committee on Magnetic Charts, with the following membership:

Dr. E. H. Vestine, Chairman
Dr. N. Ambolt
Sir Harold Spencer Jones
Mr. R. G. Madill
Capt. E. B. Roberts

The meeting adjourned at 17:30.

Morning Session of August 21, 1948

Acting President Coulomb called the meeting to order at 10:05.

The minutes of the last meeting were read and approved.

The Committee on Nominations reported the following slate of candidates for officers of the Association for the next three-year period:

Prof. S. Chapman	President
Prof. J. Coulomb) Dr. B. F. J. Schonland)	Vice-Presidents
Dr. J. W. Joyce	Secretary and Director of the Central Bureau
Dr. S. K. Banerji) Mr. L. V. Berkner) Mr. V. Laursen) Mr. O. Lützow-Holm) Dr. D. F. Martyn)	Members of the Executive Committee

The candidates were elected by unanimous vote.

The following reports of Committees appointed at Washington were presented (item VII(A) of the Agenda):

(a) Committee on Registration in Iceland of Giant Pulsations: Mr. J. Olsen, Acting Chairman.

Following this report, Dr. Harang called attention to the possible consequences of these studies to ionospheric phenomena. Mr. Olsen's proposal (item X of the Agenda) was referred to the Resolutions Committee. The matter of a subvention to support further work was passed to the Executive Committee for a decision.

The Committee was continued with the following members:

Mr. J. Olsen, Chairman
Mr. F. T. Davies
Dr. L. Harang
Dr. E. Sucksdorff

(b) Committee on Methods of Observatory Publication: Comdr. (now Capt.) E. B. Roberts, Acting Chairman.

The Secretary read the report. The recommendation concerning a selected list of magnetic observatories from which complete information will be published is of direct concern to the new Committee on Centralization and Standardization of Records, and the matter will, therefore, be considered by that Committee.

The Committee on Methods of Observatory Publication was continued with the following membership:

Dr. J. Bartels, Chairman
Dr. J. A. Fleming
Capt. E. B. Roberts
Mr. E. Selzer
Dr. B. Trumpy

(c) Committee on Classification of Magnetic Literature: H. D. Harradon, Chairman.

The consideration of the Committee's report was postponed until the next meeting, although the Association agreed that the Committee was to be discharged with thanks in accordance with its final recommendation.

(d) Committee to Promote International Comparisons of Magnetic Standards: Prof. J. Keränen, Chairman.

The Chairman read the Committee's report, which was accepted by the Association. Proposal 15 (item X of the Agenda) regarding international comparisons was approved and referred to the Resolutions Committee. The report was also discussed by Messrs. Koenigsfeld, Thellier, Egedal, Olsen, and Joyce.

The Committee was continued with the following membership:

Mr. V. Laursen, Chairman
Dr. N. Ambolt
Prof. J. Keränen
Dr. Koenigsfeld
Dr. R. G. Madill
Prof. E. Thellier

(e) Committee on Observational Technique: Mr. H. E. McComb, Chairman.

The Secretary abstracted the Committee's report. The Association accepted the report and acted to continue the Committee with the following member ship:

Mr. H. E. McComb, Chairman
Mr. S. Åslund
Mr. E. A. Chamberlain
Mr. O. Lützow-Holm
Mr. J. Olsen
Mr. E. Thellier

The Committee was instructed to consider the preparation of a manual for standardized observatory practices.

(f) Committee on Three-Hour-Range Indices for Magnetic Characterization: Mr. A. G. McNish, Acting Chairman.

At the request of Prof. Chapman, consideration of this report was postponed until the next meeting.

(g) Joint Committee of the Commission on Terrestrial Magnetism and Atmospheric Electricity and the Association on Methods and Codes to Adequately Describe Magnetic Disturbances and Perturbations: Dr. J. A. Fleming, Chairman.

The Secretary abstracted the Committee's report. The matter of C and K figures of the Committee's recommendations will be resolved when considering Mr. McNish's report. The Association accepted the report. Since the International Meteorological Organization has discontinued the Commission on Terrestrial Magnetism and Atmospheric Electricity, the proposal that the Committee be discharged and its functions assumed by the Committee on Three-Hour-Range Indices for Magnetic Characterization was approved.

(h) Joint Committee of the Association and of the International Scientific Radio Union (URSI): Sir Edward Appleton, Chairman.

Since the functions of the Committee have now been assumed by the Commission on the Ionosphere and the Commission for the Study of Solar and Terrestrial Relationships of the ICSU, and since complete reports of both are being issued, no report has been prepared for the Association. Further action on the disposition of the Committee was postponed until the next meeting.

(i) Reporter on International Collaboration for Promoting the Study of the Influence of the Moon on Geophysical Phenomena: S. Chapman.

Prof. Chapman presented his report, and as a result of his recommendations the Association approved the appointment of the following Committee to further these studies:

Prof. S. Chapman, Chairman
Dr. K. Weekes, Secretary
Prof. J. Bartels
Mr. J. Egedal
Dr. D. F. Martyn
Dr. S. K. Pramanik
Dr. K. R. Ramanathan
Rev. Antonio Romañá, S.J.
Dr. P. Rougerie
Dr. O. Schneider
Mr. A. Thomson
Dr. K. K. Tschu
Mr. M. V. Wilkes

This will be a Joint Committee with the Association of Meteorology if that Association agrees, and it will appoint additional members to the Committee. The amount of subvention to continue lunar tide studies will be resolved by the Executive Committee. [Editor's note: The Association of Meteorology has agreed to the proposal that this be a Joint Committee. The above list of names includes members from the Association of Meteorology.]

The meeting adjourned at 13:00.

Morning Session of August 23, 1948

Acting President Coulomb called the meeting to order at 10:10.

The minutes of the last meeting were read and approved.

Professor Vegard took the chair as discussion leader on the subject "Physical Aspects of the Influence of Solar Activity on Terrestrial Magnetism" (item IX(A) of the Agenda).

Following Professor Vegard's opening remarks, the following papers were presented:

Rev. Antonio Romañá: Contribution à l'étude des effects géomagnetiques des differentes manifestations de l'activité solaire.
M. Nicolet: Le problème des régions ionosphériques.
E. Thellier: Les orages magnetiques.

The following papers were read by title since authors were not present and reprints had in most cases been distributed to members of the Association:

W. C. Parkinson: Solar flares and their terrestrial effects.
T. Yonezawa: On the variation of electron and ion densities in the F2-layer at the time of the solar eclipse on February 5, 1943.
H. Nagaoka: Magnetic storms and lunar phase during sunspot maximum from standpoint of ionospheric disturbance.
Rev. E. Gherzi, S.J.: Results of some ionospheric and solar radio noise researches made at the Zi-Ka-Wei Observatory during the solar annual eclipse of May 9, 1948.
T. Nagata: Longitudinal inequality of solar diurnal variation in geomagnetic field.
H. Nagaoka: Magnetic disturbance during sudden fade-outs of radio transmission.
S. Imamiti: Radio fade-out and earth magnetic variation.

The program was discussed by Messrs. Coulomb, Romañá, Alfvén, and Olsen. Mr. Olsen presented an abstract of his paper called "Persistent Solar Rotation-Period of 26-7/8 Days and Solar Diurnal Variation in Terrestrial Magnetism" as bearing on the subject.

Professor Vegard's proposals for further study were postponed until the afternoon session, and the meeting was adjourned at 12:35.

Afternoon Session of August 23, 1948

Acting President Chapman called the meeting to order at 14:35.

The Acting President reminded the Association that since the Washington Assembly an emergency condition has existed in the Union, resulting in temporary departures from the Association's Statutes. He suggested that it would be desirable for the newly-elected officers to join with present officers in deliberations which had been referred to the Executive Committee during the Assembly, and that the new officers and Executive Committee should enter upon their duties at once but that for the purpose of future elections their period of office should be regarded as beginning at the end of this Assembly.

The Association approved this action.

The Association next considered the report of the Committee on Classification of Magnetic Literature. This report was adopted and the Secretary was instructed to communicate it to Science Abstracts and any other similar institution with a recommendation that the Committee's classification system be adopted. The Committee was not reappointed.

The report of the Committee on Three-Hour-Range Indices for Magnetic Characterization, A. G. McNish, Acting Chairman, was next considered and accepted. It was noted that the URSI Assembly at Stockholm had taken appropriate action to express appreciation for the K indices and urged that both C and K be continued.

The Mixed Commission on the Ionosphere, consisting of members of the Associations of Meteorology and Terrestrial Magnetism and Electricity of UGGI, URSI, and IAU, also requested that both C and K figures be continued. Discussion followed by Messrs. Egedal, Tuve, Spencer Jones, Olsen, Chapman, and Joyce.

The Association continued the Committee, to be known as the Committee on Characterization of Magnetic Disturbances, with the following membership:

Dr. J. Bartels, Chairman
Mr. J. Egedal
Mr. H. F. Johnston
Prof. Lahaye
Sir Harold Spencer Jones
Dr. E. Sucksdorff
Dr. J. Veldkamp

The proposals of the present Committee's report were referred to the new Committee for consideration. It was recommended that the Committee develop proposals for a method of determination of C from K indices which would give a homogeneous series of the former. When this fact could be demonstrated, the matter of discontinuing the present method of determining C could be taken up with URSI and the other interested groups.

Dr. Ambolt suggested that the Committee also consider publishing range limits at the various observatories.

The Association instructed the Secretary to express to Mr. H. F. Johnston and his colleagues its appreciation for the excellent task of preparing Bulletins 12 and 12A.

The following papers on the ionosphere were then presented (item IX(B) of the Agenda):

H. W. Wells: Rapid changes in the ionosphere.
H. W. Wells: High-speed ionospheric recording technique.
L. V. Berkner: Continuous recording of dominant ionospheric characteristics.
H. W. Wells: Characteristics of sporadic E.
J. H. Meek: Characteristics of 'E' region sporadic ionization in Canada.
H. W. Wells: Ionospheric observatories established by the Department of Terrestrial Magnetism, Carnegie Institution of Washington.
H. W. Wells: Ionospheric anomalies and future research objectives.

The remaining listed papers were read by title:

H. Uyeda: Change of the E-region in the morning and in the evening.
Otto Burkard: Elektronenvernichtung in der F2-schicht.
H. Uyeda: Worldwide distribution of the ordinary component critical frequencies of F2-layer.
Y. Aono: On the variation of minimum frequency in h'-f curve of ionospheric observation.
Y. Nakata: Formation of F12-layer.
H. Nagaoka: Diurnal variation in the production of ions in the ionosphere.
H. Nagaoka: Six-month period of terrestrial magnetic activity and its relation to F2-layer of the ionosphere.
H. Nagaoka: The formation of F1- and F2-layers of the ionosphere.
T. Nagata and N. Fukushima: Ionospheric bays accompanying geomagnetic bays.

A period of very active discussion of this group of papers followed, participated in by Mme. Vassy, Messrs. Rydbeck, Harang, Martyn, Tuve, Davies, Störmer, Marsden, Whipple, Pawsey, and others.

Following this, Prof. Vegard presented his suggestions for further studies on the subject of physical aspects of the solar activity on terrestrial magnetism.

Professor Chapman commented on Mr. Olsen's paper on the persistent solar-rotation period of 26-7/8 days.

The meeting was adjourned at 16:50.

Morning Session of August 24, 1948.

Acting President Chapman called the meeting to order at 10:05.

The minutes of the last two meetings were read and approved with minor corrections.

The Association accepted the report of the Temporary Commission on Liquidation of the Polar Year 1932-33, Jno. A. Fleming, President (item VIII of the Agenda). This report was presented by Mr. V. Laursen, who provided supple mentary information on the subject.

The following papers on terrestrial magnetic surveys and instruments were then presented (item IX(C) of the Agenda):

R. G. Madill (read by Dr. C. S. Beals): Declination results at Canadian stations north of latitude 60°N., 1938-47.
E. H. Vestine: Completion of magnetic and electric survey of the earth.
Edmond Hoge: Essai d'interprétation géologique des anomalies magnétiques décelées dans l'Est de la Belgique.
J. Bertrand and Edmond Lahaye: Sur la réalisation d'appareils de mesures magnétiques absolues.
Edouard Selzer: "Multiplicateur" de champ magnétique terrestre pour magnétrons et magnétophones enregistreurs.

The Association expressed thanks to Dr. Vestine and his colleagues for the monumental task of preparing and editing the recent two publications of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington on the main geomagnetic field of the earth and its secular change.

The Acting President informed the Association that the Executive Committee of the Union had entrusted the past functions of the Commission on Continental and Oceanographic Structure to a Joint Commission of the Associations of the Union. All Associations having an interest in the subject are invited to nominate members to the new Commission. The Association named the following as its representatives:

Dr. E. H. Vestine
Prof. A. T. Price

The following papers were read by title:

J. Veldkamp: A new magnetic survey of the Netherlands.
F. Bahnemann: Correlation of magnetic field data.
Karl Wienert: Preliminary report on the magnetic results of a journey to Sikkim and Tibet.
B. Trumpy: A magnetic survey of Norway.
H. F. Baird: Magnetic resurvey of New Zealand.
José G. Siñeriz: Las variaciones de la componente vertical del campo magnetico terrestre aplicadas a la prospeccion de minerales.
H. Nagaoka and T. Ikebe: Induction magnetograph for recording sudden changes of terrestrial magnetic field.
Y. Kato and S. Utashiro: A new method of measuring the intensity of the earth's magnetic field.
H. Nagaoka, T. Ikebe, and S. Imamiti: Comparison of induction magnetograph with induction loop at Kakioka Magnetic Observatory.

The meeting was adjourned at 12:35.

Afternoon Session of August 24, 1948

Acting President Chapman called the meeting to order at 14:35.

The following two papers on the airborne magnetometer were presented by Dr. Rumbaugh:

L. H. Rumbaugh and L. R. Alldredge: Airborne equipment for geomagnetic measurements.
J. R. Balsley: Techniques and results of aeromagnetic surveying.

In the ensuing discussion, Mr. Jarman described briefly British work with airborne magnetometers that confirmed American experience with the device (pp. 418-419).

A new Committee on Magnetic Airborne Surveys was established and the following members were appointed:

Dr. J. W. Joyce, Chairman
Dr. C. S. Beals
Mr. C. A. Jarman
Mr. J. M. Rayner
Dr. L. H. Rumbaugh
Mr. E. Selzer

A discussion of theories of the origin of the earth's magnetic field then followed (pp. 419-421). Mr. Runcorn opened the period with an account of Prof. Blackett's recent proposal, and gave results of magnetic measurements in deep mines, which had been proposed as a test of the theory. Further discussion by Messrs. Chapman, Spencer Jones, Whipple, Tuve, Alfvén, and Medi followed.

The following papers were then presented:

E. A. Johnson, T. Murphy, and O. W. Torreson (presented by Dr. Tuve): Pre-history of the earth's magnetic field.
E. Thellier and Mme. O. Thellier: Recherches sur l'intensite du champe magnétique terrestre ancien.
A. Romañá and C. Gaibar: Contribution à l'étude de la variation séculaire de la constante magnétique locale G.

The meeting adjourned at 17:45.

Morning Session of August 25, 1948

Acting President Coulomb called the meeting to order at 10:00.

The minutes of the last two meetings were read and approved.

The Secretary announced that Dr. Fleming had acknowledged with great appreciation the message the Association had sent him by cable.

The following papers were then presented:

J. Egedal: The magnetic diurnal variation of the horizontal force near the magnetic equator.

S. Chapman: Abnormal daily variations of horizontal force at Huancayo and Uganda.

These papers were discussed by Messrs. Martyn and Banerji. Resolution No. 9 was revised, following discussions between Mr. Egedal, Professor Chapman, and Dr. Martyn. As presented to the Association, it is as follows:

In view of the fundamental importance of more observations of the daily variations of the horizontal force in the region between and near the magnetic and geographical equator, the Association appointed a Committee to take care:

1. That preliminary observations of the daily variation of H be made in these regions with QHM's.
2. That provisional or permanent observatories be established in collaboration with the Committee on sites of magnetic observatories at places found most suitable from the preliminary observations.
3. That ionosphere sounding equipment be installed at these observatories.
4. That measurements of ionospheric absorption coefficients be made regularly at at least one of these observatories.
5. That all observations made be published promptly.

This proposal was referred to the Resolutions Committee.

The following papers were presented:

Edmond Lahaye: Rapport sur la réalisation d'un centre d'études geophysiques en Belgique.
Edmond Hoge et Edmond Lahaye: Sur la caratérisation magnétique des jours.

The following papers of the group were read by title:

H. H. Howe: Computing magnetic observatory results with punched cards.
H. F. Johnston, W. E. Scott, and Ella Balsam: Geomagnetic indices, C and K, 1940-47.
T. Nagata: Local geomagnetic anomalies in volcanic regions and their interpretation.
H. Nagaoka and T. Ikebe: Sudden magnetic variation during the volcanic activity of Asamayama.
H. Nagaoka and T. Ikebe: Magnetic variation during an explosion of Asamayama and its mechanism.

Professor Störmer next gave a most interesting and informative lecture on Aurora in Southern Norway, with slides and motion pictures. This was followed by a showing of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, film of the ionosphere.

Professor Störmer then took the chair for the presentation of the following papers on aurora (item IX(D) of the Agenda):

F. T. Davies: Visual auroral observations in Canada, 1943-47.
M. Nicolet and R. Dogniaux: Nouvelles suggestions au sujet de l'interprétation du spectre des aurores.

These papers were discussed by Messrs. Vegard and Vassy. The remaining papers on aurora were postponed until Thursday, and the meeting adjourned at 12:50.

Joint Session with Association of Meteorology
August 25, 1948

The joint meeting was opened by Prof. Chapman at 14:35.

The following papers were presented (item IX(E) of the Agenda):

J. Kaplan: Laboratory studies related to the physics of the upper atmosphere.
L. Vegard: Properties of the upper atmosphère revealed through spectral analysis of aurorae and twilight.
C. W. Gartlein (read by B. W. Currie): Aurora spectra showing broad hydrogen lines.

This group of papers was discussed briefly by Messrs. Chapman, Vassy, Vegard, and Nicolet. The proven periodic presence of hydrogen in the auroral spectra is most significant in studies of the upper atmosphere.

K. R. Ramanathan and R. V. Karandikar: Recent work on the measurement of atmospheric ozone and its vertical distribution in India.
C. D. Ellyett and A. C. B. Lovell (by title): Radio studies of meteoric ionization.
P. M. Millmann and D. W. R. McKinley (read by Dr. C. S. Beals): The correlation of visual meteor data with the character of meteor radar echoes.
H. Nagaoka (by title): Luminescence and ionization of meteors.
F. Link: Exploration météorique de la haute atmosphere.
L. V. Berkner and E. H. Vestine (by title): Measurement of the geomagnetic field in the ionosphere.
H. E. Newell (read by Dr. E. O. Hulburt): Upper atmospheric research with V-2 rockets.
J. A. Van Allen (read by Dr. R. E. Gibson): The use of rockets in upper atmospheric research.
E. H. Vestine (read by Prof. S. Chapman): Rocket measurements of the geomagnetic field and heights of electric current systems in the atmosphere.
R. C. Langille (by title): The scattering of ten-centimeter radio waves by rain.
F. Link (by title): Sondages optiques de la haute atmosphere a l'aide de eclipses de lune.
F. Link (by title): Sur la possibilité des sondages optiques de la haute atmosphere a l'aide des phenomenas crepusculaires.
H. Nagaoka (by title): Sudden fade-out of high-frequency electric waves caused by alpha particles formed in the uppermost atmosphere.
M. Hasegawa (by title): A suggestion for the electric conductivity of the upper atmosphere from an analysis of the diurnal variations of terrestrial magnetism.

The joint meeting adjourned at 17:10.

Morning Session of August 26, 1948

Acting President Chapman called the meeting to order at 10:10.

The minutes of the last two meetings were read and approved.

The Association granted authority to the Bureau of the Association to approve the minutes of the meetings of August 26, 1948.

A discussion of resolutions and proposals then followed, resulting in the following action:

Proposal No. 1 - Modified and adopted as Association Resolution No. 3 (p. 537).
Proposal No. 2 - Modified and approved for reference to Union as Resolution No. 10.
Proposal No. 3 - Modified and adopted as Association Resolution No. 4.
Proposal No. 4 - This proposal will be passed to the Committee on Methods of Observatory Publication, and the new Committee for Standardization and Centralization of Magnetic Research, for consideration.
Proposal No. 5 - The task of implementing methods and codes to adequately describe magnetic disturbances and perturbations was referred to the Committee on Magnetic Characterization.
Proposal No. 6 - This action has been taken by the Association (p. 20).
Proposal No. 7 - Adopted as Association Resolution No. 5.
Proposal No. 8 - The Association felt that this matter might best be referred to the Committee on Centralization and Standardization of Records.
Proposal No. 9 - The Committee to Promote Daily Determination of H Between and Near the Geographic and Magnetic Equators was established by the Association, and proposal No. 9 was referred to that Committee. In addition, the Association endorsed, as ATME Resolution No. 7, the resolution passed by the Mixed Commission on the Ionosphere of ICSU at Brussels regarding ionospheric and geomagnetic observations in this region.
Proposal No. 10 - Since no member of the Association endorsed this proposal, no action was taken.
Proposal No. 11 - Rev. Romañá endorsed this proposal, but it was decided that the intent was adequately provided for by Association Resolution No. 8.
Proposal No. 12 - Since this proposal was not endorsed by a member of the Association, no action was taken.
Proposal No. 13 - This proposal was disposed of by Executive Committee action in submitting a subvention to the Journal of Terrestrial Magnetism and Atmospheric Electricity as a part of the Association's budget for the next three years. The action was confirmed by the Association.
Proposal No. 14 - This proposal was the basis for Executive Committee action in instructing the Secretary to prepare a list of names and addresses of organizations and individuals interested in geomagnetism and geoelectricity for publica- in the Oslo Transactions of the Association.
Proposal No. 15 - This proposal was referred to the Committee to Promote International Comparison of Magnetic Standards.
Proposal No. 16 - Modified and approved as Association Resolution No. 8.

In addition, Association Resolutions Nos. 1, 2, and 6, and proposed Union Resolutions Nos. 1, 2, 3, 4, 5, 6, 7, 8, and 9 were passed by the Association. Any of the latter group not accepted by the Union will revert to the status of Association Resolutions. [Editor's note: All Resolutions referred to the Union were accepted at the final Plenary Session on August 28, 1948. Both Association Resolutions and those referred by the Association to the Union may be found in Part VI of these Transactions, pp. 537-539.]

The Association's resolution of thanks to the Norwegian National Committee for the arrangements of the Oslo Assembly will be included in the UGGI action on this matter.

The proposal was made that the Association establish a joint committee, possibly with Meteorology, on the physical characteristics of the upper atmosphere. Following discussion by Mme. Vassy and Messrs. Coulomb, Nicolet, Chapman, Hulburt, Whipple, Kaplan, Link, Martyn, and Tuve, action on the suggestion was postponed on the basis that the Mixed Commission on the Ionosphere, to which Mr. L. V. Berkner, Prof. S. Chapman, Dr. A. H. R. Goldie, and Dr. Leiv Harang have been elected as representatives of the U.G.G.I., provides a group whose function includes the consideration of upper atmosphere problems. It was further recommended and approved that the Association's delegates request the Mixed Commission to change its name to "Mixed Commission on the Upper Atmosphere and the Ionosphere."

The meeting proceeded with the presentation of the following papers on aurora:

B. W. Currie and W. D. Penn: A recording meter for auroral radiations.
W. Petrie (read by Dr. Currie): Remarks on the excitation of certain oxygen and hydrogen lines appearing in the auroral spectrum.
K. Malmfors (by title): Model experiment on the aurora.
B. W. Currie (by title): Report on auroral investigations at the University of Saskatchewan, Canada.

The meeting adjourned at 13:10.

Afternoon Session of August 26, 1948

Acting President Chapman called the meeting to order at 14:35.

The question arose regarding Association support for the observatory at Tamanrassett. It was decided that this matter was sufficiently covered by resolutions of a general nature already passed regarding observatories.

Dr. Vestine was appointed as co-editor of the Oslo Transactions.

The Acting President then requested and received the approval of the Assembly to rewrite and put into force immediately a revised set of statutes which conform to the UGGI Statutes and By-Laws adopted at Cambridge in 1946. The required changes were read and the Association gave approval, authorizing the Executive Committee to make minor editorial changes. [Editor's note: The new Statutes provided for the appointment.]

The report of the Auditing Committee, approving the Secretary's financial statement, was next presented. This completed action on the Secretary's report.

The proposed budget which had been drawn up by the Executive Committee was then reviewed and approved. The Executive Committee was authorized to subsidize the Journal of Terrestrial Magnetism and Atmospheric Electricity up to an amount of $1,500 for the three-year period January 1, 1948 to December 31, 1950. However, it was understood that if such a subsidy would not be effective in aiding the Journal, it would not be made.

Prof. P. L. Mercanton presented the report on the magnetic anomaly of Jorat in Switzerland. He further commented on an investigation of old-age inclination deduced from the magnetization of basalt blocks.

Dr. Sucksdorff made some remarks on auroral forms observed in Sodankylä, and suggested that these might be divided up into three rather different phenomena.

The following papers were read by title:

J. Bertrand and Edmond Lahaye: Sur la réalisation de comteurs d'ions et d'enregistreurs de la conductibilité électrique de l'atmosphère.
T. Koono: Meteoric impact ionization observed on radar oscilloscopes.

The following papers were then presented:

E. O. Hulburt: The brightness and polarization of the daylight sky.
O. H. Gish and G. R. Wait: Electrical surveys over thunderheads.
Antonio Romañá, S.J. et J. O. Cardús, S.J.: Contribution à l'étude de l'influence de la Lune sur les courants telluriques.

Commenting upon the last paper, Prof. Chapman proposed and it was agreed that Father. Romañá be added to the Committee on Lunar Variation.

The following papers were next presented:

W. Smosarski (by title): Quelques résultats des observations simultanées du champ electrique, de la conductibilité et des phénomènes météorologiques.
A. Kimpara (by title): The wave form of atmospherics.
D. Justin Schove (by title): The phase of the sunspot cycle through the centuries.
M. Schlumberger and G. Kunetz: Observations sur les variations rapides des courants telluriques.

The last paper was read by Prof. Coulomb, who also presented an additional paper by Mlle. Beaufils on rapid variations of earth-currents.

S. E. Forbush: Summary of cosmic-ray observations. This paper was presented by Dr.Tuve, who also drew attention to a recent work by Forbush and collaborators revealing "tunnels" for cosmic rays on certain days.

The paper was discussed by Messrs. Veldkamp, Marsden, Martyn, Tuve, and Dauvillier. The latter stated that the fundamental problem to be solved is that of the stellar-magnetic field.

Prof. Coulomb presented the papers by Rougerie and Bricard (from Supplementary Agenda).

The first of these papers was briefly commented upon by Prof. Chapman.

The meeting adjourned at 17:00.

GEOMAGNETICIANS WHOSE DEATHS HAVE BEEN REPORTED SINCE THE ASSEMBLY IN 1939*

N. N. Trubiatchinsky - During the siege of Leningrad

Prof. Boris Weinberg - During the siege of Leningrad

Prof. Dr. Franz Linke - During an air raid on Frankfurt-am-Main
For some years Director of the Apia Observatory. His contributions included both geomagnetism and geoelectricity.

Prof. Dr. Karl Haussmann - January 24, 1940
He was one of the outstanding representatives of terrestrial magnetism in Germany. He took a prominent part in forwarding magnetic surveying and mapping in that country. As Professor of Geodesy in the Technische Hochschule at Aachen and at Berlin, he did pioneer work in applying geophysical methods to mining problems.

Charles Raymond Duvall - February 3, 1940
He held the position of expert computer in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington from 1913 to his retirement in 1937. During this period he assisted Dr. L. A. Bauer in his analysis of the Earth's magnetic field and completed the reduction and compilation of the declination and its secular change in the Pacific Ocean based on the observations of the Galilee and the Carnegie. He also took part in the computation of Peary's observations obtained during his voyage of discovery to the North Pole.

D. C. Jones - March 7, 1940
Magnetic observer of the United States Coast and Geodetic Survey, for some time Observer-in-Charge of the Puerto Rico Observatory at San Juan.

Prof. Jules Schokalsky - March 26, 1940
Outstanding Russian geographer and oceanographer. Published an important treatise on oceanography and is responsible for the publication of many atlases of the physical features of the U.S.S.R.

Jules-M. Ch. Jaumotte - July 6, 1940
He was Director of the Royal Meteorological Institute of Belgium. Aside from his important meteorological researches, he took an active part in international scientific organizations, having been a member of the Belgium National Committee of Geodesy and Geophysics (1921), the Belgian Commission of the Polar Year 1932-33, and the Commission appointed for establishing a liaison between the International Meteorological Organization and the International Scientific Radio Union (1938).

Sir Frederic Stupart - September 27, 1940
He entered the Meteorological Service of Canada in December 1872, became Director in December 1904, and retired in July 1929. He was much interested in terrestrial magnetism since the Agincourt and Meanook observatories were operated under his direction. He was prominent in international meteorological meetings.

*Editor's note: Due to uncertainties of international communications experienced during the period 1939 to 1948, complete information is not available for some of the entries in this list.

Dr. Gustaf S. Ljungdal - November 2, 1940

Participated in planning first magnetic survey of Baltic, but was unable to take part personally as he accepted commission from Danish Government to establish the magnetic observatory at Godhavn. He erected the first complete Swedish magnetic observatory at Lovö. He made a magnetic survey of Sweden (86 stations). Made observations on the airship "Graf Zeppelin" on flight to arctic regions in 1931. Proposed new type of magnetic chart.

Dr. Garmt van Dijk - December 19, 1940

He was the chief figure in geomagnetism in Holland during the period from 1924 until his death in 1940. He was responsible for the plans and construction of the magnetic and seismic pavillons of the De Bilt Meteorological Institute. He took an interesting and active part in the international work organized by the International Magnetic Organization and, after the institution of the International Union of Geodesy and Geophysics, in the work of the Associations of Terrestrial Magnetism and Electricity and of Seismology. For many years he was editor of the publications (1) Caractère Magnétique de chaque jour, a work which he continued during the world war of 1914-1918, and later of (2) Caractère Magnétique numérique des jours. He took a prominent part in the preparation of the Netherlands contribution to the International Polar Year 1932-33. He was well known in international conferences, being a member of the International Commission of Terrestrial Magnetism and Atmospheric Electricity and the Commission for the International Polar Year 1932-33 of the International Meteorological Organization. He represented his country at the triennial assemblies of the International Union of Geodesy and Geophysics, from that at Prague, 1927, to that at Washington, 1939.

Dr. Willem van Bemmelen - January 28, 1941

His investigations covered a wide range of geophysics, dealing both with fundamental and practical aspects. Outstanding among his publications are the year-books and monographs of the Batavia Magnetic and Meteorological Observatory during his directorship, and especially those dealing with magnetism. His first researches dealt with the secular variation of terrestrial magnetism, his later ones with other types of variation. In 1908 he completed a geomagnetic survey of the Dutch West Indies. He was among the first to study post-perturbations and pulsations.

Daniel M. Wise - January 29, 1941

Magnetic observer during 1913-19 of Department of Terrestrial Magnetism of the Carnegie Institution of Washington who did survey work in Canada, Africa, and South America.

Lt. Comdr. Ernest W. Eickelberg - May 20, 1941

Assistant Chief of the Division of Terrestrial Magnetism and Seismology of the United States Coast and Geodetic Survey during 1931-1938.

C. W. Jeffries - June 22, 1941

Director of the Royal Observatory at Hongkong since 1932.

Carroll Christopher Ennis - November 24, 1941

Expert computer in geomagnetism investigations at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, known for his many valuable contributions.

Dan Barfod la Cour - May 19, 1942

President of Association of Terrestrial Magnetism and Electricity and International Polar Year 1932-33. Took prominent part in international conferences for promoting magnetic work. Expert on magnetic instruments and equipment.

William J. Peters - July 10, 1942

Expert on magnetic work at sea. Commander of the Galilee and Carnegie on various cruises. Leader of land expeditions for exploratory work in arctic regions. In charge of magnetic work of Ziegler Expedition.

Prof. C. Coleridge Farr - January 27, 1943

For many years Professor of Physics at Canterbury College, Christchurch, New Zealand. In 1916 Dr. Farr published "A Magnetic Survey of the Dominion of New Zealand and some of the Outlying Islands for the Epoch 30th June 1903." He was chiefly responsible for this important survey which was carried out during the period 1899 to 1909.

Prof. Carl Dorno - 1943 (?)

Founder and former Director of the Davos Physical Meteorological Observatory at Davos-Platz, Switzerland.

George Washington Littlehales - August 12, 1943

Hydraulic Engineer (1900-1932), United States Hydrographic Office. He collaborated with Dr. L. A. Bauer in proposing a magnetic survey of the North Pacific Ocean to the Carnegie Institution of Washington which led to the more extensive surveys of the oceans later carried out by the Galilee and Carnegie. Under the auspices of the Hydrographic Office, he also issued a number of publications on terrestrial magnetism dealing chiefly with those aspects of the subject relating to navigation and cartography. He represented the United States at a number of international scientific conferences.

Captain F. O. Creagh-Osbourne - September 1, 1943

Former Director of the Compass Department of the British Admiralty.

Dr. Francis John Welsh Whipple - September 25, 1943

He succeeded Dr. Charles Chree as Superintendent of the Kew Observatory. Under his leadership the scientific work of that Observatory was greatly increased. He made many valuable contributions to meteorology, seismology, and atmospheric electricity.

Prof. Pieter Zeeman - October 9, 1943

Professor Emeritus of the Chair of Experimental Physics, University of Amsterdam. One of Holland's greatest scientists. Zeeman effect.

Sir Charles Vernon Boys - April 2, 1944

Chiefly known for his studies of lightning and for the camera he devised for these investigations.

Dr. Louis Steiner - April 2, 1944

Eminent Hungarian geophysicist. His outstanding researches and publications include surveys and measurements concerning gravitation and magnetic phenomena in various districts of Hungary in collaboration with Eötvös, magnetic surveys in the Lake Balaton region in 1901, the daily course of the magnetic elements in Kingua-Fjord, and a handbook entitled "The Magnetic Phenomena of the Earth."

Prof. Adolf Schmidt - October 17, 1944

One of the most eminent of German magneticians. He was for many years in charge of the Potsdam Magnetic Observatory where he introduced many instrumental improvements and made it one of the leading centers for geomagnetic work in Europe. He gave his attention to almost every aspect of geomagnetic research as shown in the long list of his publications. He founded the "Archiv des Erdmagnetismus", "a collection of the most important results of geomagnetic observations in uniform representation." He was responsible for a new scheme of international magnetic character figures (1905) which have proved extremely useful in magnetic investigations. Inventor of Schmidt field balance.

James Mason Baldwin - 1945

Government Astronomer of Victoria, Australia, under whose direction the Melbourne Magnetic Observatory was operated and during whose administration that Observatory was transferred to Toolangi.

Carl A. Ludy - March 13, 1945

Observer-in-Charge of the Sitka Magnetic Observatory of the United States Coast and Geodetic Survey - a promising young geophysicist.

Harry Marcus Weston Edmonds - April 4, 1945

During 1901 to 1909 he was magnetic observer-in-charge of the Sitka Magnetic Observatory. On June 1, 1910, he joined the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, where he remained until his retirement on December 31, 1930. He took part in the various cruises of the Carnegie, commanding the vessel during her fifth cruise. He did magnetic field work in northern Canada, and took part in the construction and equipping of the Huancayo Magnetic Observatory.

Captain Roy Fitzsimmons - May 5, 1945

Carried out magnetic observations in the arctic and antarctic.

Prof. Gustav Angenheister - June 28, 1945

Head of Geophysikalisches Institute, Göttingen. His early work was done while he was in charge of the Samoa (Apia) Observatory. He investigated many phenomena connected with geomagnetism and geoelectricity, particularly magnetic activity and its relation to the sun. He was active in the establishment and conduct of the Geophysikalische Zeitschrift.

Dr. Walter Knoche - July 3, 1945

Although primarily a climatologist, he took much interest in atmospheric electricity. In 1912, he took part, in cooperation with the Carnegie Institution of Washington, in an expedition to Brazil for obtaining atmospheric-electric observations during the solar eclipse of October of that year. About 30 of his early papers deal with observations on atmospheric electricity, electrical discharges in the Andes, and radioactivity of the atmospheric air and sea water.

Prof. Blas Cabrera - August 1, 1945

Formerly professor at the University of Madrid and widely known for his investigations in the domain of magnetism.

Dr. Harry Bateman - January 21, 1946

Professor of Mathematics, Theoretical Physics and Aeronautics at California Institute of Technology. Spent summer in 1915 at Department of Terrestrial

Magnetism of the Carnegie Institution of Washington studying methods for reducing magnetic observations to common epoch. Attended Edinburgh meeting of IGGU.

Prof. Stanislas Kalinowski - March 27, 1946

He was the organizer and Director of the Swider Geophysical Observatory. He did much to increase the knowledge of the distribution of the geomagnetic elements in Poland both by survey and observatory work. Familiar figure at international scientific meetings.

Sir Carruthers Beattie - September 10, 1946
Prof. J. T. Morrison - October 1944

Pioneers in geomagnetic surveys and investigations in Africa. Both spent most of 1909 in making a magnetic survey from Cape Town to Cairo, a great undertaking considering difficulties of transport and of obtaining accurate observations at that time. They did much toward the development of university education in South Africa.

H. H. Clayton - October 27, 1946

While his chief work concerned meteorology and especially methods of long-range forecasting, he was interested in, and contributed to, investigations on the relations of solar activity, aurora, and geomagnetism.

Prof. Johann Georg Koenigsberger - 1947 (?)

He is regarded as an authority on the magnetic properties of minerals - on this subject he published many papers. Suspended from his position at the University of Freiburg in Brausgau in 1934 for political reasons, he was reinstated at the close of hostilities of World War II. Here he carried on his theoretical work under difficulties until the time of his death.

Harry Fawset Skey - January 16, 1947

Associated with the Magnetic Survey of New Zealand from May 1899 until his retirement in May 1940. He took a large share in installing the instruments at the Christchurch Magnetic Observatory and later, when this Observatory was rendered useless by electric tram-system, he performed similar service at Amberley. He was a fine observer and did almost all of the actual observations on the original magnetic survey of New Zealand.

Mrs. E. Walter Maunder - September 15, 1947

In collaboration with her husband, she carried out a series of important investigations on sunspots, the sunspot-cycle, and the association of sunspots with magnetic storms.

Dr. Alexander G. Adie - November 1, 1947

Professor of Meteorology at Harvard University and for 18 years Director of Blue Hill Observatory, Milton, Massachusetts. He was greatly interested in atmospheric electricity and published several papers on that subject.

Dr. Egon von Schweidler - February 11, 1948

Prof. Alexander Ogg - February 24, 1948

Largely responsible for establishment of Polar Year Magnetic Station at Cape Town, South Africa, for its survival during the next fateful years and for its eventual emergence in 1937 as a permanent branch of the Trignometrical Survey Office. His outstanding services as Magnetic Survey Adviser to the Union Government led in 1940 to his appointment as first Director of the Hermanus Magnetic

Observatory which was established mainly by his exertions. He instituted in 1938 a comprehensive, long-term secular-variation program for South Africa.

Dr. A. S. Eve - March 24, 1948

Widely known for his work on the application of geomagnetism to geophysical prospecting and for his courses bearing on terrestrial magnetism at the University of Toronto.

Prof. Henri Labrouste - May 10, 1948

For many years a member of the Institut de Physique du Globe at Paris, where, in collaboration with his wife, he carried out many theoretical studies in terrestrial magnetism and atmospheric electricity.

Washington, D. C.
June 24, 1948

APPENDICES TO THE MINUTES

ADDRESS OF THE RETIRING PRESIDENT

Some Needs and Challenges of Geomagnetism

Introduction

Your retiring President keenly regrets that he cannot be present to take part in the deliberations of the Association at Oslo. He thanks you for the honor accorded him and for the privilege of markedly unselfish aid extended him by colleagues in his responsibilities for so many years--an interval much in excess of the constitutional limit of two three-year terms because of the action taken in Washington in 1939 which continued officers in their respective positions until the next Assembly could be had.

It is now nine years since our Assembly of 1939 in Washington. World War II meanwhile cast its tragic shadow over most all human efforts other than those concerned in the long struggle. While activities in geomagnetism and geoelectricity were somewhat curtailed during these nine years, there has been much constructive work accomplished and many new paths of research have been discovered. Many of these have resulted from practical applications of past fundamental scientific advances. We may well note the statement Secretary David G. Knapp of the Section, corresponding to our Association, in the American Geophysical Union, in his report to our Assembly, "the gradual restoration of constructive endeavor following the halocaust of World War II finds heartening sustenance in the remarkable recent growth of interest and activity accruing to the geophysical sciences. This resurgence has been particularly noteworthy in the realm of the Association of Terrestrial Magnetism and Electricity".

Reappraisal of Committees Responsibilities

The long interval since the Washington Assembly affords opportunity for careful reappraisal of the responsibilities and performances of our 14 special committees with emphasis on unity of purpose and direction. Doubtless some of the committees, having completed their functions, will ask to be discharged. Developments along newer and recently matured avenues of approach warrant consideration of the appointment of several new committees.

One matter of grave concern is the prompt compilation and publication of data obtained at the 69 observatories in the world net. Many organizations and men doing intensive research in geomagnetism and other geophysical subjects do not have available the resources necessary to provide for the laborious scaling and reduction of photographic records. It is of first importance that observatories prepare and publish the data obtained in tabular form in accordance with Resolution 10 of the Washington Assembly concerning Recommendations Regarding Publication of Observatory Data [Bulletin 11, p. 552 (1940)]. Too often limitations are set by lack of available funds and personnel. It is indeed a large and costly task, particularly in man-hours, to prepare and publish the formal volumes of results in accordance with our needs and recommendations. From time to time attempts have been made to lessen, without too great sacrifice, this labor, for example, by Adolf Schmidt at Potsdam and the more recent series of the United States Coast and Geodetic Survey reproducing magnetograms for each day during each half-year at its observatories. Reproductions of magnetograms are most useful in any general survey by an investigator looking for unique events in long series of records. They will not, however, meet the needs of the investigator who deals with world-wide studies and must have detailed tabular data. The distribution of existing observatories is quite dense in some regions. The selection by this Association of a number of "key" observatories, each of which would publish complete data in accordance with the recommendations of the Washington Assembly, might be a solution to this difficult problem. In that case, the other observatories could act as standby stations and supply data for more intensive local investigations.

Recent rapid developments in mechanical computing and tabulating machines offer real possibilities in application to reduction and compilation of observatory data. Publication would be greatly accelerated by the introduction of mechanical methods for compilation and possible automatic scaling of records, at one or two central computing bureaus having various kinds of tabulating machines with great saving in time of personnel. It seems well worth while to authorize a Special Committee to study the feasibility of using labor-saving mechanical devices and of international cooperation and coordination at one or two central bureaus in the preparation, compilation, and eventual printing by the photo-offset method of observatory data.

The volume of Transactions [Bull. 11, viii + 556 pp. (1940)] of the 1939 Assembly in Washington was completed by General Secretary A. H. R. Goldie in collaboration with J. W. Joyce, to both of whom the Association owes much for a good job under most unusual difficulties. It is indeed a compendium on geomagnetic and geoelectric progress in the three years from 1936. Partly because of postal restrictions and partly because of lack of clerical assistance, distribution of our Transactions and of other informative material on the international objectives and achievements of the Association has been inadequate. The advance, during the past decade, in recognition by the general public of the great use of scientific results to human welfare, presents an opportunity which should be utilized to improve future service of the Association and of the Union. The accomplishments of our Association from 1919 in coordination and promotion of international relations afford firm foundation for diffusion more generally of knowledge gained thereby and increased public understanding of our objectives--all of large value to all people. Care must be used to see that copies of resolutions and constructive comments for governments, academies, and other organizations are appropriately communicated to the respective agencies in other countries, including those not adhering to the Union. Concise and readable statements of progress made should be given world-wide distribution in order that scientists, as well as lay citizens, may become acquainted and better appreciate the significance of progress made. This would increase both private and governmental efforts to enhance the social value of the natural sciences in national and international relationships. It would also encourage communications and constructive suggestions from national bodies and scholars bearing on the activities of our Association.

A requirement for satisfactory distribution of publications and information, from the viewpoint of the Association and that of scientists everywhere, is the preparation of an up-to-date directory of scientific investigators, laboratories, and organizations engaged in our fields in all countries. Appropriate steps should be taken by the Association to prepare such a list--only specialists in given fields can prepare presently lists of scientists and organizations through proper judgment of the qualifications of either interested men or organizations. Unquestionably the original preparation of specialized lists having to do with the natural sciences should be the responsibility of the several Associations of our Union and of other Unions.

We should encourage and develop means for world-wide exchange of scholars and students to make for more personal contacts and thus spread new concepts for, and fresh approaches to, our scientific problems and those borderline domains involving the several Associations or two or more Unions.

Governments should be encouraged to assume responsibility within their own boundaries and for international coordination over the oceans and in the air for factual surveys. Progress in equipment suitable for aerial surveys has been made during the past decade, and advantage should be taken of opportunities so afforded for rapid and accurate observations of the geomagnetic and geoelectric fields in the air as well as on the Earth's surface. Heretofore, too frequently, too great demands for surveys have been made on the resources and personnel of private scientific organizations with consequent loss to greatly needed theoretical discussions and research on factual material.

We should do our utmost to find means to ameliorate the present deplorable inadequacy of the manufacture and supply of scientific apparatus and to prepare statements of the technical requirements and standardization of types. A directory of instrument-making organizations would be of inestimable service to scientists everywhere. Many long-established observatories dealing in the natural sciences have suffered destruction in part or in whole to buildings and equipment during World War II. We should implement some provision which would help meet their dire needs.

Our Association and other Associations of the Union must make grateful acknowledgment to the United Nations Educational, Scientific, and Cultural Organization (UNESCO) for the substantial grants-in-aid during the years 1947 and 1948. These grants have been made after consideration of requests submitted by the General Secretaries of the Association and Union to the General Secretary of the International Council of Scientific Unions, and in turn have been referred by him to UNESCO. These grants have measurably increased the productivity of our Association.

Some Recent Progress

Long strides have been made since 1939 in ionospheric research concerned with geomagnetic phenomena. A world net of nearly 60 ionospheric stations--many near magnetic observatories--has been set up. Noteworthy developments and improvements have been made in automatically recording ionospheric equipment. This has paved the way for international research on long-term programs of ionospheric characteristics, specific exploratory experiments, improved understanding of solar and cosmic relationships with terrestrial phenomena, and theoretical and analytical studies of processes in the upper atmosphere. Rapid changes in the ionosphere are now recorded in motion-picture film at intervals of a few seconds, thus furnishing a wealth of data for critical study and visualization of ionospheric dynamics.

Important progress has been made in investigation of terrestrial effects of solar flares on geomagnetic and ionospheric disturbances as evidenced by the short-lived, small-amplitude variations--the so-called "crochets".

These have been forwarded by the study of geomagnetic activity, long provided by the Association in reporting (a) the simple magnetic character-number C and (b) the more complex three-hour-range index K. The interruption of the war prevented compilation and periodic publication of these indices from 1940. It was important to study and discussion that the material supplied by many observatories from 1940, and which involved an immense amount of labor and time, be assembled. It was possible, with the cooperation of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the United States Coast and Geodetic Survey to compile and publish in 1948, as Bulletins 12 (330 pp.) and 12-A (55 pp.) of the Association, complete tabulations of the indices C and K for the eight years 1940-47. The bulletins have been widely distributed. These eight years of data will make it possible to determine any relation existing between the two measures. In view of the progress since 1939 in ionospheric research and its geomagnetic correlations and particularly the proven value thereto of the K-index, it may be that the Association should consider discontinuation of reports on the C-index, say after another year, and concentrate effort on compiling and publishing K-indices only.

Particularly noteworthy are the advances in investigating the pre-history of the Earth's magnetic field through the intensive study of glacial varves, ocean-bottom samples, and rock-cores.

There has been completed an extended discussion of the geomagnetic and geoelectric survey operations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Two large volumes describing the Earth's main magnetic field and secular-variations from 1905-1945 were recently published.

The hypothesis that any body became magnetic on rotation as suggested by Sutherland (1903-08) and Schuster (1912) was revived in 1947 by Blackett following Babcock's spectrographic determination of the magnetic field of the rapidly rotating star 78 Virginus and of other stars. This discussion attempts to express a relation between magnetic moment and angular momentum of massive bodies, the gravitational constant, and the velocity of light as the source of magnetic fields. Thus the polar magnetic fields for the Earth, Sun, and 78 Virginus, respectively, are about 0.6, 53, and 1500 Gauss. Despite the earlier negative experimental results by Barnett, this proposal again focuses attention on the possibility that the geomagnetic field does arise because of the greatness and rotation of the Earth.

Excellent progress has been made in another field of cosmic relation, namely, cosmic radiation. Here again the value of continued records of a natural phenomenon--cosmic rays--over a period of years has been evidenced. Study of the records revealed world-wide changes in cosmic-ray intensity during geomagnetic storms and that most major changes were associated with geomagnetic activity. A few records indicate a mechanism of sudden increases of cosmic-ray intensity with solar flares, in that time-variations of the magnetic field of sunspot-groups in which flares occurred, are capable of accelerating charged particles to explain the observed increases, in latitudes where they were recorded. Thus a solar phenomenon and not a geomagnetic storm seems responsible for infrequently observed <u>increases</u> in cosmic-ray intensity.

The above examples illustrate only some of the great resurgence of interest in our fields. Of great importance is the future prosecution through coordination of international effort of geomagnetic surveys to furnish data for continued studies of spatial features of geomagnetism.

Geomagnetic Survey at Sea

The large portion of the Earth covered by the oceans makes the determination of accurate values of the geomagnetic elements at sea a major objective of any world survey. It was not until 1905-29 that realization of this objective was obtained through the systematic oceanic surveys sponsored by the Carnegie Institution of Washington through its Department of Terrestrial Magnetism. Earlier magnetic surveys at sea included, among others, those of the Paramour (1698-1700), the Erebus, the Terror and the Pagoda (1840-45), the Novara (1857-60), the Challenger (1872-76), and the Gazelle (1874-76). Observations were also made by naval services of various countries and more lately by the Discovery, the Gauss, and vessels of other Antarctic expeditions. The past ten years have seen an increasing number of expeditions to both polar regions.

The earlier observations through 1900 were of varying degrees of accuracy set by available instruments and by those disturbing factors inherent in the magnetic character of the vessels and in the constant motion of the sea. Their distribution, both as regards position and epoch, did not readily yield coordinated surface charts applying to definite epochs and was frequently limited to but one or two elements. The data obtained during the cruises of the Carnegie (1909-29), because of newly designed instruments capable of results of high accuracy under the difficult conditions inseparable in work at sea, included three geomagnetic elements, declination, horizontal intensity, and inclination. The Carnegie and her special equipment were developed following earlier experience (1905-08) on the wooden brigantine Galilee.

Earlier data had demonstrated that irregularities in the surface distribution of the geomagnetic field over continental areas do bear relation to geologic features of the Earth's crust. They indicated possible intensive utilization helpful in investigating the character of geologic sub-structure. A considerable part of the observed Earth's geomagnetic field may be ascribed to a uniformly magnetized sphere. The difference between this uniform or normal magnetization and the whole observed field, that is, the residual field, reflects irregularities caused by geologic formations. The Earth's outer crust or shell is not homogeneous and is not uniform in its magnetic behavior. There are regions of local magnetic disturbance, many caused by magnetic ore-deposits, some so great as to give rise to local poles and other irregularities of intensity twofold or even threefold the normal value in those regions. Anomalies of this kind are strikingly illustrated by observed irregularities over many continental areas. Thus the huge Pilansberg system of Paleozoic volcanic dykes in South Africa shows strong magnetization in a direction opposite to the present-day geomagnetic field.

The magnetic anomalies over continental areas must have counterparts in the great oceanic basins. Their study, therefore, must aid investigation of oceanic structure. Indeed, observations on isolated islands and island groups almost invariably indicate abnormal magnetic conditions, and the magnetic survey of the oceans by the Carnegie Institution of Washington has revealed some like conditions at sea.

The application of surface magnetic-survey results to the investigation of crustal features of the ocean bottom depends, however, both on differences in substructural physical properties and upon the magnitude of these differences. The magnetic susceptibility of rocks, some of which are strongly magnetic, as iron-ores and igneous and metamorphic rocks, and some weakly magnetic, as most sedimentary rocks, are important factors. Thus observed surface magnetic anomalies afford a general reconnaissance method indicating regions for other more intensive geophysical studies. This approach lacks depth-control; geologic features must increase in proportion to depth if they are to be revealed by geomagnetic data. Unless the magnetic anomaly observed at sea is over shallow water, or if over deep water, is of enormous proportions, no immediate exact information regarding particular areas of bottom substructure may be obtained by study only of charts showing surface isomagnetic contours.

The geomagnetic field undergoes changes with time, that is, secular variation--a phenomenon whose investigation is a large potentiality in studies of the Earth's crust. Herein is the great need of continuance of the accurate surface magnetic survey of the oceans to determine the character of such changes with epoch and their accelerations at various places.

From data observed during several centuries--a fragment only of the Earth's history--the apparent regularity of secular variation has been noted when considering only a single station or a small part of the Earth's surface such as western Europe--say one-hundredth of the Earth's surface. When the observational data over the whole Earth are taken into account, however, it is found that secular variation is not a phenomenon which may be explained by periodic movements of the Earth's magnetic poles and the like, but is a regional one connected with the general geological structure of oceans and continents and the deeper layers of the Earth's crust. The development of methods and techniques and of experimental research in the laboratory during the past decade for the organization and interpretation of the data have demonstrated avenues of research which will supply information on basic physical problems related to this subject.

Surface secular-variation data are compiled from isomagnetic charts for various epochs. Shifts of the isomagnetics occur in succeeding epochs. Lines or contours joining points of equal annual change are called isopors. The foci of rapid isoporic changes raise questions of broad geophysical significance. Surface isopors for geomagnetic total intensity for the epoch 1942.5, based on the recently published intensive analysis by the Carnegie Institution of Washington from data obtained during 1905-1945, afford evidence in this matter. A large part of these changes may have origin in influences impressed by forces deep within the Earth. The rise and fall of the rate of secular change and the slow expansion and then the gradual retraction of the surface areas within which there have been excessive alterations in the magnetic elements are significant. The distribution of isoporic foci is noteworthy. They are practically all in or near the great land-masses. Those foci found in the Pacific Ocean are generally of moderate intensity and not well defined. These relations to the surface structure of the Earth indicate a causal relation with crustal or subcrustal movements and conditions.

Attention may be called to the apparent diminution of the intensity of the Earth's magnetic field which is marked over oceanic areas, especially in the Western and Southern hemispheres. This is strikingly shown by the contours of equal values for the ratio of annual change to the value of total geomagnetic intensity for the epoch 1942.5 as in Figure 1.

Observed earthquake-wave velocities and reflections for different regions and depths give some evidence that the crustal layer is thin under the Pacific

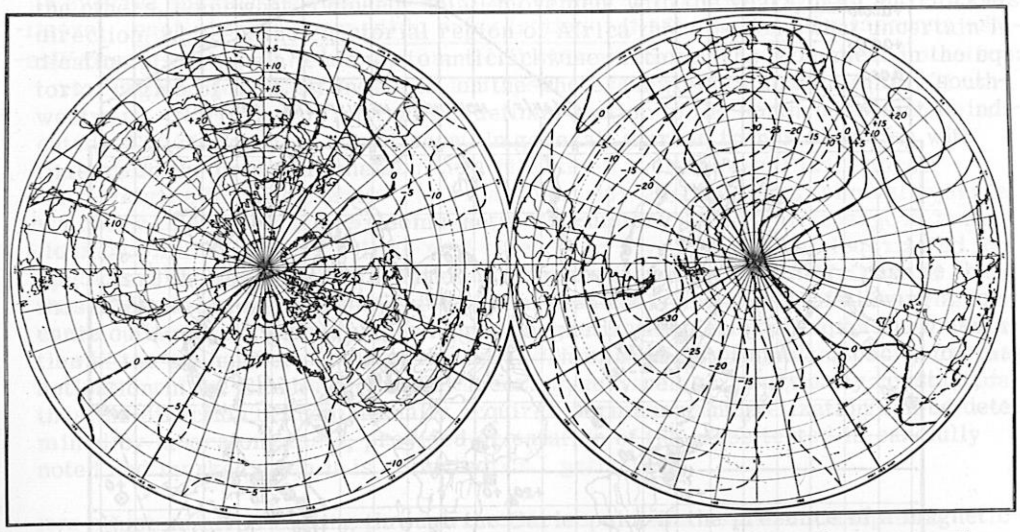


Fig. 1--Lines of equal values of ratio of annual change to values of geomagnetic total intensity (ΔF/F), epoch 1942.5, expressed in units of 0.0001; positive values shown by full lines, negative ones by dashed lines.

Ocean. Under the Atlantic and Indian oceans this layer is of appreciable depth. Under the Pacific Ocean different geological and geophysical properties from those found elsewhere may be expected. Thus longitudinal distribution of surface isoporic foci agrees with that of land-areas as shown by the modest rates of annual change over the Pacific as compared with those over the Atlantic and adjoining continental areas. A definite control is necessary for a number of epochs in investigating causes producing and governing these surface progressive changes. Therefore there is great need of accurate knowledge of the accelerations and distribution of the isoporic foci--knowledge which can be obtained only by continued intensive surveys of the entire Earth.

Further data on correlation between the surface-distribution of secular-change activity promise conclusions concerning secular-variation processes localized in the crustal layer as well as the character of the layer. Continued magnetic surveys at sea will aid discussions and interpretation of seismic, magnetic, and possibly gravimetric phenomena in relation to the Earth's crust.

Figures 1 and 2 have been compiled to show some of the interesting features associated with isopors of geomagnetic total intensity. These are based on compilations made using the tabulations of Dr. E. H. Vestine and his colleagues in the volume "Description of the Earth's Main Magnetic Field and Its Secular Change, 1905-1945" [Publication No. 578, Dep. Terr. Mag., Carnegie Inst., Washington (1947)]. Figure 1 shows the lines of equal value for 1942.5 of the ratio between the annual rates of change and the geomagnetic total intensity, that is (ΔF/F). It is to be noted that the region of increasing values of (ΔF/F) is generally confined to the great continental areas of Europe, Asia, North Africa, and the Antarctic, while large negative values, as a rule, are to be found over oceanic areas and in much smaller degree over the continents of North and South America. It appears that any tendency to positive values of this ratio over the oceans is controlled largely by the proximity of large land areas. Noteworthy also is the preponderance

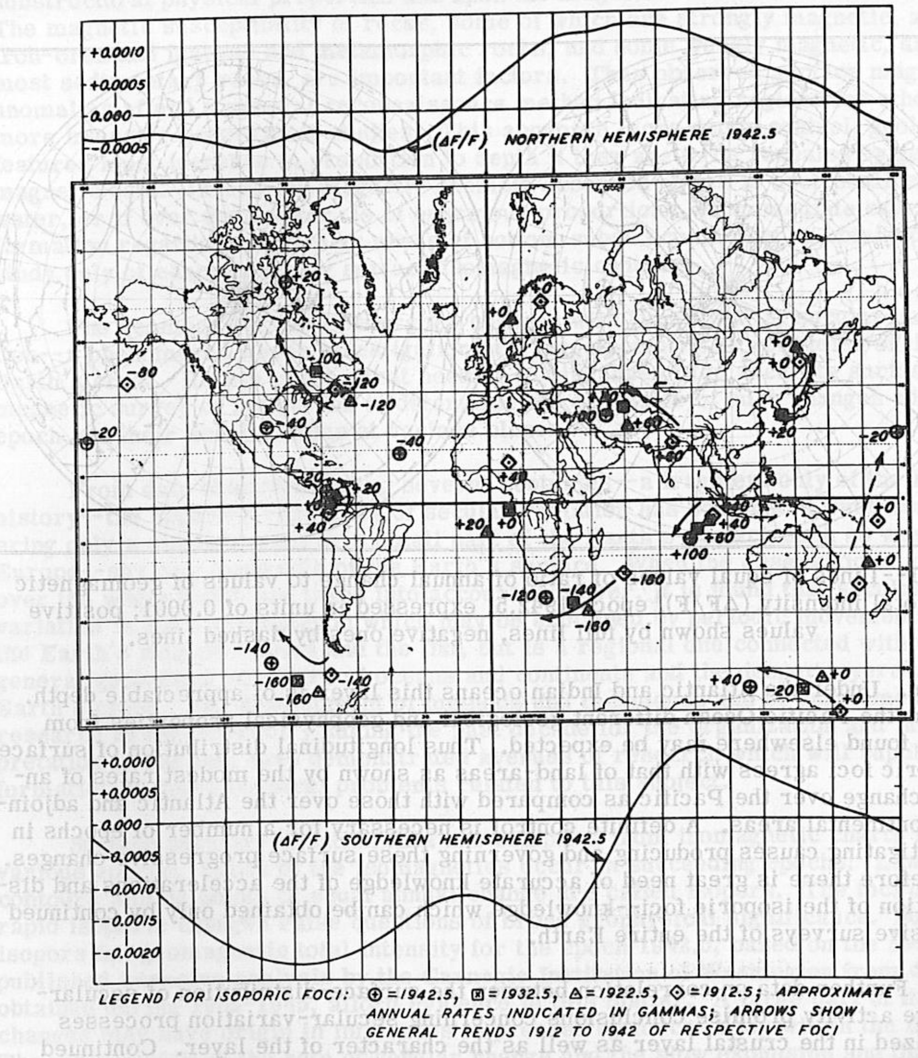


Fig. 2--World isoporic foci of total geomagnetic intensity (F) for epochs 1912.5, 1922.5, 1932.5, and 1942.5 and their general trends (center); graphs of ratio (ΔF/F) for epoch 1942.5 in Northern and Southern Hemispheres as averaged for 10° quadrilaterals of latitude and longitude (top and bottom).

of negative values over the world as a whole. This is perhaps better illustrated by the graphs of (ΔF/F) for the Northern and Southern Hemispheres at the top and bottom of Figure 2 where the values are averaged for 10° quadrilaterals of longitude and latitude. The world chart of Figure 2 shows the trends of the principal isoporic foci at 10-year intervals from 1912.5 to 1942.5. The foci of maximum and minimum are generally confined to, or are just off, large land masses. In the Southern Hemisphere the trends are mainly somewhat southerly and to the westward. In the Northern Hemisphere the trends are less definite in direction though mostly northward and westward. The group just north of the magnetic equator in

South America is noteworthy in what appears to be, relatively as contrasted with the others, somewhat confused, small movement with the years in an anticlockwise direction, while in the equatorial region of Africa there is somewhat uncertain indication of perhaps a tendency to anticlockwise motion. The movement in the equatorial region of the East Indies is, on the whole, small but more definitely southwestward. Northeast of Australia a definite motion to the north-northeast is indicated. The weaker foci do not show, in general, marked trends of motion with time as do the principal ones.

Geomagnetic Pre-history

Secular-variation information may be extended to times more remote than those for which observations exist. When lava cools and freezes following a volcanic outburst, it takes up a permanent magnetization dependent upon the orientation of the geomagnetic field at the time. This, because of small capacity for magnetization in the Earth's field after freezing, may remain practically constant; thus the direction of the originally acquired permanent magnetization can be determined by laboratory tests, provided orientation of the mass tested is carefully noted and marked when it is collected.

Just as lavas cooling through the Curie-point in the presence of a magnetic field become magnetized in the direction of the field, so sediments containing microscopic magnetizable particles also assume the direction of the prevailing magnetic field. This is "fossil" magnetization for the magnetic field of the epoch of deposition maintained in the sediment. Whether this fossil magnetism remains as a connate property or whether it is destroyed by subsequent events, depends upon the postnatal experience of the sediment. In so far as it remains, it affords a record of geomagnetism and an important clue to geomagnetic history.

Geomagnetic measurements at great depths in the sea may now be obtained by magnetic examination of bottom core-samples. Special equipment, already designed and tested, permits accurate measurements to determine the magnetic axes of direction and of intensity for successive horizontal sections of core-samples. Tests on cores show distinct differences in the direction and intensity of magnetization for succeeding horizontal sections. Through interrelating individual cores by similarities in their magnetization, it may be possible ultimately to determine more accurately than by surface observations the extent and character of regional magnetic anomalies over the oceans. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington has done outstanding research upon glacial varves and core-samples of the ocean bottom and is now engaged in like collections and experimental studies of rock-cores collected in the Rocky Mountains.

The excess of gravity in the oceans and a sudden decrease at the continental borders and resulting deviations of isostasy cannot arise only from sources in the Earth's crust but from far into the plastic layers below and create current-systems below the crust--possibly downward below the oceans and upward below the continents. The surface chart of isoporic foci and their motions with time (see Fig. 2) certainly lend strength to the idea that the interior of the Earth is more mobile than the external layers, not only as a whole but regionally. Interior currents may convey deep material with special magnetic properties accounting for disturbances at the crust.

While more information on secular-variation changes in the Earth's magnetism is required for navigation, yet future geomagnetic data over the oceans are necessary to advance theoretical studies. It is of first importance to continue the work of the Carnegie, which was lost in 1929, because further surface surveys of like accuracy will enhance the theoretical value of the work already done. Investigation on diminution of the geomagnetic field--so marked in the Southern and Western Hemispheres as already stated--requires continued gathering of data over the oceans.

Theoretical investigations demanding continuation of oceanic geomagnetic surveys include, among others, the following: (a) Determination of secular-variation of progressive changes and accelerations of the geomagnetic field, which cannot be extrapolated reliably over periods as long as five years. Definite control must be available for many epochs to enlarge understanding of causes producing and governing these progressive changes. (b) Surveys of regions of local disturbance and particularly of those indicated by earlier work over "deep-sea" areas including accompanying determination of oceanic depths and of gravity and the study of core-samples. (c) The determination of additional distribution-data in a few large areas not already covered.

Floating Laboratories

The question arises whether the theoretical requirements might not be met at less cost than through construction and maintenance of non-magnetic vessels. Control of secular-variation data over the oceans between 60° north and 60° south latitude cannot be satisfactorily obtained by observations on land only. The maximum control which could be so effected on the surface might be from results at some 150 secular-variation stations along the coasts of the continents and on islands. Some 90 of these stations are readily accessible. The remainder include the more inaccessible islands which are subject, generally, to magnetic local disturbance. This would introduce uncertainties both in the effects upon secular-variation changes and the relation between the normal and the island value. The reduction to common epoch would be more difficult because of the length of intervals between reoccupations and of the lack of the better distribution of data to be had from observations at sea.

Even if a complete scheme for control by observations on land could be attained, the areas lacking in data would be very large. These areas approximate nearly 15,000,000 square miles in the Pacific Ocean, over 3,000,000 square miles in the Atlantic Ocean, and some 6,000,000 square miles in the Indian Ocean--a total of nearly 25 million square miles in the oceanic areas between parallels 60° north and 60° south. Local disturbances at many stations on islands, as above stated, would make some results unsuitable for discussion and would thus increase the total area lacking geomagnetic detail. These areas involve portions of the Earth's surface where there are at present the greatest irregularities in the progressive character of the secular variation in the central and south Atlantic, Indian, north Pacific, east central Pacific, and south Pacific oceans. For the polar regions--one-seventh of the Earth--dependence would continue to be through special expeditions on land and soon probably in the air.

Because of the great need of continuing the operations conducted for a quarter-century by the Carnegie Institution of Washington and of the Institution's decision not to replace the Carnegie, the British Admiralty designed and has nearly completed the non-magnetic vessel Research. Already there are marked uncertainties in isomagnetic charts because of rapid isoporic changes in certain regions. Cruises by the Research are, therefore, urgent.

The task of the geophysical surface survey of the oceans is so great that the hydrographic services of other nations should provide vessels similar to the Research with suitable equipment and personnel to share in executing and coordinating the geomagnetic world survey. The resumption of the oceanic geomagnetic survey by the British Admiralty on the Research doubtless would do much to stimulate the early participation of other nations in this truly international need.

Aeromagnetic Survey

The present slow and costly methods of surface geomagnetic surveys, both on land and sea, may now be supplemented by new techniques and methods. The procedure of measuring the Earth's field at different times in different places in one region during one year or several years and in another at a different epoch is inadequate to all the needs. What is required is a description of the geomagnetic field during a given year based on measurements made during that year at points sufficiently close together and distributed nearly independently of topography, areas of land and sea, and climate. Instrumental developments during World War II indicate that measurements are now feasible and that aeromagnetic surveys mav be soon possible.

However accurately the magnetic elements are determined at a given surface point, absence of observations at intervening points leaves information still inadequate for surface isomagnetic maps unless almost an infinite number of stations is attained. This may now be remedied by magnetic observations with instruments airborne above the surface of the Earth, and thus farther away from magnetic anomalies which depreciate the accuracy of surface observations. Travelling at high speeds, continuous observations may be obtained over a large area in a single day, and in a relatively short time a survey of the normal geomagnetic field can be made. The accuracy of such techniques can be kept more than adequate for both practical and theoretical purposes.

The advantages of an effective airborne instrument include: (a) Large areas may be covered quickly and continuously. (b) Surface anomalies, which are of no significance in the preparation of charts of the normal field may be eliminated; thus, by flying at altitudes of, say, 20,000 feet, the background field free of local irregularity may be obtained directly, without the necessity of mathematical treatment or judgment in processing the data. (c) Flights in two or more horizontal planes may define uniquely the fine structure of the magnetic field.

The United States Geological Survey has already done aeromagnetic surveys in the past few years over some 100,000 square miles. Published charts of the regions surveyed, as given in the Survey's preliminary reports, givé good evidence of the practical and theoretical value of the method. Perfection of suitable airborne instruments for absolute determinations will require considerable time and funds. Nevertheless, the end-results will justify large expenditure of both time and funds.

A complement to the aerial magnetic survey which offers promise is that of rocket measurements of the geomagnetic field and heights of electric current systems in the atmosphere. Another most promising one is that proposed by Berkner and Vestine on possible radio methods for measurement of the geomagnetic field at great heights.

Conclusion

The problems of our Association in geomagnetism, geoelectricity, and cosmic relationships are complex. Their solutions and explanations concern not only the interior and exterior of the Earth, but also phenomena of the universe. Through the fog of human superstition and myth and despite the seeming chaotic and random character of the natural phenomena, there has gradually emerged, in the past two or three centuries, scientific understanding and order, even in the apparent inconstancy of the behavior of the geomagnetic and geoelectric fields.

While all substances of the Earth show magnetic properties, there are only a few that are strongly magnetic. In any case, it may well be assumed that an orderly arrangement or interaction of particles of matter within the Earth make it a magnet. Solution of the outstanding problems must look toward future development of the laws of atomic structure and the magnetic and electric properties coming from research in nuclear physics to explain the origin of the geomagnetic and geoelectric fields, the ionospheric and Earth-current contributions therein, and the behavior of atmospheric ions and attachment particles participating in the air-Earth current.

It is the implementation of attacks on our problems that is important--the necessity of the thoughtful scrutiny and selection of those attacks to be pushed and of those men to work on them.

It is only with the generous and selfless cooperation of all that we may further those high aims for international coordination of effort in our fields set forth in the statutes of our Association and of our Union. Mutual determination and goodwill are necessary to solve the fundamental problems in international cooperation in the natural sciences, which are limited by no horizon. Patient and nonspectacular work is required for the solutions of many problems. While our activities now cover well-developed areas represented by our special Committees, we must consider undeveloped areas. Above all, we must have no discriminations against minorities and must see that democratic representation is maintained for all national and geographic groups. The greatest importance is to be attached to free exchange of information among all nations. We must give advisory service on national needs within our domains.

It is only through mutual appreciation of each other's problems that we advance international understanding and thus carry our share in the ultimate establishment of pacific conditions. We must aim at practical working arrangements, not only for existing and potential units of our Association, but also for those involving contacts with other Associations of the Union and with other scientific organizations. We must respect the dignity and worth of the individual which underlie stable conditions and enduring progress for every nation.

Washington, D.C., U.S.A., August 10, 1948

REPORT OF THE SECRETARY AND DIRECTOR OF THE CENTRAL BUREAU FOR THE PERIOD 1939 - 1948

Washington Assembly

The Secretary (Dr. A. H. R. Goldie) had been due to sail from England to the United States on 26 August 1939. A few days before that date the intended sailing of various British delegates, including the Secretary, was cancelled owing to the imminence of war. All papers for the Washington Assembly had been made ready and had previously been sent on to Washington, and Dr. Joyce acted as Secretary during the meetings.

The Executive Committee

Dr. G. van Dijk died 19 December 1940. All of the remaining members of the Executive Committee have remained active during the interval since the Washington Assembly.

In a letter to the members of the Executive Committee dated 17 April 1947, Dr. Goldie asked to be relieved of the Secretaryship of the Association. He further indicated that Dr. J. W. Joyce had been proposed as his successor, with Mr. Lloyd V. Berkner as Assistant Secretary.

Subsequent action by the Executive Committee resulted in the appointment of Dr. Joyce as Secretary and Director of the Central Bureau of the Association to fill out Dr. Goldie's unexpired term of office. Mr. Berkner was unable to act as Assistant Secretary, and instead, Commander Elliott B. Roberts of the U. S. Coast and Geodetic Survey was chosen. Dr. Joyce and Commander Roberts assumed office on 1 July 1947.

On 1 March 1948, Dr. Maurain advised the President that he would be unable to attend the Oslo Assembly and suggested that consideration be given to the appointment of Prof. J. Coulomb of France to act in his place as one of the Vice-Presidents of the Association at Oslo. Subsequent action by the Executive Committee approved this suggestion.

Activities and Publications

Since many of the papers and reports intended to appear in the Transactions of the Washington Assembly had been set up in proof, it was decided that the best course was if possible to complete the printing of the volume Bulletin No. 11 before greater difficulties supervened. With the assistance of notes supplied by Dr. Joyce, the volume was completed and the printing was finished (in Edinburgh) by October 1940.

Copies were distributed within the British Isles, to the Argentine, Brazil, Canada, Egypt, India, New Zealand, Siam, South Africa, the United States, and Uruguay, the number so disposed of being about 457. The losses in transit are not fully known, but out of 320 copies sent to the United States, 300 arrived safely. The remaining stock of 443 copies was divided into two portions and stored for safety, one at Edinburgh and the other at Eskdalemuir. These stocks are now available for issue.

The President was able to arrange for the inception of the Three-hour-range Index (Resolution 2 of the Washington Assembly) and for the collection of the appropriate data to the Carnegie Institution of Washington. Since 1939, collection and coordination of data relating to magnetic activity have so far as possible been maintained by the Carnegie Institution of Washington and summaries have been published in the Journal of Terrestrial Magnetism and Atmospheric Electricity.

Through the efforts of the President and Mr. H. F. Johnston, aided by W. E. Scott and Ella Balsam of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, Bulletin No. 12, Geomagnetic Indices C and K, 1940-1946, and Bulletin No. 12a, Geomagnetic Indices C and K, 1947, were issued during May 1948. Three hundred (300) copies of each were printed. A world-wide distribution of both bulletins was made in June 1948 in order to provide time for a study and evaluation of the data prior to the General Assembly at Oslo in August 1948.

Since the Carnegie Institution of Washington has indicated that it will be unable to continue the collection and processing of magnetic activity indices, C and K, due to reduced endowment income, the Association must find other means to continue this most valuable contribution to the international aspects of terrestrial magnetism.

Oslo Assembly

Immediately upon assuming office on 1 July 1947, the Secretary took the initial steps in the preparation of a scientific agenda for the Association for the Eighth General Assembly of the Union to be held in Oslo in August 1948. This consisted of the compilation of a list of addresses of all known National Committee organizations supplied by the retiring Secretary, Dr. Goldie, as well as addresses of individuals and organizations over the world known to be interested in terrestrial magnetism and electricity. The President, Dr. Fleming, gave invaluable aid in securing this latter compilation.

Following the preparation of this mailing list, it was planned to send out a series of circular letters to all, National Organizations and individuals alike. While this procedure of addressing individuals is not entirely regular, it was adopted as an emergency measure, since time was short, and pending a more complete reactivation of National Committee structures, direct contact with individuals held the greatest promise of expeditious action. Also, all letters, without exception, sent out of the United States were sent by air-mail to further expedite arrangements. Subsequent results have justified both actions.

Several circular letters were issued prior to the distribution of the Oslo Agenda. Circular letter No. 1 dated 10 September 1947 was the opening announcement of the Oslo Assembly as far as the participation of the Association of Terrestrial Magnetism and Electricity was concerned. A proposed agenda was indicated and the submission of National reports, special committee reports, and technical communications and proposals dealing with international aspects of terrestrial magnetism and electricity were solicited. This letter went to approximately 1250 addresses, 750 in the United States (including members of Section d, Terrestrial Magnetism and Electricity of the American Geophysical Union) and 500 to other countries throughout the world.

Circular letter No. 2 dated 24 December 1947 was a follow-up, and was given the same distribution as No. 1 with some few additions.

A special circular letter A dated 24 October 1947 went to over 100 National Committee and observatory addresses, requesting that national reports include, wherever possible, statements regarding

(a) Control of variometer and absolute instruments in accordance with ATME Resolution No. 4 of the Washington Assembly, and
(b) Recommendations regarding the publication of observatory data in accordance with ATME Resolution No. 10 of the Washington Assembly.

In the meantime, following a conference in Washington in the fall of 1947 with Dr. Jno. A. Fleming, Prof. J. Keränen, and Dr. J. W. Joyce, temporary appointments were made to the various special committees of the Association chosen at the Washington Assembly, to fill gaps caused by deaths, illnesses, and other causes. These were as follows:

1. Committee on the selection of sites of new observatories for terrestrial magnetism and electricity: Dr. V. Laursen to replace Dr. D. la Cour.
2. Auroral Committee: Dr. W. B. Currie to replace Dr. D. la Cour.
3. Committee on the study of the relationship between solar activity and terrestrial magnetism: No changes.
4. Committee on secular variation stations: Dr. E. H. Vestine to replace Capt. N. H. Heck as Chairman (at Capt. Heck's suggestion); Mr. H. F. Johnston as an additional member.
5. Committee on ionic equilibrium: No changes.
6. Committees on magnetic charts:
   (a) Organization of the work: Commander E. B. Roberts to replace Capt. N. H. Heck.
   (b) Methodology: Dr. E. H. Vestine to replace Dr. G. S. Ljungdahl as Chairman.
7. Committee on registration in Iceland of giant pulsations: Dr. J. Olsen to replace Dr. D. la Cour as Chairman.
8. Committee on methods of observatory publication: Commander E. B. Roberts to replace Capt. N. H. Heck (Prof. Ch. Maurain later requested Commander Roberts to act as Chairman and to prepare the report of the Committee).
9. Committee on classification of magnetic literature: No changes.
10. Committee to promote international comparisons of magnetic standards: Prof. J. Keränen to replace Dr. D. la Cour as Chairman; Mr. H. E. McComb as an additional member.
11. Committee on observational technique: No changes.
12. Committee on three-hour-range indices for magnetic characterization: Mr. A. G. McNish to replace Dr. J. Bartels as Chairman; Mr. H. F. Johnston as an additional member.
13. Joint Committee of the Commission of Terrestrial Magnetism and Atmospheric Electricity and the Association on methods and codes to adequately describe magnetic disturbances and perturbations: No changes.
14. Joint Committee of the Association and of the International Scientific Radio Union: No changes.

A final agenda for Oslo was released in late June 1948 and 1700 copies were distributed over a world-wide mailing list.

The response to the Central Bureau's request for reprints of agenda reports and technical communications for distribution to the delegates at Oslo has been excellent. Approximately 80 items have been so supplied. An additional 36 items were reprinted by the Central Bureau. All of this material was sent by surface express to Oslo in mid-July 1948.

From 1 July 1947 to 30 July 1948, the Central Bureau has received approximately 250 letters and has sent out 300, exclusive of circular letters previously reported.

Finances

In Dr. Goldie's account of the activities of the Association, given on pages 54-55 and 63-64 of the U.G.G.I. publication entitled "Report of the Union for the War Years 1939-1945 with the proceedings of the Executive Committee of the Union, Oxford, December 1945, and the Extraordinary Assembly, Cambridge, July 1946", edited by J. M. Stagg, General Secretary of the U.G.G.I., appears a statement of the accounts of the Association for the period 31 December 1938 to 31 December 1945. There is published in the Report of the General Secretary for the period 1 January 1946 to 31 December 1947 a similar statement of accounts of the Association for that period. Both statements include due notice of audit by qualified auditors. These two statements, combined for convenience into one composite listing of receipts and expenditures for the period 31 December 1938 to 31 December 1947, are appended.

On 20 September 1947, on authority contained in the General Secretary's letter 104/292 dated 15 September 1947, addressed to Dr. Fleming, the latter transferred the sum of $500.00 to the ATME from U.G.G.I. sub-account funds in Washington. On 18 February 1948, on authority of the General Secretary (letter No. UGGI/156 dated 6 February 1948 to Dr. Fleming), Dr. Fleming transferred an additional Ł3000 less $500.00 already advanced the previous September, or $12,030.00 (at exchange rate of $4.01 per pound sterling) from U.G.G.I. Washington sub-account to the ATME. A final transfer from Dr. Fleming of $155.68 on 26 February 1948 brought the total amount of funds turned over to the Secretary to $12,685.68 (equivalent of Ł3163/10/3 specified as available by Dr. Goldie in his letter dated 20 February 1948 to the General Secretary). The difference between Ł3163/10/3 and Ł3164/5/3-1/2 shown as funds on hand 31 December 1947, namely Ł0/15/0-1/2, represented cash held against further miscellaneous expenditures in England.

From 31 December 1947 to 31 July 1948, the Association has made the following expenditures:

Preparation and publication of magnetic indices C and K, 1940-46 (Bulletin No. 12) and 1947 (Bulletin No. 12a) (300 copies of each)	$1,588.00
Preparation and publication of reprints of National and special reports and scientific papers for Oslo (110 copies)	481.75
Transportation of Oslo reprints, Washington to Oslo (estimated)	50.00

Management expenses, stationery, clerical, postage, etc.	$ 440.57
Oslo Agenda (1700 copies)	48.50
Oslo program	22.50
Total	$2,631.32

Costs on completion of the Thesaurus of Observatories, Part VIII, are not yet available. In addition, there will be a few additional miscellaneous items.

Explanations of various items of the appended statement of accounts for the period 31 December 1938 to 31 December 1947 are given below:

(1) Printing of final programs for the Washington meeting was accomplished for Ł10 as against an allotment of Ł13.

(2) The printing of the Transactions of the Washington Assembly, Bulletin No. 11, cost Ł538/8/5, with an additional item of Ł10 for editing and proofreading, as against an allocation of Ł450. There was also an item of Ł30 allotted for miscellaneous expenses in connection with the Washington meeting which was not used and could be applied against the cost of the Transactions.

(3) Central Bureau expenses for nine years, including auditor's fees, amounted to Ł57/1/0-1/2 plus $336.29 against an allocation of Ł50 for three years' operation. The economy of operation up to 1 July 1947 was due to reduced activity of the Central Bureau as well as the generous assistance of the British Meteorological Office.

(4) A sum of Ł300 was allocated for publication of caractère numérique magnetique des jours, or of corresponding publication for the new measure adopted from 1 January 1940--with an additional 90 for publication of caractère magnétique de chaque jour. Against these items Ł100 was granted for the first and Ł30 for the second items. The balance of Ł260 ($1,042.60) was applied to the preparation and publication of Bulletins No. 12 and 12a. The Executive Committee approved an additional $1,000.00 for this work. The final cost was $1,588.00.

(5) There remained in Dr. la Cour's hands on 31 December 1938, the following amounts:

	Ł	s	d
(a) Photographic reproductions of records jointly with Polar Year work	132	5	11
(b) International Comparison of Magnetic Standards	35	3	3
(c) Investigation in Iceland of giant pulsations	28	9	8
	196	1	10

For the period 1 January 1939 to 19 May 1942, the date of Dr. la Cour's death, there had been spent the following:

(a) Photographic reproduction work	352	11	6
(b) Loss in rate of exchange		14	0
	353	5	6
Less income from interest and sale of films	42	5	11
	310	19	7
Balance on hand 31 December 1938 (see above)	196	1	10
Deficit	114	17	9

The amount of this deficit was loaned from the funds of the International Polar Year Commission.

It is noted that at the Washington Assembly £100 were allocated for Photographic reproduction of records; international comparison of magnetic standards; investigation of giant pulsations; Polar-year work. There have as yet been no charges against this item.

UNESCO Grants-in-Aid

In July 1947, at the request of the General Secretary of the Union, estimates were submitted for 1948 UNESCO grants-in-aid for the Association. These are listed below, together with amounts actually made available in July 1948.

	Requested	Granted
(a) Clerical services for the Association 1948	$ 3,000.00	$ 0.00
(b) International comparison of magnetic standards	2,000.00	1,200.00
(c) Publication of ATME Transactions of Oslo Assembly	6,000.00	600.00
(d) Traveling expenses ATME		
Officers of Association	3,400.00	350.00
Young geophysicists	3,000.00	250.00
(e) Publication of monthly and quarterly geomagnetic character figures	-----	300.00
	$17,400.00	$2,700.00

Additional estimates, tabulated below, were submitted in June 1948 to the General Secretary for 1949 UNESCO grants-in-aid.

(a) Aid in publication of daily, monthly, and annual geomagnetic character figures	$ 500.00
(b) International comparison of magnetic standards	2,000.00
(c) Additional aid in publishing ATME Transactions of Oslo Assembly	3,000.00
(d) Aid in making a study of machine or punch-card methods of reducing geomagnetic observatory data and in establishing standard reduction and publication practices for selected world observatories	2,000.00
(e) Aid in projects of international scope established by Oslo Assembly (This item was subsequently omitted since UNESCO requires more specific details.)	1,500.00
	$9,000.00

UNESCO has now indicated that it will not issue grants-in-aid for administrative expenses such as salaries and office supplies, nor will it finance completely publications.

Future Expenditures

In conclusion, it must be stressed that due to the reduced annuities of privately endowed organizations in the United States and understaffed clerical complements in Federal Government offices, future allocations must provide for a realistic amount of clerical assistance as long as Central Bureau activities remain in the United States.

FINANCE

Statement of Accounts for the period 31 December 1938 to 31 December 1947

Receipts

	£	s	d	U.S.Dollars
Balance on 31 December 1938	2769	9	0	
Received during period 31 December 1938 to 31 December 1945				
From General Secretary	831	17	4	
Sale of Transactions	65	2	3	
Interest	211	2	3	
Received during period 31 December 1945 to 31 December 1947				
Sale of Publications	1	5	0	
Interest	41	3	11	
Advanced from UGGI for expenses, pending transfer of funds to U.S.A. bureau				$500.00
Total	3919	19	9	$500.00

Payments

	£	s	d	U.S.Dollars
From 31 December 1938 to 31 December 1945				
Preparation of "Caractère Magnétique numérique des jours"	100	0	0	
Preparation of "Caractère Magnétique de chaque jour"	30	0	0	
Preparation for Washington General Assembly	10	0	0	
Editing and proofreading Transactions of the Washington General Assembly	10	0	0	
Printing for the Washington General Assembly	538	8	5	
Preparation of Auroral Atlases	10	5	0	
Chartered Accountant's Fee	5	5	0	
Management Account: Bank charges, postage, stationery, and miscellaneous	44	18	4-1/2	
From 31 December 1945 to 31 December 1947				
Audit fee	3	3	0	
Management Expenses:				
Stationery		2	6	$ 36.91
Clerical				64.38
Postage	3	12	2	232.50
Miscellaneous				2.50
Printing preliminary notices of Oslo Assembly				38.20
Balance 31 December 1947				
Deposits	3051	3	10	
Cash	113	1	5-1/2	125.51
Total	3919	19	9	$500.00

MINUTES OF THE FIRST MEETING OF THE EXECUTIVE COMMITTEE OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY ON WEDNESDAY, AUGUST 18, 1948, AT OSLO

The following members of the Executive Committee were present: Prof. S. Chapman, Prof. J. Coulomb, Dr. J. W. Joyce, Prof. J. Keränen, Prof. C. Störmer. In addition, Prof. L. Vegard, the local secretary for the Association at the Oslo Assembly, attended on invitation.

Professor Chapman called the meeting to order at 15:10.

Special committees--The following special committees were nominated for presentation to the Association for its consideration:

A. Auditing Committee:
  Mr. J. Egedal
  Prof. E. Thellier
  Dr. M. A. Tuve

B. Nominations Committee:
  Mr. J. Egedal
  Prof. L. Harang
  Sir Harold Spencer Jones
  Prof. E. Thellier
  Dr. M. A. Tuve

C. Resolutions Committee:
  Prof. S. Chapman
  Prof. J. Coulomb
  Dr. J. W. Joyce
  Dr. J. T. Wilson

Budget--The budget for the Association for the three-year period January 1, 1948 to December 31, 1950, was next considered. After some preliminary discussion the composition of the budget was deferred until the second meeting of the Executive Committee.

Advisor on UNESCO estimates--It has been proposed that an advisor be appointed to aid the Secretary of the Association in preparing and presenting UNESCO grants-in-aid for the ensuing three years. This proposal was approved by the Executive Committee, and Dr. J. A. Fleming was appointed as the advisor in such matters.

List of addresses of geomagneticians--In order to facilitate the distribution of reports and other material on terrestrial magnetism and electricity, it has been proposed that the Secretary prepare a list of interested individuals and organizations in all countries of the world for publication in the Transactions of the Oslo Assembly. The Executive Committee agreed that such a list is desirable if its publication is practicable. It was suggested that this list be limited to approximately 1,000 names; that in the case of adhering countries the appropriate national committees be requested to submit the names of individuals and organizations in their respective countries; and that in the case of non-member countries the Secretary attempt to develop such a list from any sources which may be at his disposal.

If any further guidance is necessary in the preparation of this list, the Secretary will contact the members of the Executive Committee by mail.

Transactions of the Oslo Assembly--The following policies with regard to the publication of the Transactions of the Oslo Assembly were approved:

A. The use of offset printing.
B. An edition of approximately 1,500 copies.
C. Reprints of technical communications up to 100 in quantity.
D. It is suggested that the Transactions include a portrait of Dr. Fleming as the retiring President of the Association.

Supplemental Agenda for the Oslo Assembly--The supplemental Agenda for the Oslo Assembly, presented by the Secretary, which included additional reports and technical communications, was approved for presentation to the Assembly.

Increasing the size of the Executive Committee--A proposal had been made that the size of the Executive Committee be increased to permit a wider distribution of membership. It was decided that action on this matter be deferred until further changes are required in the Statutes.

Additional Committees of the Association--It was proposed to ask the Association to consider the formation of two additional committees:

A. Committee on the study of the influence of the moon on geophysical phenomena. (This would be a joint committee with the Association of Meteorology, subject to the approval by this Association, and would replace the present reporter on this subject appointed at the Washington Assembly.)

B. Committee on aerial magnetic surveys.

Presiding Officer at meetings of the Association--In the absence of the President of the Association, and since the senior Vice-President is also the President of Meteorology, the Executive Committee agreed that Prof. J. Coulomb should act as presiding officer at meetings of the Association that Prof. S. Chapman can can not attend.

The meeting of the Executive Committee adjourned at 17:10.

J. W. Joyce,
Secretary and Director of the Central Bureau

MINUTES OF THE SECOND MEETING OF THE EXECUTIVE COMMITTEE OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY ON WEDNESDAY, AUGUST 25, 1948, AT OSLO

The members of the present Executive Committee, as well as those elected for the next period, met at 09:30 on Wednesday, August 25, 1948, to consider the Budget of the Association for the period January 1, 1948 to December 31, 1950.

Those present were: Dr. S. K. Banerji, Prof. S. Chapman, Prof. J. Coulomb, Dr. J. W. Joyce, Prof. J. Keränen, Mr. V. Laursen, Mr. O. Lützow-Holm, Prof. C. Störmer, Dr. M. A. Tuve (alternate for Mr. L. V. Berkner).

The Budget adopted is as follows:

Management expenses	$ 900.00
Oslo programs, printing	71.00*
Oslo reprints, including shipping charges	537.00*
Oslo Transactions (UNESCO $600.00 in 1948) .	3,000.00
Oslo miscellaneous costs.	150.00
Preparation for 1951 Assembly:	
Agenda notices	200.00
Postage	100.00
Subventions:	
Bulletins 12 and 12A.	1,588.00*
Thesaurus, Vol. VIII.	331.00*
Danish deficit	465.00
Intercomparisons (UNESCO $1,200 in 1948)	1,500.00
Journal T.M. and A.E. (Provisional, subject to approval by assembly of ATME)	1,500.00
Lunar tides studies	2,000.00
Magnetic characterization (grant-in-aid) . .	2,000.00
	$14,342.00

*Items so marked represent expenditures made with authority of the Executive Committee prior to the Oslo Assembly. They are confirmed herewith for completeness.

In addition to the above, a sum of £350 ($1,400.00) allocated at the Edinburgh Assembly for study of giant pulsations is still available.

The meeting adjourned at 10:00.

J. W. Joyce,
Secretary and Director of the Central Bureau

REPORT OF THE AUDITING COMMITTEE

Auditing Committee of the IATME recommends that the financial report submitted by the Secretary, Dr. Joyce, be accepted as it stands, on the basis of the technical report of the Public Accountant.

(Signed) M. A. Tuve
J. Egedal
E. Thellier

Oslo, Norway,
August 21, 1948

PART II

STATUTES

STATUTS DE L'ASSOCIATION DE MAGNÉTISME ET ÉLECTRICITE TERRESTRES DE L'UNION GÉODÉSIQUE ET GÉOPHYSIQUE INTERNATIONALE

I. -- Objets de l'Association

1. L'Association a pour objets:
   (1) d'étudier des questions qui concernent le magnétisme et l'électricité terrestres en tant que ces questions exigent la coopération internationale pour en assurer l'étude effective;
   (2) d'encourager l'étude de ces sujets par les différents pays, institutions, ou les particuliers.

II. -- Membres de l'Association

2. Les pays qui adhèrent à l'Union Géodésique et Géophysique Internationale auront le droit de s'inscrire comme membres de l'Association et de nommer des délégués pour se faire représenter aux réunions de l'Association.

III. -- Comités Nationaux

3. Avec l'approbation de son Comité National de l'Union Géodésique et Géophysique Internationale, chacun des pays, en devenant membre de l'Association, peut créer un Comité National pour faire progresser les objets de l'Association dans son propre territoire. Ces Comités Nationaux auront le droit de déterminer leur propre constitution et de régler leurs affaires en accord avec ces statuts et ceux de l'Union Géodésique et Géophysique Internationale. Ils auront aussi le droit de nommer des délégués à chaque réunion de l'Association et de soumettre à ces réunions des questions à discuter pourvu que ces questions soient parvenues au Secrétaire de l'Association au moins quatre mois avant la réunion de l'Assemblée où elles sont à discuter.

4. La correspondance entre un Comité National de l'Association et le Comité Exécutif de l'Association sera conduite par le Comité National local de l'Union Géodésique et Géophysique Internationale.

IV. -- Administration de l'Association

5. Les travaux de l'Association seront dirigés par l'assemblée générale des délégués choisis par les Comités Nationaux de l'Association.

6. L'Association aura un Comité Exécutif élu par l'Assemblée Générale.

7. L'intervalle entre la clôture d'une Assemblée Générale et la clôture de la suivante sera appelé, pour les buts de ces statuts, une période. Le Comité

Exécutif comprend le Président, deux Vice-présidents, le Secrétaire qui est en même temps directeur du Bureau Central de l'Association, cinq autres membres, enfin le président sortant s'il y en a un.

8. Le président et les vice-présidents sont élus pour une période et rééligibles une seule fois. Le Secrétaire est élu pour deux périodes et rééligible par périodes successives. Les cinq membres additionnels sont élus pour une période et rééligibles par périodes successives. Le président sortant est membre de droit pour une période seulement.

9. Le Comité Exécutif aura le droit de pourvoir aux vacances qui surviendraient dans son sein pendant l'intervalle entre deux assemblées générales. Toute personne désignée dans ces conditions restera en fonctions jusqu'à l'assemblée générale suivante et sa rééligibilité par conséquent ne sera pas affectée. Si la vacance est celle du Président, le Comité Exécutif nommera un des Vice-Présidents pour le remplacer jusqu'à l'assemblée générale suivante.

10. Le Président présidera toutes les assemblées générales et les séances du Comité Exécutif et, en conférence avec le Secrétaire, réglera les affaires de l'Association entre les assemblées générales.

11. Les Vice-Présidents, l'un ou l'autre, conformément aux dispositions que prendra le Comité Exécutif, présideront les assemblées générales en l'absence du Président.

12. Les fonctions du Secrétaire seront les suivantes: (1) D'expédier toute correspondance relative aux affaires de l'Association; (2) de recevoir et de gérer les sommes qui peuvent être allouées par l'Union Géodésique et Géophysique Internationale ou d'autre provenance; (3) de débourser telles sommes conformément aux décisions de l'assemblée générale ou aux instructions du Comité Exécutif; (4) de tenir le compte de tout l'argent reçu et dépensé et de soumettre ce compte, certifié par un comptable qualifié, à l'examen d'un comité financier nommé à cet effet par l'assemblée générale; (5) de rédiger et publier les comptes-rendus de l'Association et de procéder à leur distribution selon les directives de l'assemblée générale.

13. Soumis aux directives générales et spéciales de l'assemblée générale, le Comité Exécutif aura le droit: (1) de fixer l'ordre du jour de chaque assemblée générale; (2) de confier à des commissions spéciales ou à des particuliers la préparation de rapports sur des sujets rentrant dans la compétence de l'Association; (3) de choisir et de consulter des personnes et des institutions représentatives des pays qui n'adhèrent pas à l'Association, ces personnes ou institutions étant considérées comme membres correspondants de l'Association.

14. Si, pour un motif qui semblerait bon et suffisant, le Comité Exécutif considère nécessaire ou désirable de s'écarter de la décision ou des instructions de l'assemblée générale ou bien de l'interprétation formelle de ces statuts, il en aura le droit pourvu qu'un exposé de l'action réalisée ou non réalisée, appuyé des motifs, soit présenté à l'assemblée générale suivante.

V. -- Assemblées de l'Association

15. Une assemblée générale ordinaire se tiendra à l'occasion de l'assemblée générale ordinaire de l'Union Géodésique et Géophysique Internationale.

16. Le Président peut, avec l'approbation du Comité Exécutif, convoquer une assemblée générale extraordinaire de l'Association. Il sera tenu de le faire à la demande d'au moins la moitié des voix des pays adhérents à l'Association, exprimée par leurs Comités Nationaux.

17. Avec le consentement du Comité Exécutif, le Président peut inviter comme hôtes des représentants d'institutions ou d'autres personnes intéressées à assister aux séances d'une assemblée générale.

18. Sauf dans le cas de modification de ces statuts ou de questions financières, toutes les questions présentées à une assemblée générale seront décidées à la majorité des voix des délégués. Sur les questions relatives à la modification de ces statuts, chaque pays représenté dans l'assemblée générale aura une voix, laquelle sera donnée par un représentant choisi par les délégués du pays considéré. En ce qui concerne les questions financières, le scrutin se fera selon les statuts de l'Union Géodésique et Géophysique Internationale. Dans tout cas ne concernant pas une modification aux statuts, s'il y a égalité de voix, celle du Président sera prépondérante.

19. L'ordre du jour d'une assemblée générale sera préparé par le Secrétaire et communiqué aux membres de l'assemblée générale au moins trois mois avant l'ouverture de la session. Il y figurera toutes les questions qui auront été soumises par les Comités Nationaux pour être discutées à l'assemblée générale, avec d'autres questions qui peuvent être mises à l'ordre du jour par le Comité Exécutif. Toute question qui n'a pas été ainsi communiquée ne peut être prise en considération qu'avec l'assentiment de l'assemblée générale.

VI. -- Budget

20. Le Secrétaire préparera un budget de prévision de recettes et dépenses pour la période comprise entre deux assemblées générales ordinaires successives. Il présentera ce budget au Comité Exécutif au cours des sessions de l'assemblée générale qui précède immédiatement cette période et, après en avoir reçu l'approbation, il peut procéder au déboursement des fonds conformément à cette approbation.

21. A chaque assemblée générale ordinaire, un Comité sera institué pour examiner les comptes et présenter à l'Association un rapport sur les résultats de cet examen.

VII. -- Interprétation et modification des statuts

22. Le présent texte français servira exclusivement pour l'interprétation à donner à ces statuts.

23. Aucun changement ne pourra y être apporté sauf dans le cas où:

(1) Un pays, par l'intermédiaire de son Comité National, fait savoir son intention de proposer une modification--cette intention ayant été communiquée au Secrétaire au moins six mois avant l'assemblée générale à laquelle la question doit être étudiée.

(2) Le changement reçoit l'approbation d'au moins deux tiers du nombre des pays appartenant à l'Association.

STATUTES OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

I. -- Objects of the Association

1. The objects of the Association are:
   (1) The study of questions relating to terrestrial magnetism and electricity in so far as these questions require international cooperation for their effective investigation.
   (2) The encouragement of research in the above subjects by individual countries, institutions, or persons.

II. -- Members of the Association

2. The countries which adhere to the International Union of Geodesy and Geophysics shall be eligible as members of the Association, and may appoint delegates to represent them at meetings of the Association.

III. -- National Committees

3. With the approval of its National Committee of the International Union of Geodesy and Geophysics, any country becoming a member of the Association may constitute a National Committee for the purpose of furthering the aims of the Association within its territory. Such National Committees shall have power to determine their own constitution and to regulate their own procedure in accordance with these Statutes and the Statutes of the International Union of Geodesy and Geophysics. They have also the right to appoint delegates to each meeting of the Association and to submit subjects for discussion at these meetings, provided that notice of such subjects is received by the Secretary of the Association not less than four months before the meeting of the Assembly at which they are to be discussed.

4. Correspondence between a National Committee of the Association and the Executive Committee of the Association shall be carried on through the local National Committee of the International Union of Geodesy and Geophysics.

IV. -- Administration of the Association

5. The work of the Association shall be transacted by the general assembly of the delegates appointed by the National Committees of the Association.

6. The Association shall have an Executive Committee elected by the General Assembly.

7. The interval elapsing between the end of one general assembly and the end of the next one, will, for the purposes of the Statutes, be termed one period. The Executive Committee shall consist of the President, two Vice-Presidents, the Secretary who is simultaneously Director of the Central Bureau of the Association, five other members, and the retiring President if there is one.

8. The President and the Vice-Presidents shall be elected for one period and may be reelected once. The Secretary shall be elected for two periods and may be

reelected for successive single periods. The five additional members shall be elected for one period and reelected for successive single periods. The retiring President is member ex-officio for only one period.

9. In the event of any vacancy in the Executive Committee occurring in its membership during the interval between two general assemblies, the Executive Committee shall have power to fill the vacancy, such election being valid until the next general assembly, and the eligibility for reelection of the person so elected shall not be affected by such election. Provided that if the vacancy be that of the office of President, the Executive Committee shall appoint one of the Vice-Presidents to act until the next general assembly.

10. The duties of the President are to preside at all general assemblies of the Association and at meetings of the Executive Committee, and, in consultation with the Secretary, to regulate the current business of the Association between general assemblies.

11. It is the duty of the Vice-Presidents, one or other as may be determined by the Executive Committee, to preside at general assemblies in the absence of the President.

12. The duties of the Secretary shall comprise the following: (1) To carry on all correspondence relating to the affairs of the Association; (2) to receive and keep charge of such funds as may be allotted by the International Union of Geodesy and Geophysics to the Association, or as may be received from any other source; (3) to disburse such funds in accordance with the decisions of the general assembly or with the instructions of the Executive Committee; (4) to keep the account of all receipts and disbursements and to submit such account, audited by a qualified accountant, for examination by any financial committee appointed for the purpose by the general assembly; (5) to prepare and publish the transactions of the Association, and to arrange for their distribution in accordance with the directions of the general assembly.

13. Subject to the general or special directions of the general assembly, the Executive Committee shall have power: (1) To arrange the agenda of each general assembly; (2) to entrust to special commissions or to particular individuals the preparation of reports on subjects within the province of the Association; (3) to select and consult with persons or representative institutions belonging to countries which are not within the Association, such persons or institutions being deemed corresponding members of the Association.

14. If, for any reasons that may appear to it to be good and sufficient, the Executive Committee considers it necessary or desirable to depart either from the decision or the instructions of the general assembly or from the strict interpretation of these Statutes, it shall have power to do so, provided that a statement of the action taken or not taken, with reasons for the same, shall be laid before the next general assembly.

V. -- Assemblies of the Association

15. An ordinary general assembly of the Association shall be held in connection with the ordinary general assembly of the International Union of Geodesy and Geophysics.

16. The President may, with the approval of the Executive Committee, call an extraordinary general assembly of the Association. He shall be obliged to do so on the request of not less than one-half of the votes of the countries adhering to the Association, as expressed by their National Committees.

17. With the consent of the Executive Committee, the President may invite as guests representatives of institutions or other interested persons to be present at meetings of a general assembly.

18. Except in questions relating to the alteration of these Statutes or to financial questions, all questions before a general assembly shall be decided by the majority of votes of those delegates then present. In questions relating to the alteration of these Statutes, each country represented at a general assembly shall have one vote, to be given by a representative chosen by the delegates from the respective country. In all financial questions, the voting shall be in accordance with the Statutes of the International Union of Geodesy and Geophysics. In all questions not relating to the alteration of these Statutes, if there be an equality of votes, the President has a casting vote in addition to his own deliberative vote.

19. The agenda of a general assembly shall be prepared by the Secretary and circulated to members of the general assembly not less than three months before the opening of the general assembly. It shall include all questions which have been submitted by National Committees for discussion at the general assembly, together with any other questions placed on the agenda by the Executive Committee. Any questions of which notice has not thus been given may only be discussed with the consent of the general assembly.

VI. -- Budget

20. The Secretary shall prepare, for each period intervening between two successive ordinary general assemblies, a budget estimate of receipts and expenditures during that period. He shall lay this before the Executive Committee during the meetings of the general assembly immediately preceding that period, and, having received its approval, he may proceed with the disbursement of funds in accordance with that approval.

21. At each ordinary general assembly a committee shall be appointed to examine the accounts and to report the results of their examination to the Association.

VII. -- Interpretation and Alteration of Statutes

22. The French text shall serve exclusively for interpretation of these Statutes.

23. No change may be made in the present Statutes except:
(1) By notice being given by any country, through its National Committee, of its intention to move an alteration, such notice being given to the Secretary not less than six months before the general assembly at which it is intended to be discussed.
(2) By the approval of at least two-thirds of the number of countries included in the Association.

PART III

NATIONAL REPORTS

ARGENTINA

REPORT OF WORK IN TERRESTRIAL MAGNETISM DURING THE PERIOD 1939-1948

Department of Geophysics of the National Meteorological Service, Secretary of Aeronautics

The geophysical observatories of La Quiaca, Pilar, and the South Orkneys were in continuous operation throughout the period. Continuous photographic registrations of the variations in the three magnetic elements (declination, horizontal force, and vertical force) were made at Pilar with one set of Eschenhagen and another set of Edelmann type variometers, and at La Quiaca and the South Orkneys with one set of the Eschenhagen type. At each observatory ten sets of absolute observations of declination, inclination, and horizontal force were made monthly. Within the next five years magnetic observatories will be constructed at Corrientes, at somewhere in the province of Buenos Aires, at Zapala, and at Rio Galleges.

Field work--About 180 stations were occupied and magnetic maps of declination, inclination, horizontal force, and vertical force were published for the epoch 1944.0.

During May, June, and July 1948, 19 magnetic stations were occupied, 14 of which were reoccupation stations. The field work will be intensified during the coming years, expecting to reach a thousand stations within the next ten years.

It is proposed to establish a considerable number of geophysical observatories, where seismic work, observations of atmospheric electricity, solar radiation, and other types of geophysical work will be carried out.

The National University of La Plata

In the period in review, the Astronomical Observatory of the National University of La Plata has enlarged its activities in the following ways: (1) by teaching of the material in the Higher School of Astronomical and Allied Sciences as part of the rotative course of Geophysics in charge of the Chief of the Department, Ing. Simon Gershanik; (2) by magnetic survey in the north part of the Province of Jujuy, and (3) by establishment of two magnetic observatories.

Point (1) does not require special comment.

(2) Magnetic Survey--Near the end of 1939 and the beginning of 1940 a magnetic survey was carried out in the north zone of the Province of Jujuy, where 23 stations were established between 65° 15′ and 67° 10′ west of Greenwich and 22° and 22° 50′ of south latitude, all in the plateau region called Puna.

The survey was organized by using the facilities at its disposal as a result of the realization of geodetic work in the border zone between Argentina and Bolivia for demarkation of the international frontier, in the operation of which those participating were personnel of the Instituto Geografico Militar Argentino and the Observatory of La Plata, also representatives of the Republic of Bolivia. Determinations of declination, horizontal intensity, and vertical intensity were made, using an Askania magnetometer furnished by the Instituto Geografico Militar and a Schmidt balance belonging to the Observatory.

The instrumental constants and their drift were determined at the Magnetic Observatory of La Quiaca.

The results of D and H are completely satisfactory, but those of Z are below standard due to instrumental deficiencies.

This survey was in charge of Surveyor Miguel Itzigsohn.

(3) New stations--In this same period two new magnetic stations were established: One in the South of the Province of Buenos Aires, and the other in the Astro-Geophysics station "Felix Aguilar", which is being constructed in Patagonia, as indicated in the report on Seismology.

After a prolonged study, the decision was arrived at for the most adequate type of buildings, and corresponding plans were formulated with help of the National Office of Architecture, the department in charge of construction, and construction work began in December 1947.

At the end of the same year, details for the purchase of instrumental equipment were arranged, and it is hoped that at the next Assembly information regarding operation and results can be given.

AUSTRALIA

STATEMENT ON MAGNETIC SURVEY OF AUSTRALIA

By J. M. RAYNER

General

The magnetic survey of Australia and surrounding areas is carried out by the Geophysical Section, Bureau of Mineral Resources Geology and Geophysics in the Commonwealth Department of Supply and Development.

The general plan of operations and some of the equipment was taken over from the Department of Terrestrial Magnetism, Carnegie Institution of Washington, in 1936. The magneticians in the Geophysical Section received their training at the Watheroo Magnetic Observatory in Western Australia.

The areas to be covered by magnetic survey include Australia, Papua, the Mandated Territory of New Guinea, some of the islands neighboring Australia, portions of Antarctica and some of the Sub-Antarctic islands.

Field Surveys

In the last few years field observations have been carried out in all Australian States except Tasmania, on Cocos Island (Indian Ocean) and in the Sub-Antarctic areas on Kerguelan, Heard Island, and Macquarie Island. A party has recently been in the Antarctic area but until its return it is not certain what observations have been made. In this work the emphasis has been on the reoccupation of stations for obtaining data on secular variation but a number of new stations have also been observed.

The instrumental equipment at present in use includes (1) C.I.W. Mag/E. 1 No. 6, (2) C.I.W. Mag/E. 1 No. 18, (3) Mag/Dip Circle on loan from the Hydrographic Office, U. S. Navy, (4) Vertical and Horizontal Force Field Balances.

Proposed Field Surveys

In the near future, observations will be carried out in New Guinea and Tasmania for both reoccupations and new stations. Over the next few years a considerable amount of magnetic work will also be carried out on Antarctica.

Consideration is now being given to ways in which the body of equipment may be expanded. Both in Australia and in the Antarctic areas it is proposed to make use of the airborne magnetometer.

Existing Geophysical Observatories

As from July 1 of last year, this Bureau took over the control and operation of the Watheroo Magnetic Observatory, Western Australia, from the Carnegie Institution of Washington. As is generally known, this Observatory is equipped for magnetic, ionospheric, earth-current, and atmospheric electrical work. Plans are being made to expand the activities and establishment of the Observatory.

This Bureau has also recently taken over from the Mount Stromlo Observatory (which had previously taken over from the Melbourne Observatory) the control and operation of the Toolangi Magnetic Observatory in Victoria. Only magnetic work is carried out there at present but it is proposed to expand the program to include other geophysical observations.

Proposed Geophysical Observatories

Plans are being made for the construction of a geophysical observatory in New Guinea (probably near Port Moresby). Its principal functions will be to make magnetic and seismic observations and to be a base station for magnetic, gravity, and other field surveys in New Guinea.

It is proposed also to establish small observatories on Heard Island and Macquarie Island in the Sub-Antarctic area. These will also make magnetic and seismic observations and act as base stations for other geophysical investigations. The earliest at which these stations could commence continuous observations would be about March 1949, but a further delay is likely due to difficulties of obtaining equipment.

It is also proposed to establish at least one observatory on Antarctica, possibly at Commonwealth Bay or Cape Fresh-field. Magnetic, seismic, and other types of geophysical work will be carried out at, or based on, this station. It will not be possible to establish this observatory until about December 1949.

Related Activities

Other activities of the Geophysical Section in geomagnetism include (1) periodical preparation of magnetic maps, (2) magnetic investigation of major earth features, (3) magnetic prospecting for minerals, (4) fossil magnetism and the magnetic orientation of drill cores.

Distribution Results

Data from the field surveys and observatories are distributed to a number of organizations but additions to the exchange list would be welcomed. Data, technical inquiries, and other communications may be forwarded to - Chief Geophysicist, Bureau of Mineral Resources, Geology and Geophysics, 485 Bourke Street, Melbourne, Australia.

The Geophysical Section is at present rapidly expanding its activities in pure and applied geophysics and any comments and advice concerning the location of the magnetic observatories, program of field surveys, instrumental matters, etc., would be appreciated.

BELGIQUE

RAPPORT SUR L'ACTIVITÉ SCIENTIFIQUE DEVELOPPÉE DANS LE DOMAINE DU MAGNÉTISME TERRESTRE ET DE L'ÉLECTRICITÉ AU COURS DE LA PÉRIODE 1939-1947

Par EDMOND LAHAYE

Au cours de la période 1939-1947, les activités qui se sont développées en Belgique sont diverses et s'inspirent des tendances nouvelles qui se manifestent dans l'étude des phénomènes magnétiques.

Les enregistrements continus du champ magnétique terrestre

La station magnétique de l'Institut Royal Météorologique, située à Uccle, a enregistré pendant cette période d'une manière quasi ininterrompue, la déclinaison magnétique. Malgré le voisinage des lignes de tramways et grâce à des amortisseurs électromagnétiques, des résultats intéressants ont pu être déduits de ces enregistrements pour la période 1939-1943 (1,2). Les observations des années 1946 et 1947 seront bientôt publiées.

La station magnétique établie à Manhay par l'Université de Liège a enregistré, au cours de la période 1939-1943, les éléments D, H, et Z. En 1944, au cours de l'offensive allemande des Ardennes, les appareils furent partiellement détruits et les enregistrements de 1944 furent brûlés. La station a été progressivement remise en état à partir du 1er janvier 1946; actuellement, elle fonctionne régulièrement.

Prospections géophysiques et levés magnétiques

Des prospections locales ont été effectuées en Belgique au moyen de balances magnétiques. Les résultats ont été publiés dans les études mentionnées ci-dessous (4,5,6).

M. Hermans a publié les résultats des nombreuses observations qu'il a effectuées au Congo Belge de 1934 à 1938 pour l'établissement de la carte magnétique (3).

Relations entre les phénomènes solaires, ionosphériques et magnétiques

Ces relations ont été étudiées à un point de vue statistique par M. Lahaye (2). M. Nicolet a recherché l'origine des relations qui existent entre les phénomènes solaires et les phénomènes dont la haute atmosphère terrestre est le siège. Il a étudié en conséquence l'émission ultra-violette du ciel nocturne et interprété les mécanismes d'émissions. Il a proposé une théorie sur l'origine et la structure de l'ionosphère. Il a également proposé des interprétations nouvelles des relations émises dans les aurores boréales. Il a fait une analyse approfondie du spectre des éclairs.

Création d'un Centre d'observations de Physique du Globe

Les recherches actuelles dans le domaine du Magnétisme terrestre ont mis en évidence l'interdépendance des phénomènes solaires, ionosphériques et magnétiques. Il n'est donc plus possible, dans une étude approfondie des manifestations du champ magnétique terrestre, de s'en tenir à la conception périmée d'un observatoire magnétique qui n'observerait que les éléments du champ magnétique terrestre. Aussi, le service du Magnétisme terrestre et d'Electricité de l'Institut Royal Météorologique de Belgique s'est-il préoccupé de réaliser dans une région non perturbée, un Centre d'observations et de recherches où soient simultanément étudiés et observés les phénomènes magnétiques, telluriques, ionosphériques, cosmiques, ainsi, que développer l'étude de la lumière du ciel nocturne et des aurores et l'étude de la structure de la haute atmosphère. D'autre part, le champ magnétique terrestre étant lié fondamentalement à la structure interne du Globe, il devient nécessaire de pouvoir associer aux mesures magnétiques, des observations séismiques et gravimétriques.

C'est dans cet esprit qu'a été conçue la création d'un Centre d'observations de Physique du Globe, qui sera érigé à Dourbes (Belgique) (coordonnées lat. N. 50° 05′ 49″ 5; long. E. de Bruxelles 0° 13′ 43″). Dans ce Centre, seront enregistrés les phénomènes suivants: champ magnétique terrestre courants telluriques, structure de l'ionosphère, rayonnement cosmique. Des caves seront spécialement aménagées pour des observations séismiques complètes, et pour des mesures gravimétriques. D'autre part, grâce au profil du terrain et sa situation en dehors de toute ville ou région industrielle, l'étude de l'état électrique de l'atmosphère, par la mesure des conductibilités de l'air, du gradient, du dénombrement des ions petits, moyens et gros, pourra se faire dans une atmosphère particulièrement pure. Ces circonstances très favorables seront mises à profit pour poursuivre également des observations très détaillées des divers aspect du rayonnement solaire. Des caves avec spectrographes seront spécialement conçues pour entreprendre l'étude de la lumière du ciel nocturne et des aurores visibles en Belgique.

La détermination, dans le temps, des divers phénomènes observés sera faite avec une très haute précision au moyen d'une horloge à quartz; il devient en effet nécessaire de pouvoir disposer pour certaines observations magnétiques et pour les observations séismiques et gravimétriques, d'un garde temps dont la marche journalière soit inférieure au 0.1 de seconde.

Un terrain d'une étendue de 14 hectares a été acquis, ainsi que la majeure partie des instruments scientifiques destinés à équiper le Centre de Physique du Globe de Dourbes. Les crédits nécessaires à la construction du pavillon des mesures magnétiques et de la cave des enregistreurs ayant été accordés, celle-ci pourra être entreprise au cours de l'année 1948. Une des premières initiatives qui en résultera sera un levé magnétique détaillé de la Belgique et l'établissement de plusieurs stations pour l'étude des variations séculaires du champ magnétique terrestre.

Publications

<u>Abreviations</u>: I.R.M. = Institut Royal Météorologique de Belgique. B.A.R. = Bulletin de la Classe des Sciences de l'Académie Royale de Belgique.

1. E. LAHAYE et G. BOURLET: Etude de l'influence des lignes de transports électriques sur les enregistrements de la déclinaison magnétique à Uccle au cours de l'année 1941 (I.R.M. - Misc. fasc. XXXII).
2. E. LAHAYE: Les perturbations de la déclinaison magnétique enregistrées à Uccle pendant la période 1939-1943 (I.R.M. - Misc. vol. XXI).
3. L. HERMANS: Résultats des observations magnétiques effectuées de 1934 à 1938 pour l'établissement de la carte du Congo Belge. fasc. prélim. - Aperçu des méthodes et nomenclature des stations; fasc. I - Elisabethville et le Katanga; fasc. II - Kivu - Ruanda - Région des Parcs Nationaux; fasc. III - Région des Mines d'Or de Kilo-Moto; Ituri; Haut-Uele (Mémoires de l'Inst. Roy. Colon. Belge - T. III).
4. P. EVRARD et L. KOENIGSFELD: Levé géomagnétique du Salmien supérieur manganésifère de la Lienne. (Ann. soc. géol. de Belg. - T. LXVII - 1944).
5. I. DE MAGNÉE et J. RAYMOND: Etude magnétique de la tectonique du Cambrien du Brabant à l'Est de Court-St-Etienne. (Ann. soc. géol. de Belg. - T. LXVII - 1944).
6. E. HOGE: L'étude des anomalies magnétiques en Belgique. ("La Météorologie" - Revue de la soc. météo. de France. - 3 ème série 1939 - Paris).
7. G. HEINRICHS: Le magnétisme terrestre au Katanga. (Publicat. du Comité spécial du Katanga - 1942).
8. M. NICOLET: Introduction à l'étude des relations entre les phénomènes solaires et terrestres: Le Soleil - Bruxelles - 1943 - 138 pp.
9. ________: L'absorption de la radiation solaire dans la haute atmosphère. (6ème Rap. commis. pour Etude des relat. entre phénom. solaires et terrestres - 1947).
10. ________. Le problème atomique dans l'atmosphère supérieure. (I.R.M. - Mém. vol. XI - 1939).
11. ________. Les atomes présents dans l'atmosphère supérieure. (Congrès des A.F.A.S. - Liège - Comptes rendus, p. 21 - 1941).
12. ________. Deductions regarding the state of the high atmosphere. (Conference on the "Emission spectra of the night sky and aurorae" - London, July 1947).
13. ________. Le mécanisme d'excitation des radiations du sodium atmosphérique en relation avec l'altitude de la couche émettrice. (B.A.R. p. 29, 367 - 1943).
14. ________. L'ozone et ses relations avec la situation atmosphérique. (I.R.M. Misc. - vol. XIX - 1945).
15. ________. Une équation générale d'ionisation. (B.A.R. p. 28, 768 - 1942).
16. ________. Contribution à l'étude de la structure de l'ionosphère. (I.R.M. Mém. - vol. XIX - 1945).
17. ________. L'ionosphère. (Scientia 40, 11 - 1946).
18. ________. Rayonnement solaire et origine de l'ionosphère. (Conférence internationale sur les relations entre les phénomènes solaires et géophysiques. - Lyon, Sept. 1947 - Ann. de géophys. 1947).
19. ________. Sur les identifications des raies permises de l'oxygène et de l'azote dans le spectre de l'aurore. (Ann. d'Astr. Paris, 1, 381, 1938).
20. ________. Considérations sur les transitions des transitions interdites atomiques dans les spectres de l'aurore et du ciel nocturne. (B.A.R. - p. 25, 81 - 1939).
21. ________. Mechanism of excitation in the forbidden lines of oxygen and nitrogen in the spectra of the aurora and the night sky. (Nature - London - p. 143, 639 - 1939).
22. ________. Processus spécial d'excitation des raies rouges de OI dans le spectre de l'aurore. (Congrès des A.F.A.S. - Liège, 1939 - Comptes-rendus, p. 23 - 1941).

23. M. NICOLET: Sur la présence de l'azote à l'état atomique dans la haute atmosphère. (Congrès des A.F.A.S. - Liège 1939 - "La Météorologie" Paris).
24. _________. L'atome d'azote dans la haute atmosphère. (Bull. de la soc. roy. des Sc. de Liège, p. 11, 97 - 1942).
25. _________. Nouveaux aspects du problème de l'interprétation des radiations de l'aurore. (Conference on the "Emission spectra of the night sky and aurorae", London, July 1947).
26. _________. Le spectre des éclairs. (I.R.M. Misc. fasc. X - 1942).

APPENDIX

NOTE ON GEOMAGNETIC WORK IN THE BELGIAN CONGO

By P. HERRINCK

1. The Elisabethville Magnetic Observatory--A magnetic observatory was installed in Elisabethville for the polar year 1932-33 by Dr. Molle under the patronage of Liège University. Through lack of skilled personnel, observations were discontinued in 1934. At the request of Prof. Dehalu the observatory was taken over by the Comité Special du Katanga and placed under the direction of Mr. Heinrichs, who resurrected and abandoned instruments. Observations were resumed in 1937. Since then the observatory has been in continuous operation. In 1946 the observatory was taken over by the government of the Belgian Congo, Division of Meteorology, with M. Herrinck in charge until M. Heinrichs' return in June 1948.

A description of the observatory buildings and site has been made by Dr. Molle in the publications of the "Institut Royal Colonial Belge"

The instruments used for variometers are: one set of la Cour's standard types (1 hr = 15 mm) having the following scale values: 6.2 γ/mm for H, 0.'9 '/mm for D, 5.9 γ/mm for Z.

For absolute measurements a medium Chasselon magnetometer and a Weber earth inductor were used since 1932. In 1945 the Carnegie Institution of Washington lent CIW 17 magnetometer inductor to the observatory, where it was fully used. In 1946 the instrument was transferred to the Manhay Observatory in Belgium where it was used for two years. The instrument is now back in Elisabethville.

CIW 17 was standardized in Washington in 1921 (?) and comparisons were made in Hermanus. The Chasselon magnetometer and the Weber inductor were also compared with the Hermanus instruments (1945). The differences obtained between CIW standards and Chasselon-Weber values were very small.

Results have been published for the polar year by Dr. Koenigsfeld and for the period 1937-1945 by Mr. Heinrichs in the publications of the "Institut Royal Colonial Belge".

The precision in the measurements of H and Z is not up to international requirements because of the poor condition of the instruments and the unsatisfactory site.

2. Field work--Very little systematic field work for geological purposes has been done by private companies. Prof. de Magnée experimented with vertical intensity traverse on copper ore deposits and Kimberlite pipes in conjunction with electrical measurements. The electrical tests have given the most satisfactory results. The geodetic mission of the Comité Special du Katanga has, wherever a triangulation point was established, determined the compass declination. Unfortunately, very little of this data has yet been made available.

3. Secular variation stations--The earliest measurements of declination were made along the Congo River in 1890 by Delporte and Gillis, and in the Katanga in 1900 by Lemaire. This was followed by Prof. Dehalu's work in the north-east involving determinations of H, D, and I.

Secular variation stations were also established by CIW in 1914, 1917, and 1921, respectively.

From 1933 to 1937, Dr. Hermans covered all the east of the Congo with 500 secular variation stations. Most of Dr. Hermans' big work has been published by the "Institut Royal Colonial Belge".

4. Projected extension of magnetic work--The need for a better knowledge of the magnetic field and its changes in Central Africa cannot be overemphasized. A project was developed by M. Herrinck at the request of M. van der Elst, Chief of the Meteorological Division. It involves (a) The creation of three observatories equipped with variometers and absolute instruments. The main one will be situated in the north-east (north of Albert Lake) between the two equators; electrical and magnetic measurements of the field will be performed there. The second one will replace the actual unsatisfactory observatory in Elisabethville. The third should be established west of Leopoldville. (b) The operation of a permanent secular variation mission, the first objective of which is the establishment of 135 secular variation stations (one per territory), re-using if possible the ones already established.

The mission will carry a Schmidt horizontal recording balance, a Schmidt H balance, and a CIW magnetometer inductor. The selection of site will be made after a magnetic prospection. Necessary steps will be taken for the magnetic service to become proprietor of the site. Measurements will be made on non-magnetic concrete pillars.

Approval of this project by the Union would be very much appreciated.

BRITISH EAST AFRICA

MAGNETIC OBSERVATIONS MADE IN BRITISH EAST AFRICA DURING THE PERIOD 1939 TO 1942

By W. A. GRINSTED

Following the receipt in August, 1938, of magnetometer-inductor No. CIW 13, on loan from the Carnegie Institution of Washington, arrangements were made for regular observations to be made of D, H, and I at the Nairobi "permanent" station at Kabete and for a series of field observations, with as many re-occupations as possible, to be undertaken in conjunction with normal inspection tours.

Regular observations were commenced at Kabete in January, 1939, and were continued until August, 1939, when the outbreak of war interrupted the series. A few further observations were made at Kabete as opportunity arose and, in addition, observations were made at 18 stations in Uganda, four in Kenya, two in Tanganyika, and one in Seychelles. Declination observations were also made at four stations in southern Tanganyika in 1942, but these were of a lower order of accuracy.

All observations made with magnetometer-inductor CIW 13 were carried out by Mr. A. Walter, O.B.E., then Director of the Meteorological Service, with the exception of observations at Kabete from April to August, 1939, made by Mr. W.A. Grinsted. The declinometer observations in southern Tanganyika were made by Mr. J. R. Clackson.

No trouble was experienced with the CIW magnetometer-inductor, only cleaning and minor routine adjustments being necessary. The instrumental corrections determined by the Carnegie Institution have been applied to the results, and are as follows: Declination, -0.'6 (west declination negative), horizontal intensity, -4 γ, inclination, -0.'6.

The instrument used in southern Tanganyika was a declinometer belonging to the Survey Department. The instrumental errors of this instrument are not known and no opportunity arose for comparing it with CIW 13. The results were considered to be correct to within 2′.

No serviceable magnetometers are at present held by the Meteorological Department, and some time is likely to elapse before observations can be resumed. In addition, the "permanent" Nairobi station which, at the time of its construction in 1932 was considered to be sited well away from development areas, is now in process of being rendered unusable owing to building in its immediate vicinity, and a new site will have to be found.

In May, 1941, the Meteorological Department issued "Preliminary results of the magnetic survey in Uganda, 1941", and the following is taken from Mr. A. Walter's report:

> During the months of February and March, 1941, magnetic observations were secured at 18 stations in Uganda, six of which were close re-occupations of previous Carnegie stations.

A full discussion of the results, embodying those secured by earlier observers, is in preparation, but as the chart for Uganda is greatly in need of revision it has been considered advisable to issue the results of the observations secured in the form of a preliminary report.

Determinations were also made at three stations in Kenya on the return journey and also at Mombasa and Dar es Salaam in September, 1940. These results are added at the end of the Uganda table as well as those made at the beginning of the year in Nairobi.

The stations occupied in Uganda are as follows:

Hoima	(Carnegie station 1909, 1934)	Jinja (Carnegie station 1934)
Butiaba	(Carnegie station 1909)	Kampala
Moyo		Masaka (Carnegie station 1909)
Arua		Mbarara
Kitgum		Kabale
Gulu		Kichwamba (Carnegie station 1934)
Lira		Fort Portal (Carnegie station 1934)
Soroti		Mubende
Tororo		Busia

All observations were made by the Director during a tour of inspection of the Second Order Meteorological stations of the British East African Meteorological Service.

It was not possible to make the itinerary coincide with that of the Morrison-Beattie itinerary of 1909, even had it been possible to locate the sites previously occupied. Many of these sites have since been built over.

The stations at which observations were made for the present survey are likely to remain permanent. In each case they have been marked by small concrete slabs with "1941" inscribed on them. A full description of each station, with a cadastral chart, will be given in the final report, which will include the results of all known observations made in the four Territories at present covered by the Meteorological Service - Kenya, Uganda, Tanganyika, and Zanzibar.

The only marked case of local disturbance in the present series is Tororo, although other irregularities are revealed in the region of Masaka. The Director of Geological Surveys, Uganda, Dr. Davies, has promised to indicate, for inclusion in the final report, other localities where local disturbance may be expected from the nature of the geological structure. A preliminary chart of the isogonal lines over Uganda is attached.

Latitudes have been taken from the cadastral charts. Longitudes were determined by comparison of the chronometers against the Greenwich wireless time signals. These values were compared with the cadastral values, the results of which will be discussed in the final report.

Times are given in hours and decimals of an hour of local mean time. There is a marked diurnal variation in both declination and horizontal intensity, but no corrections have been applied to these results to reduce to a fixed period of the day.

Of the stations not in Uganda, the following were re-occupations: Equator, Kisumu, Nairobi, Arusha, Mombasa, and Dar es Salaam.

There follow, as appendices, three tables and three diagrams. Table A gives the results of observations made at the Nairobi "permanent" station, Table B gives the observations made at other stations in East Africa, and Table C gives the results of observations made to determine the diurnal variation of D and H, stations being listed in order of increasing southerly latitude. The first two diagrams are the observations of Table C, and the third diagram is a chart of D over East Africa for the epoch 1942.5 as derived from all available data at that time.

Table A--Magnetic observations made at Kabete magnetic station, Nairobi, 1939-1942

(Kabete: 1° 16'.0 S; 36° 48'.0 E)

Instrument: CIW 13

Date	Declination		Inclination		Horizontal force	
1939	LMT h	Value W	LMT h	Value S	LMT h	Value γ
Jan. 16	15.2	2° 41'.9	15.9	26° 35'.7	16.4	30782
24	15.3	40.4	.....	.....	16.0	30818
Feb. 9	15.0	40.8	.....	.....	.....	....
16	14.8	41.0	16.3	33.3	15.2	30808
23	14.6	39.6	16.2	32.8	15.1	30821
Mar. 1	14.9	43.3	16.5	33.3	15.4	30768
11	9.4	44.9	11.0	31.7	9.9	30812
16	14.6	42.6	16.0	34.0	15.6	30751
24	14.5	40.6	15.9	33.8	15.2	30781
Apr. 1	8.4	46.3	9.8	35.2	8.8	30770
7	10.0	48.8	10.9	30.5	10.3	30882
15	8.3	47.3	9.2	32.2	8.6	30786
22	8.1	45.2	9.0	32.8	8.5	30762
29	8.8	46.9	9.8	34.0	9.2	30768
May 6	8.5	44.9	9.5	27.7	8.8	30833
12	.....	.....	15.2	31.7	14.8	30790
27	9.1	43.5	10.1	31.5	9.6	30785
June 5	8.8	43.4	9.7	30.7	9.1	30782
12	9.3	40.4	.....	.....	.....	....
21	9.2	44.4	10.1	32.5	9.5	30818
28	8.2	42.9	9.0	31.0	8.5	30816
July 5	8.6	40.3	9.3	35.1	8.8	30723
12	8.1	44.3	8.9	32.6	8.4	30805
19	8.2	41.0	8.9	32.3	8.5	30793
30	9.1	45.1	9.8	32.4	9.3	30798
Aug. 16	8.2	45.3	9.0	31.8	8.8	30748
23	9.2	40.6	9.9	36.1	9.1	30712

Table A--Magnetic observations made at Kabete magnetic station, Nairobi, 1939-1942--concluded

Date	Declination		Inclination		Horizontal force	
	LMT h	Value W	LMT h	Value S	LMT h	Value γ
1940						
Jan. 25	11.2	2° 41!4	.....	.....	.....	....
Feb.16	10.9	47.1	.....	.....	11.8	30841
Mar.20	10.3	40.8	12.2	26° 33!2	10.8	30821
28	10.8	41.9	12.7	32.8	11.3	30826
28	12.2	39.1	.....	.....	11.9	30819
Apr. 4	11.3	39.6	.....	.....	11.7	30764
Oct. 2	9.3	41.6	11.8	32.9	9.9	30817
2	11.1	42.3	.....	.....	10.7	30823
16	8.6	43.6	.....	.....	9.0	30808
Nov. 6	9.0	41.7	10.5	32.0	9.5	30804
20	14.5	41.0	15.8	29.9	14.9	30802
Dec. 4	14.7	38.6	15.8	35.2	15.0	30787
18	10.2	40.8	11.6	33.1	10.5	30839
1941						
Jan. 1	14.9	40.9	16.2	33.6	15.3	30803
Oct. 2	10.1	41.3	.....	.....	10.5	30814
2	.....	.....	.....	.....	11.2	30840
24	10.0	39.4	11.1	33.0	10.3	30815
1942						
Mar.11	9.0	42.0	10.3	33.4	9.4	30812
11	9.9	43.1	.....	.....	.....	....
25	9.8	39.6	11.5	30.3	10.1	30854
25	10.7	38.4	.....	.....	.....	....
Aug.10	16.4	39.9	.....	.....	.....	....
11	15.1	38.4	.....	.....	.....	....
11	17.1	39.7	.....	.....	.....	....

Table B--Magnetic observations made at various field stations in British East Africa, 1939-1942

Instrument CIW 13, unless otherwise specified

Station	Lat.	Long.	Date	Declination		Inclination		Horizontal force	
	N	E		LMT h	Value W	LMT h	Value S	LMT h	Value γ
Moyo	3°39.'2	31°42.'9	2/11/41	15.0	2°52.'7	.....	°.....'	15.4	32936
			2/11/41	16.1	2 53.3	.....	......	.....	....
			2/12/41	6.7	2 52.9	9.7	15 39.4	7.1	32926
			2/12/41	.....	......	.....	......	8.8	32975
Kitgum	3 17.5	32 51.2	2/15/41	10.7	2 39.5	12.3	16 25.1	10.5	32901
			2/15/41	12.0	2 37.0	.....	......	11.8	32902
Arua	3 1.3	30 54.9	2/12/41	18.1	3 11.4	.....	......	.....	....
			2/13/41	7.5	3 14.0	10.7	17 11.4	7.7	32649
			2/13/41	9.2	3 14.3	.....	......	8.7	32658
Gulu	2 46.8	32 16.5	2/14/41	15.4	2 54.1	.....	......	16.0	32562
			2/14/41	15.6	2 54.4	.....	......	17.7	32582
			2/14/41	17.4	2 56.3	.....	......	.....	....
			2/16/41	10.1	2 57.1	11.1	17 37.1	10.4	32638
Lira	2 14.8	32 54.8	2/17/41	8.3	2 49.9	10.6	18 43.3	8.7	32389
			2/17/41	10.0	2 49.3	.....	......	9.5	32421
Butiaba	1 49.3	31 19.3	2/ 9/41	9.4	3 29.9	12.4	20 4.8	9.8	32094
			2/ 9/41	10.8	3 29.0	.....	......	10.5	32115
			2/ 9/41	11.3	3 29.6	.....	......	10.7	32119
			2/ 9/41	.....	......	.....	......	11.7	32160
Soroti	1 43.3	33 37.6	2/18/41	8.5	2 58.5	11.2	20 12.4	9.2	32233
			2/18/41	10.5	2 58.2	.....	......	9.9	32245
			2/18/41	10.7	2 58.0	.....	......	.....	....
Hoima	1 25.6	31 21.3	2/ 7/41	15.2	3 25.3	.....	......	16.3	31844
			2/ 7/41	.....	......	.....	......	17.0	31817
			2/ 8/41	6.8	3 25.8	12.8	21 0.2	10.6	31872
			2/ 8/41	10.1	3 24.7	.....	......	11.1	31869
			2/ 8/41	11.5	3 24.9	.....	......	12.0	31859
Kitale	1 0.2	35 0.0	3/13/41	9.2	2 41.2	11.0	21 35.5	9.1	32018
			3/13/41	10.4	2 39.4	.....	......	10.2	32011
Tororo	0 41.2	34 9.6	2/19/41	10.6	3 46.6	17.4	21 55.8	11.1	32056
			2/19/41	12.0	3 45.3	.....	......	12.1	32054
			2/19/41	14.5	3 44.1	.....	......	15.7	32020
			2/19/41	16.6	3 44.7	.....	......	16.0	32024
Fort Portal	0 40.0	30 17.0	3/ 4/41	9.8	3 53.3	12.2	22 48.7	10.2	31613
			3/ 4/41	11.4	3 51.1	.....	......	11.1	31610
			3/ 4/41	15.3	3 45.4	.....	......	.....	....

Table B--Magnetic observations made at various field stations in British East Africa, 1939-1942--continued

Station	Lat.	Long.	Date	Declination		Inclination		Horizontal force	
				LMT	Value	LMT	Value	LMT	Value
	N	E		h	W	h	S	h	γ
Mubende	0°34.'3	31°23.'3	3/ 5/41	13.7	3°42.'1	15.8	22°28.'5	14.3	31296
			3/ 5/41	16.6	3 42.7	.....	......	.....	....
Busia	0 26.0	34 03.2	3/10/41	17.2	2 57.8	.....	......	17.6	31568
			3/11/41	7.7	3 0.2	10.7	23 1.1	8.0	31593
			3/11/41	9.3	3 2.0	.....	......	8.5	31666
Jinja	0 25.2	33 12.0	2/25/41	10.0	3 27.5	15.4	23 5.4	10.6	31762
			2/25/41	11.3	3 25.0	.....	......	14.7	31676
			2/25/41	14.3	3 20.8	.....	......	.....	....
			8/21/41	17.0	3 23.0	.....	......	.....	....
			8/22/41	8.6	3 20.8	10.1	23 1.6	10.4	31761
			8/22/41	9.9	3 26.0	.....	......	11.1	31759
			8/22/41	11.5	3 24.0	.....	......	.....	....
			8/23/41	9.4	3 24.4	.....	......	.....	....
Kampala	0 20.0	32 36.0	4/14/40	11.0	3 28.4	13.2	23 11.6	11.5	31427
			4/14/40	12.5	3 27.7	.....	......	12.0	31389
			4/15/40	9.2	3 29.3	11.3	23 10.1	9.6	31412
			4/15/40	10.4	3 29.5	15.7	23 16.8	10.0	31409
			4/15/40	14.1	3 28.7	.....	......	14.4	31369
			4/15/40	15.1	3 28.5	.....	......	14.8	31374
			4/17/40	6.3	3 26.8	.....	......	.....	....
			2/ 4/41	9.0	3 32.0	10.6	23 13.4	9.3	31381
			2/ 4/41	10.0	3 33.0	.....	......	10.2	31373
			3/ 7/41	11.4	3 26.6	.....	......	.....	....
			3/ 8/41	.....	......	.....	......	12.4	31359
			8/24/41	10.0	3 26.0	17.4	23 13.5	10.3	31430
			8/24/41	11.2	3 28.0	.....	......	10.9	31397
	S	E							
Equator	0 0.7	35 32.5	3/14/41	8.3	2 48.4	10.3	23 40.6	9.0	31437
			3/14/41	9.9	2 46.0	.....	......	9.7	31434
Kisumu	0 5.1	34 45.1	3/12/41	8.1	2 50.3	10.1	23 47.7	8.5	31293
			3/12/41	9.6	2 49.5	.....	......	9.3	31295
Kichwamba	0 15.1	30 5.3	3/ 2/41	17.4	3 53.9	.....	......	.....	....
			3/ 3/41	8.4	3 58.2	11.0	24 24.7	8.8	30795
			3/ 3/41	9.9	3 57.6	.....	......	9.6	30828
Masaka	0 20.3	31 43.8	2/26/41	14.9	3 20.7	.....	......	16.8	30702
			2/26/41	17.3	3 22.7	.....	......	.....	....
			2/27/41	9.1	3 23.5	10.8	24 27.8	9.5	30751
			2/27/41	10.1	3 23.8	.....	......	.....	....
Mbarara	0 36.7	30 38.6	2/28/41	8.8	4 2.8	11.8	25 9.2	9.6	30864
			2/28/41	10.8	4 2.9	.....	......	10.5	30870

Table B--Magnetic observations made at various field stations in British East Africa, 1939-1942--concluded

Station	Lat.	Long.	Date	Declination		Inclination		Horizontal force	
	S	E		LMT h	Value W	LMT h	Value S	LMT h	Value γ
Kabale	1°15.′0	29°57.′9	3/ 1/41	9.0	4°17.′9	11.2	27°17.′6	9.7	30794
			3/ 1/41	10.7	4 12.2	.....	......	10.4	30771
Nairobi (see Table A)	1 16.0	36 48.0							
Arusha	3 22.6	36 41.3	10/18/41	15.6	3 7.1	.....	......	15.9	29573
			10/18/41	17.3	3 8.1	.....	......	16.8	29576
			10/19/41	8.9	3 9.0	10.8	30 58.4	9.2	29591
			10/19/41	.....	......	.....	......	10.0	29606
Mombasa	4 3.2	39 40.8	9/10/40	8.8	2 56.5	15.2	31 46.5	10.1	29528
			9/10/40	11.1	2 58.3	.....	......	10.7	29518
			9/10/40	15.9	2 54.2	.....	......	16.3	29512
			9/10/40	17.1	2 54.5	.....	......	16.7	29502
			9/12/40	10.3	2 57.9	9.7	31 34.7	10.6	29567
			9/12/40	.....	......	16.4	31 35.3	.....	....
Seychelles (Port Victoria)	4 37.6	55 27.2	1/20/42	10.7	4 2.9	.....	......	11.1	30745
			1/20/42	12.9	3 59.9	.....	......	12.7	30738
			1/21/42	14.9	3 56.9	16.2	30 19.3	15.1	30794
Dar es Salaam	6 48.7	39 18.0	9/21/40	15.4	3 37.9	.....	......	15.9	27635
			9/21/40	.....	......	.....	......	16.4	27626
			9/22/40	8.5	3 40.5	16.9	37 21.5	10.7	27707
			9/22/40	10.2	3 41.7	.....	......	11.2	27714
			9/22/40	13.5	3 40.2	.....	......	13.9	27695
			9/22/40	16.1	3 39.0	.....	......	14.3	27685
			9/22/40	.....	......	.....	......	14.9	27683
			9/23/40	9.6	3 44.6	8.8	37 17.7	10.3	27715
			9/23/40	11.5	3 41.8	.....	......	11.1	27710
Chunya*	8 32.0	33 25.0	9/26/42	17.5	6 1.0	.....	......	.....	....
			9/26/42	17.8	6 1.0	.....	......	.....	....
			9/27/42	9.2	6 1.0	.....	......	.....	....
			9/27/42	9.7	6 2.0	.....	......	.....	....
Lindi*	10 0.0	39 42.0	9/14/42	15.9	4 48.0	.....	......	.....	....
			9/14/42	16.4	4 47.0	.....	......	.....	....
			9/15/42	8.9	4 48.0	.....	......	.....	....
			9/15/42	9.2	4 49.0	.....	......	.....	....
			9/15/42	9.9	4 51.0	.....	......	.....	....
Songea*	10 41.0	35 40.0	9/20/42	15.7	5 34.0	.....	......	.....	....
			9/20/42	15.9	5 35.0	.....	......	.....	....
Newala*	10 57.0	39 18.0	9/16/42	16.4	5 21.0	.....	......	.....	....
			9/17/42	10.6	5 30.0	.....	......	.....	....
			9/17/42	11.1	5 31.0	.....	......	.....	....

* Observations with Tanganyika survey declinometer. Instrumental error not known, but results stated to be correct to ± 2′

Table C--Diurnal variation observations of declination and horizontal force taken at four stations in East Africa during 1940-42

Station	Lat.	Long.	Date	Declination		Horizontal force	
	S	E		LMT h	Value W	LMT h	Value γ
Kampala	0°20′.0	32°36′.0	4/17/40	6.3	3°26′.8	6.5	31301
				6.7	26.8	8.2	31438
				6.9	27.6	9.8	31411
				7.4	28.0	11.8	31408
				8.0	29.3	12.7	31371
				8.4	29.1	16.4	31341
				9.4	29.2	17.7	31325
				10.4	28.8		
				11.4	28.9		
				12.4	29.0		
				13.4	28.8		
				14.4	28.7		
				15.4	27.9		
				16.2	27.4		
				16.4	27.4		
				17.4	28.0		
				17.8	28.5		
			3/7/41	5.8	27.7		
				5.9	27.8		
				6.7	27.3		
				7.0	27.6		
				8.7	29.1		
				8.8	29.5		
				8.9	29.0		
				9.2	29.0		
				9.4	28.7		
				9.7	28.5		
				9.9	28.7		
				10.2	28.5		
				10.4	28.0		
				10.9	27.1		
				11.2	26.9		
				11.4	26.6		
				12.3	26.5		
				12.4	26.4		
				12.7	26.4		
				12.9	26.4		
				13.2	25.7		
				14.1	26.6		
				15.4	26.2		
				15.6	26.1		
				15.7	25.7		
				15.9	26.0		
				16.2	26.4		
				16.4	26.4		
				16.7	27.0		

Table C--Diurnal variation observations of declination and horizontal force taken at four stations in East Africa during 1940-42--continued

Station	Lat.	Long.	Date	Declination		Horizontal force	
	S	E		LMT h	Value W	LMT h	Value γ
Kampala (concluded)	0° 20′.0	32° 36′.0	3/7/41	16.8	3° 26′.9		
				17.2	26.9		
				17.3	27.0		
				17.5	27.3		
				17.7	27.2		
				17.8	27.3		
				17.9	27.1		
				18.7	26.4		
				20.4	26.8		
				21.4	27.0		
				22.0	26.6		
			3/8/41			5.9	31279
						6.9	31319
						10.6	31419
						10.7	31429
						10.8	31330
						12.4	31359
						13.9	31370
						15.6	31254
						17.0	31332
						17.5	31374
						17.9	31345
Mombasa	4 3.2	39 40.8	9/11/40	7.7	2 54.7	7.6	29500
				8.0	55.0	8.7	29495
				8.3	55.7	9.5	29549
				8.6	55.8	10.6	29568
				8.7	55.7	11.5	29549
				9.0	56.3	14.1	29557
				9.3	56.3	15.1	29525
				9.5	56.6	16.0	29519
				9.7	56.6		
				10.0	56.6		
				10.3	56.6		
				10.5	55.8		
				10.7	55.8		
				11.0	55.7		
				11.3	55.6		
				11.5	55.4		
				11.7	54.9		
				14.0	52.6		
				14.3	52.2		
				14.5	51.9		
				14.7	52.1		
				15.0	51.8		
				15.3	52.1		

Table C--Diurnal variation observations of declination and horizontal force taken at four stations in East Africa during 1940-42--concluded

Station	Lat.	Long.	Date	Declination		Horizontal force	
	S	E		LMT h	Value W	LMT h	Value γ
Mombasa (concluded)	4° 3′.2	39° 40′.8	9/11/40	15.5	2° 52′.1		
				15.7	52.3		
				16.1	52.6		
Seychelles	4 37.6	55 27.2	1/22/42	6.6	4 1.6	7.8	30601
				6.9	1.7	8.8	30788
				7.5	2.6	12.1	30844
				7.9	2.2	14.6	30816
				8.5	2.2	17.8	30734
				8.9	2.4	18.0	30746
				9.5	2.0	22.1	30710
				9.9	2.8		
				10.5	3.0		
				10.9	3.1		
				11.1	3.2		
				11.5	1.2		
				11.9	0.4		
				12.2	0.4		
				12.5	3 59.0		
				12.9	58.3		
				13.5	57.8		
				13.9	57.7		
				14.5	57.5		
				14.9	57.4		
				15.5	56.8		
				15.9	57.5		
				16.5	57.5		
				16.9	57.5		
				17.5	57.5		
				17.9	58.4		
				18.9	58.1		
				22.1	59.3		
Dar es Salaam	6 48.7	39 18.0	9/22/40	8.5	40.5	10.7	27707
				10.7	41.7	11.2	27714
				13.5	40.2	13.9	27695
				14.6	38.9	14.3	27685
				15.0	38.9	14.9	27683
				15.3	38.6		
				15.5	38.9		
				15.8	38.6		
				16.0	38.9		
				16.1	39.0		
				16.2	39.0		

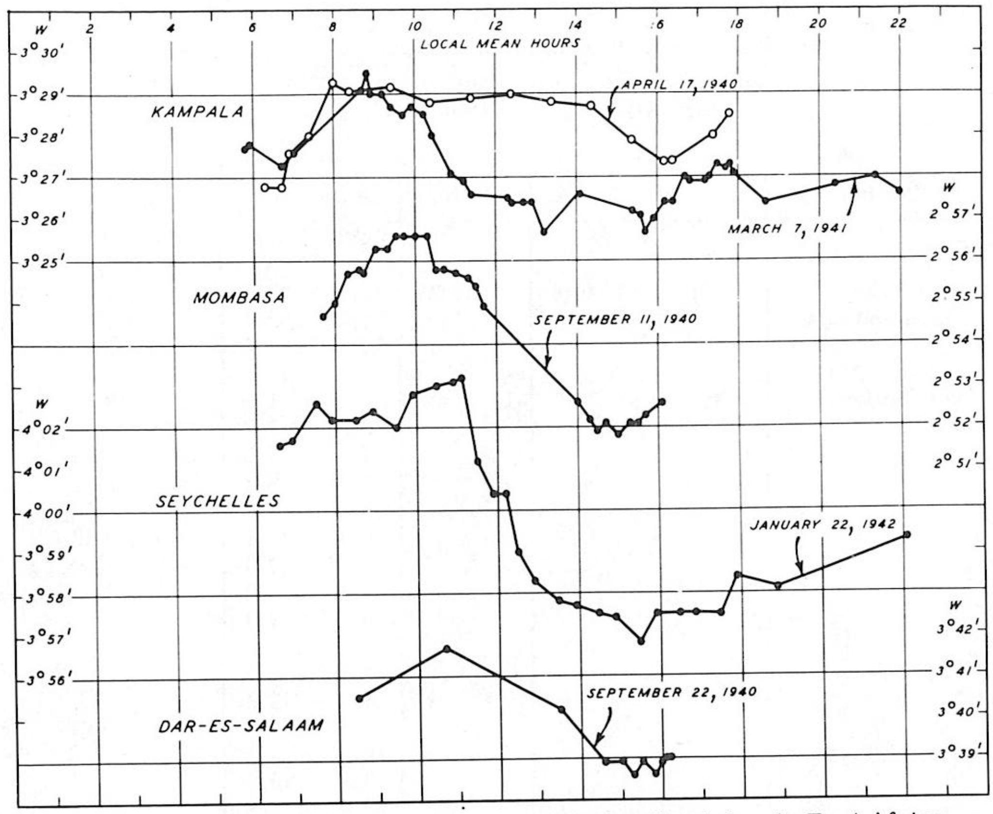


Fig. 1--Diurnal variation observations of declination taken in East Africa

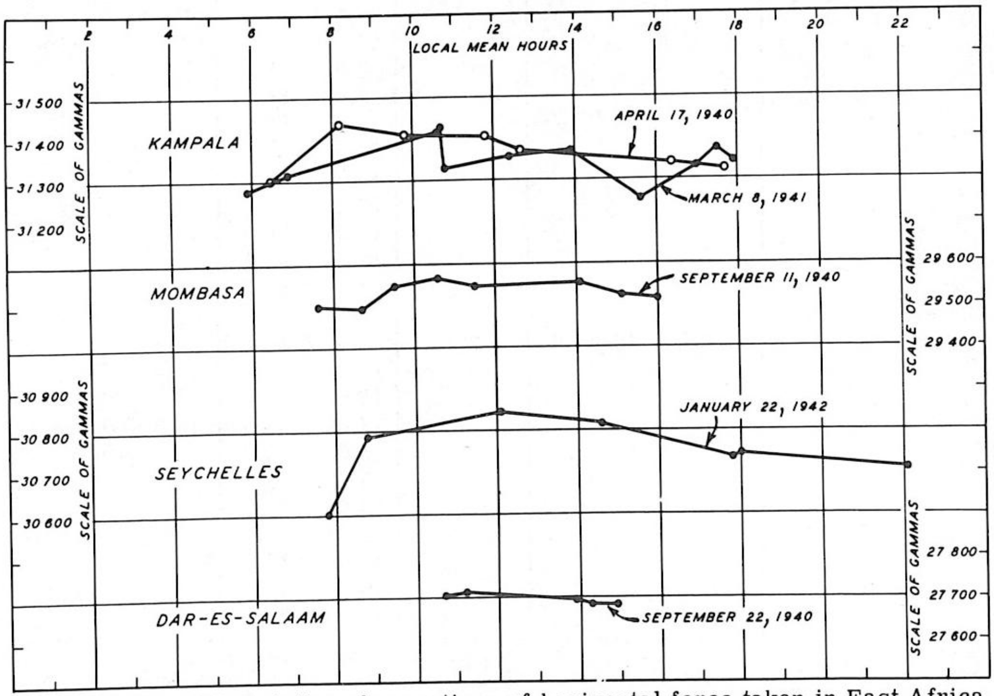


Fig. 2--Diurnal variation observations of horizontal force taken in East Africa

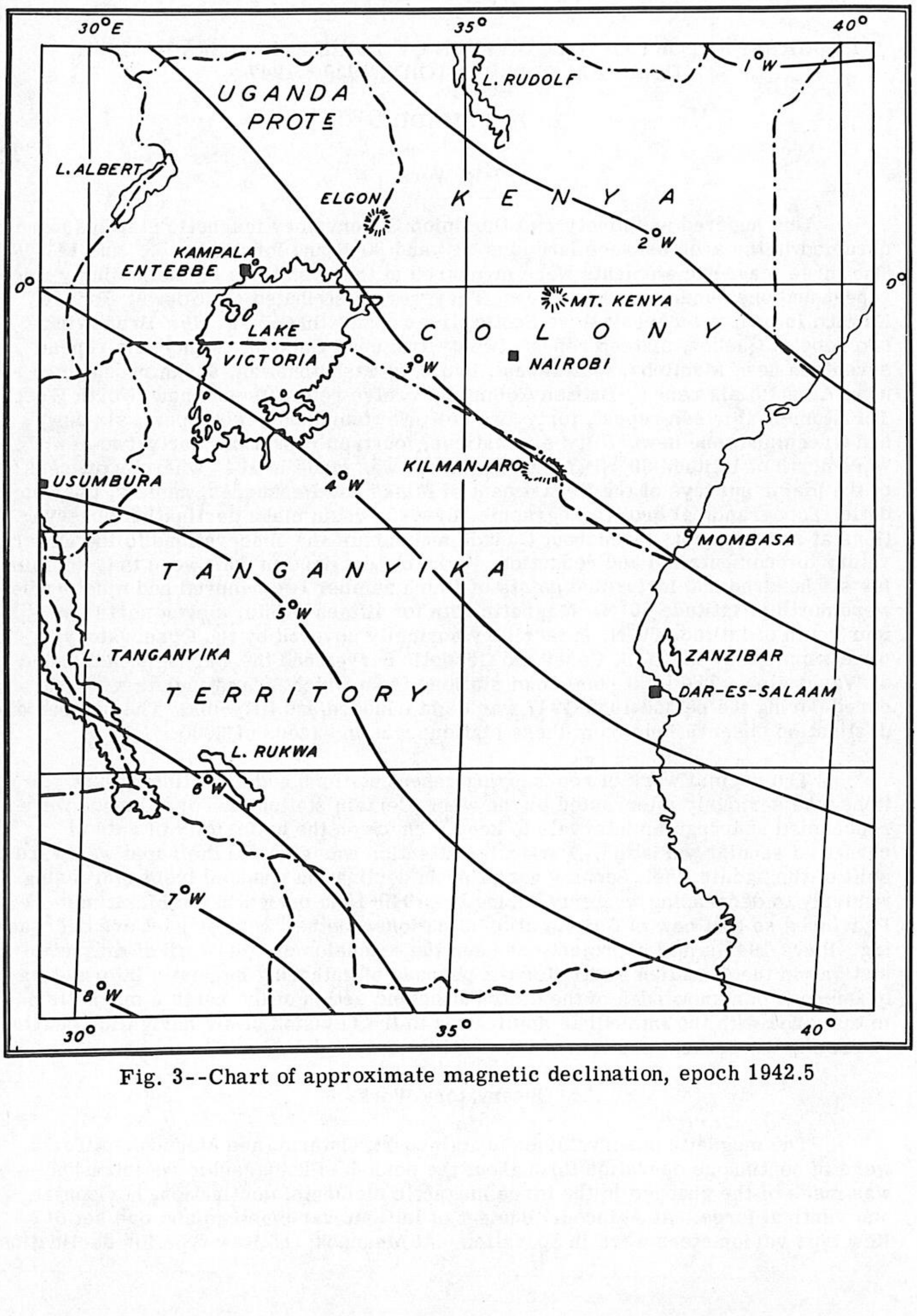


Fig. 3--Chart of approximate magnetic declination, epoch 1942.5

CANADA

PROGRESS REPORT OF THE DIVISION OF TERRESTRIAL MAGNETISM, DOMINION OBSERVATORY, 1939 - 1947

By R. G. MADILL

Field Work

One hundred and ninety-two Dominion Observatory magnetic stations were occupied in the area between latitudes 42′′ and 80°N and longitudes 53° and 141°W. The three magnetic elements were measured at these stations of which ninety were repeat and one hundred and two new. They were distributed as follows: Prince Edward Island, two repeat; Nova Scotia, five repeat, three new; New Brunswick, two repeat; Quebec, sixteen repeat, twenty-two new; Ontario, twenty-one repeat, seventeen new; Manitoba, four repeat, two new; Saskatchewan, seven repeat, two new; Alberta, six repeat; British Columbia, twelve repeat, seven new; North West Territories, thirteen repeat, forty-two new; Newfoundland, two repeat, six new; and Greenland, one new. Fifty-six stations, fourteen repeat and forty-two new, were north of latitude 60°N. An arrangement was made in 1943 whereby officers of the major surveys of the Department of Mines and Resources, namely, the Geodetic, Topographical and Hydrographic Surveys, would make declination observations at survey points throughout Canada and submit the observations to the Observatory for computation and reduction. Valuable declination data were thus supplied for six hundred and forty-nine points of which number two hundred and ninety-five were north of latitude 60°N. Magnetic data for fifteen points, eleven north and four south of latitude 60°N, in territory normally covered by the Observatory, were supplied by the U. S. Coast and Geodetic Survey and the Carnegie Institution of Washington. The total number of stations from which magnetic data were secured during the period 1939-1947 was eight hundred and fifty-six. The number of declination observations from these stations was in excess of 3000.

The normal work of reoccupying repeat stations and establishing new stations was seriously interrupted by the war. Certain stations across Canada were reoccupied at irregular intervals to keep a check on the uniformity of rate of change in secular variation. Particular attention was given to the rapid westward shift of the agonic line. Secular variation in declination changed from increasing westerly to decreasing westerly during the 1940-1945 period in the Maritime Provinces so that now in Canada all declinations whether west or east are decreasing. Since 1945 a major project has been the extension of a network of magnetic stations in the Canadian Arctic for the purpose of gathering magnetic information to improve our knowledge of the distribution and action of the earth's magnetism in that area with the immediate application to the revision of air navigation charts and fixing the present position of the north magnetic pole.

Observatory Work

The magnetic observatories at Agincourt, Ontario, and Meanook, Alberta, were in continuous operation throughout the period. Photographic registration was made of the changes in the three magnetic elements; declination, horizontal, and vertical force. At Agincourt one set of la Cour variometers and one set of Kew type variometers were in operation. At Meanook, the Kew type for declination and horizontal force and two sets of la Cour variometers, one of which was of low sensitivity, were employed. Certain changes were made in the equipment relative to lamp supports to ensure better records. Abstracts from magnetograms were kept fairly well up to date and the schedules of absolute observations maintained.

A temporary magnetic observatory was established at Baker Lake, Northwest Territories, in December, 1947. Eye readings for declination, horizontal and vertical force and visual auroral observations continued throughout the winter months. The eye-reading equipment will be replaced by recording instruments as soon as the proper type is available.

Instrument Design

The requirements for instruments to measure horizontal force on rapid reconnaissance surveys not requiring high precision when such instruments were not available by purchase, were met by the adaptation of theodolites for this purpose. The design was based on that of the United States Coast and Geodetic Survey whereby a theodolite with an auxiliary compass was employed in conjunction with an auxiliary magnet mounted above the instrument in such a way that it could be reversed for horizontal force readings.

An instrument development project of major importance was the design and construction of an electrical induction type magnetometer in which the detecting element was mounted on the telescope tube of a theodolite. With this instrument, measurements of declination, inclination and total force could be made with rapidity and precision. The instrument was severely tested in the environs of the north magnetic pole in the 1947 field season and performed better than expected. No difficulty was experienced in measuring the magnetic elements where the standard types of the magnetometers were useless. After the completion of field work the instrument was adapted for use with a pen and ink recorder. Records made with this instrument at Ottawa exhibited a remarkable correlation with the magnetograms from Agincourt Observatory which is distant about 200 miles (320 km) southeasterly. For continuous recording at a fixed station, current from an alternating current power supply may be used. An additional instrument for field work is partially completed and six sets of recording instruments for Arctic stations are being assembled.

Wartime Activities

The facilities of the Division of Terrestrial Magnetism were made available to the various branches of the armed services and many investigations of a restricted and specific nature were completed. Many tests of magnetic instruments used by the Armed Forces were made. Equipment was set up and supervised for use of the British Admiralty in testing compasses manufactured by commercial firms. Magnetic charts of the polar regions were constructed for use by the Air Force. Basic magnetic observations were made at naval bases in Canada and Newfoundland in relation to counter measures against magnetic mines.

General Research

Investigations of a research nature were halted due to the lack of opportunity when the emergencies of the time favored practical applications rather than theoretical studies. However, some advance was made in the analyses of daily variation effects in high magnetic latitudes. Also, satisfactory progress was made in finding out the distance from a fixed observatory at which daily variations and disturbances in vertical force from observatory magnetograms could be applied directly to observations made on magnetic surveys in mining areas. Progress was made in an analysis of the earth's magnetic field in the Canadian Arctic to enable the position and movement of the north magnetic pole to be definitely established.

Publications

No major publications have been issued due to their suspension during the war years. Conditions are now changed and several magnetic observatory publications now in manuscript form will be forthcoming in the near future.

Staff Changes

C. A. French retired from the Observatory in 1940 and W. E. W. Jackson in 1945. In 1939 the staff numbered six. Since then there have been four retirements and eight appointments so that the staff now numbers ten. Usually three university graduates or undergraduates have been employed during the summer seasons since 1944.

PROGRESS REPORT ON ATMOSPHERIC IONIZATION IN CANADA, 1939 - 1948

By FRANK T. DAVIES

Ionospheric Observatories

With the exception of the publication in 1940 by the Canadian Meteorological Service, of the Report on Canadian Polar Year Expeditions of 1932-33, little was done in atmospheric ionization until 1942 when an ionospheric observatory was established near Ottawa by Royal Canadian Navy with the assistance of the National Research Council.

Perhaps the greatest single contribution to knowledge of atmospheric ionization in Canada resulted from the establishment between 1942 and 1946 of six ionospheric observatories, operated by different departments under the sponsorship of the Canadian Radio Wave Propagation Committee. The work is directed and the observations utilized by the Radio Propagation Laboratory of Defence Research Board. The sites of these observatories, dates of commencement of operation, and operating agencies are as follows:

Jan. 1942, Royal Canadian Navy Station at Ottawa, Ontario. 45°.5 N 75°.8 W.
Aug. 1943, Royal Canadian Navy Station at Churchill, Manitoba. 58°.8 N 94°.2 W.
Aug. 1943, Department of Transport Station at Clyde, Baffin Island. 70°.5 N 68°.6 W. [This station was established and operated until 1945 by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.]
May 1945, Department of Transport Station at St. John's, Newfoundland. 47°.6 N 52°.7 W.

June 1945, Canadian Army Station at Prince Rupert, British Columbia. 54°3 N 130°3 W.

June 1946, Royal Canadian Air Force Station at Portage la Prairie, Manitoba. 49°9 N 98°3 W.

Summaries of hourly observations of the virtual heights and critical frequencies of ionospheric layers have been published in the monthly F-series of the Central Radio Propagation Laboratory at Washington, and given international circulation.

These data, as well as measurements of sporadic ionization, aurora, and signal strengths of sky wave transmissions, have been analyzed and the results utilized in radio propagation problems. Ionospheric measurements in the auroral zone have been particularly interesting in relation to magnetic disturbance and aurora. Ionospheric measurements and visual auroral observations have been particularly useful at Churchill and Ottawa because the observations have continued through the minimum and maximum of the present sunspot cycle and because Churchill is at the center of the auroral zone and Ottawa near the southern edge of the effective auroral zone. Some of the results are described in two papers submitted to this Assembly.

Some unexpected variations were found in the magnetic field at 100 to 300 kilometers height at high latitudes, the field being computed from ionospheric data. Investigation of this is proceeding at Radio Propagation Laboratory.

Sporadic ionization of the E-region has been shown to be a complex phenomenon very dependent in diurnal and seasonal variation and in intensity, on the latitude in the auroral zone.

Qualitative measurements of attenuation of radio signals and hence the intensity of ionization in the D-level of the ionosphere, also show marked changes in different latitudes in the auroral zone.

In addition to the fixed observatories a mobile observatory was used for ionospheric measurements by the National Research Council during the summers of 1945 and 1946. It was not possible to operate in winter but the results of relatively short series of observations in summer have been interesting.

Observations at Victoria Beach, Manitoba, showed changes in layer densities and heights in the totality belt of the solar eclipse of July 9, 1945. Automatic ionospheric equipment recorded ionospheric sweeps at five minute intervals for an eight hour period which included the eclipse. The eclipse observations were compared with observations at 15 minute intervals during the remainder of the month. The time delays in ionization minima compared to time of totality in E-region and the computed recombination coefficients were as follows:

Region	Delay (Minutes)	α
E	5.5 ± 2	$2.0 \times 10^{-8} \pm 10$ per cent
F_1	4.5 ± 2	$1.0 \times 10^{-8} \pm 10$ per cent
F_2	7 ± 4	0.1 to 0.2×10^{-8}

During the summer of 1946 ionospheric measurements in Manitoba at Portage, Swan River, The Pas, Gillam (with the mobile observatory), and at the

Churchill station, indicated that maximum D-region ionization occurred some three degrees of latitude south of Churchill. Only summer observations were made and at the time these were interpreted as indicating that D-region ionization reached a maximum to the south of the maximum of visual aurora.

Later analyses of ionospheric, auroral and transmission data by Radio Propagation Laboratory determined the seasonal variation of the center of the auroral zone. It is furthest south in summer and furthest north in winter. Thus the attenuation measurements of the summer of 1946 are consistent with the assumption that D-region ionization is of highest intensity at the maximum of auroral frequency. This is not yet proved to be the case but it appears possible. Radio Propagation Laboratory will begin operation of a mobile ionospheric-magnetic-auroral observatory in the auroral zone in summer 1948 and will continue operation throughout the year. It is hoped that the observations will show the diurnal, seasonal and latitude relations between these interrelated geophysical phenomena.

Section on Atmospheric Ionization

This section, formed in 1947 by the National Committee on Geodesy and Geophysics, includes members from the universities, Dominion Observatory, National Research Council Radio and Physics Divisions, and from the Radio Propagation Laboratory of Defence Research Board. During the past year research projects on aurora and atmospheric electricity have been sponsored by the section.

An auroral luminosity meter has been constructed and used at Saskatoon, the site being within the effective auroral zone. Theoretical studies on atomic emission in the upper atmosphere are proceeding with two parallel experimental investigations. One is the spectroscopic examination of discharges in atmospheric gases and the other includes the development and use of a spectroscope of high light-gathering power for study of auroral spectra, particularly atomic emission. Two papers on progress in auroral studies are submitted to this Assembly on the work done by the Physics Department of the University of Saskatchewan.

The large amount of auroral data of the Canadian Polar Year Expeditions of 1932-33, only part of which has yet been studied, is to be analyzed completely. These data include parallactic and single station photographs and visual observations.

Visual auroral observations made at several sites in North West Canada are being analyzed by the Dominion Observatory.

Studies of cosmic ray ionization at high altitudes using sensitized emulsions, have been commenced by le departement de Physique de l'Université de Montreal and by the Physics Division of National Research Council. This work is to be extended considerably.

A very interesting series of simultaneous measurements of meteors by photographic and radar techniques is being conducted by the Dominion Observatory and Radio Division of the National Research Council at Ottawa. A paper on these experiments is submitted to this Assembly.

Electrostatic charges produced by breaking and melting snow and ice crystals are being investigated at the Physics Department of the University of Saskatchewan. Experiments conducted indoors with artificial snow storms have shown quite different results from those made outdoors in blizzards. A Lindemann electrometer with microscope of medium magnifying power was used for the measurements. It was found that erratic variations in electrometer deflections were caused by small thermally-induced electromotive forces developed under the low temperature conditions of the experiments. A Bendorff electrometer is in use for recording changes in the atmospheric potential-gradient during blizzards, and a small portable Faraday chamber for measuring charges on snow samples. Observed charges on falling snow particles have been much smaller than those previously reported, and charges of different sign tend to predominate in particular storms.

Other Experiments of Interest in Geophysics

Several experiments of interest in geophysics but related more closely to meteorology and radio science have been conducted in Canada since 1944. Among these are:

(a) Tropospheric effects on microwave propagation determined by the Suffield, Alberta, experiments of Radio Division of the National Research Council, the Meteorological Service, and the Department of National Defence.

(b) Detection and analysis of rain storms by radar, carried out by the Canadian Army Operational Research Group and by the Radio Propagation Laboratory of Defence Research Board. Some of these results are described in a paper submitted to this Assembly.

Many of the publications of results in ionospheric, radio propagation, tropospheric, and radio-meteorological experiments, are unfortunately out of print. These results are gradually being incorporated in publications more widely circulated.

Radio Propagation Laboratory
Defence Research Board, Ottawa
April, 1948

CHINA

REPORT OF THE GEOMAGNETIC WORK IN CHINA

By PARKER C. CHEN

The works of terrestrial magnetism as well as geophysics by Chinese themselves were initiated by Prof. S. L. Ting (then the Director of Institute of Physics, Academia Sinica) and carried on since 1932.

Geomagnetic Survey

The National Geological Survey of China occupied during 1940-1943, 67 stations, which were distributed in the provinces of Szechuan, Yunnan, Kweichow, and Hunan, while the Academia Sinica has sent field parties to make the following surveys in different parts of China:

1936	14 stations along the SE coast.
1937	2 stations in Chekiang province.
1939	20 stations in Kwangsi province.
1940	1 station in Kwangsi province.
1941-42	17 stations in Fukien province.
1943	3 stations in Kwangsi province.
1946	32 stations in Szechuan province.
1946-47	21 stations along the Yangtze River from Chungking down to Woosung near Shanghai.
1947	10 stations in Islands of the South Sea and ports along the SE coast.

The total number of stations occupied by the Geological Survey and The Academia Sinica, 1936-1947, amounted to 187, of which 74 were repeat stations.

During the war years the Chinese Ordnance Survey has made determinations of magnetic declination at quite a number of triangulation stations, where no azimuth observation is necessary. The work was done by the observers trained in the use of the Declinator specially designed and constructed by Academia Sinica. The regions covered were from Kweilin to Kweiyang, from Chungking to Chentu, and in Kansu province.

Geomagnetic Observatory

The Geomagnetic Observatory, which was attached to the Institute of Physics, Academia Sinica, was first established in 1932. It was composed of an absolute room with its variation house behind it, a laboratory, an office, and a dormitory. The buildings were not all finished until 1936. It was situated on a small plateau at the northern slope of Tsi-King-Shan near Nanking and its geographical coordinates were: Latitude 32° 04'.1 N; longitude 118° 48'.8 E Gr.

The whole observatory, whose observations were begun in 1933, was not functioning until 1937, but was interrupted soon afterwards by the Japanese invasion. All the important instruments were fortunately saved and moved to Kwangsi, where a new observatory was erected at Yenshan, Liafeng, 22 km south of Kweilin with its location: Latitude 25° 04'.7 N; longitude 110° 17'.3 E Gr.

In the meantime during the building of this observatory a party consisting of Chi-Chiang Chen, Chien-Chang Woo, and myself was sent to Chungan, Fukien for the observations on the occasion of the total solar eclipse on September 21, 1941. The results have proved the earth's magnetism was affected by the radiation of ultra-violet light from the sun, as the phenomena during the eclipse-time has shown the same effect that would happen during the night when that portion of the earth does face toward the sun. At the same time a temporary observatory was set up and there were magnetic data for almost four months from September to December, 1941.

The Yenshan Observatory began operations from June 1943 and the magnetic elements H, D, and Z were recorded continuously and photographically for a whole year. Then the work was stopped again because of the Japanese invasion from Hengyang in June 1944.

In 1947 the staff members of this Observatory were back again at Nanking with its equipment. It was found that the observatory at Tsi-King-Shan was completely ruined during the time of the Japanese occupation of the locality. For one reason or another an observatory could not be built in its original site, and in the latter part of the same year the temporary observatory was built in the vicinity of the Institute of Meteorology, on a small ridge in the east side of it. Its approximate coordinates are: Latitude 32° 03!2 N; longitude 118° 46!9 E Gr.

It consists of an absolute room 48 feet by 16 feet and a variation house 20 feet by 16 feet connected together. The former is made entirely of wood, while the latter was built with double stone wall to maintain a constant room temperature. The installation of instruments was started at the end of the year and then the observational work was resumed, but the recording instruments were not functioning properly until March 11, 1948.

Instruments

For the absolute measurements at the observatory, the Schuster-Smith Coil-Magnetometer and the Cambridge Large Earth-Inductor were used. The coil, wound upon a marble cylinder, was with reluctance completely destroyed in Kwangsi-Kweichow Railway during the evacuation from Kweilin.

For the field surveys a Smith Portable Magnetometer and an Askania small Earth-Inductor were used during 1936-1946. Since then the National Geological Survey has generously loaned us a complete Askania Portable Theodolite Magnetometer. At present the set of former instruments is used for the absolute measurements twice a week in this observatory.

The instruments of Academia Sinica were compared with those of Zi-Ka-Wei Observatory at Zo-Sé in March and July, 1936. On the latter occasion there was an opportunity of making a comparison with CIW-Standard, for Mr. F. C. Brown also took part in that intercomparison.

Since then no intercomparison has taken place, although recently the Academia Sinica can send observers to Zo-Sé to compare their instruments once more, but I doubt if the values obtained from their observations can still be in good agreement with the International Standard. It is rather an urgent matter that some QHM be sent to this part of the world by the Association of Terrestrial Magnetism and Electricity, IUGG. Yet, for the present, it is perhaps not the right time to make such a proposal.

For variometers, the magnetographs of la Cour's standard type in ordinary run (1 hr = 15 mm) are used. As they are working now, the scale value is 2.57 γ/mm for H, 4.13 γ/mm for Z, and 1'/mm for D. All scale values are determined once a week.

Division of Geomagnetism

As a result of reorganization in the scope of researches among institutes of the Academia Sinica, the Division of Geomagnetism was shifted from the Institute of Physics to the Institute of Meteorology, which was extended from August 1947 to include researches of geophysics in the broader sense.

This Division, through its magnetic work, furnishes data needed on charts and maps by aviators and magnetic information for various governmental organizations as well as scientific individuals interested in this subject. So far the Division has accumulated some observational data, whose working-out is under way and will be published as a memoir or special bulletin of the Institute of Meteorology, Academia Sinica.

The magnetic work planned to be done in China for the future is proposed as the following:

The number of field stations should be increased so that their distribution is more uniform in this country, the distance among them should be shortened and more repeat-stations should be occupied more frequently. Moreover, permanent observatories should be increased in number, specially an observatory in northwestern China, fully expected to be established in following the Association's resolution. But how and when this plan could be carried out remains to be seen because of the unsettled conditions prevailing everywhere, especially at present in China.

Geophysical Organizations

Institutions in China and the fields of investigation in geophysics and allied subjects sponsored by them may be briefly listed as follows:

Chinese Petroleum Corporation, National Resources Commission--Geophysical prospecting by gravitational method and electric method.
Institute of Physics, Academia Sinica--Ionosphere.
Institute of Physics, National Academy of Peiping--Gravity measurement; geophysical prospecting by electric method and magnetic method.
Institute of Meteorology, Academia Sinica--Meteorology; geomagnetism; seismology; general geophysics.
National Geological Survey of China--Seismological observation; geomagnetic survey; geophysical prospecting by gravitational method and magnetic method.
Physics Department, National Wuhan University--Ionosphere.
Radiophysics Research Institute, National Tsinhua University--Ionosphere.
Radio Wave Research Laboratory, Central Broadcasting Administration--Ionosphere.
Tsingtao Observatory--Observations in astronomy, meteorology, oceanography, and terrestrial magnetism.
Zi-Ka-Wei Observatory--Astronomy; meteorology; seismology; terrestrial magnetism.

The scientists who are actually working in geophysics and allied subjects have organized the Geophysical Society of China, so that they can cooperate more closely. The membership of the society, which was formed in August 1947, totals 41 at present. It plans to publish the Geophysical Journal twice yearly, which will appear in the near future to serve as a prompt and efficient medium for publication of research and pertinent information.

DENMARK

REPORT ON MAGNETIC WORK IN THE YEARS 1939-1947

Part I

By J. EGEDAL

The magnetic observatory at Rude Skov has, in spite of the war, functioned without interruptions during the whole period from 1939 to 1947. Records of normal speed from sensitive and insensitive variometers as well as records from a la Cour quick-run recorder are available. The orientation of the magnets of the variometers has been examined regularly (Resolution 3, Edinburgh 1936, and Resolutions 4 and 10e, Washington 1939). As some foreign magnetic observatories are using the standards of the Rude Skov Observatory, and as the constants of the different la Cour magnetic instruments, delivered abroad by the Danish Meteorological Institute, are based on these standards too, the absolute determinations have been carried out with a special deference to these matters. The determinations of the magnetic declination and inclination have been carried out with zero-corrected instruments (cfr. Trans, p. 532-534, and Resolution 4b, Washington Meeting 1939). The determinations of the horizontal force have been examined more closely in 1947 in order to state whether some alteration of the standard may have taken place since 1890 and in order to secure the standard in the future.

A modified type of the Godhavn Balance has been constructed by A. Groot Hansen and J. Egedal (Terr. Magn., 50, 241, 1945). In this instrument the magnet and the temperature compensation bilamella are placed in the same chamber, and therefore the compensation of the effect of temperature variations is more satisfactory.

The measurements at the ten secular variation stations have been continued without interruptions, measurements being made in 1940 and 1945.

Field measurements have been made in 1939 and in 1946 in order to make the magnetic survey of Denmark more complete. The distance between stations for horizontal and vertical force was about 4 km, and between stations for declination about 8 km.

The magnetic observations from the observatory at Rude Skov and from the secular variation stations have been published in Annuaire Magnétique, lère Partie: Le Danemark. The Annuaire Magnétique has been issued regularly, the observations from one year being published in the succeeding year; thus, the observations from the year 1946 will be published before the end of 1947. In the Annuaire Magnétique for the year 1940 is given a communication on the lunar daily variation of the magnetic declination at Rude Skov in the years 1930-1940.

Part II

By JOHANNES OLSEN

The magnetic observatory, Godhavn, Greenland, has been functioning without interruption during the whole period thanks to a high-appreciated help from the Carnegie Institution, Washington, during the great war. As the Danish connections with Greenland were interrupted the 9th of April 1940, Dr. la Cour asked Dr. Jno. A. Fleming for help concerning supplies of photographic material to Godhavn. Ten days after Dr. Fleming had received this letter supplies for one year were on board a ship bound for Godhavn. During the whole war and the first year succeeding the peace the Carnegie Institution continued to send the necessary supplies to Godhavn. Records for D, H, and Z of a speed of 15 mm/hour for the sensitive and the insensitive variometers and for quick-run (180 mm/hour) are available for the total period. During the whole war K. Thiesen has continued as leader of the observatory. During his vacation in Denmark 1945-46, Mr. A. Lundbak acted as chief. In the autumn 1946 Mr. Johannes Olsen, leader of the observatory 1926-33, visited Godhavn for inspection.

The old Mascart type recorder for the insensitive variometers was in the last month of 1945 exchanged by a recorder of the la Cour type. In 1945, 1946, and 1947 a QHM and a BMZ have been sent from Denmark to Greenland to assure that the results obtained at Godhavn were in accordance with the values at Rude Skov. During the whole period the orientation of the variometer magnets have been examined every year. From February 1943 the observatory has sent every Monday a radio message to the Carnegie Institution, Washington, containing the K-indices for the preceding week.

The Cosmic Ray Observatory at Godhavn, established in 1938, has been working during the whole period, the records every year being sent to the Carnegie Institution for examination.

In Copenhagen the work with the publication of the yearbook for Godhavn: Annuaire Magnétique II, le Groenland, has been continued. Following the yearbook 1932-33 the yearbooks for 1926-30 and for 1934-38 have been published; 1931 is in press (Oct. 1947).

The results of an examination of the horizontal force at Godhavn seems to indicate that a recurrence-tendency of S_D with a period of 26-7/8 days has been prevailing during the epoch 1926-40 [J. Olsen: Persistent solar rotation period of 26.875 days and solar-diurnal variation in Terrestrial Magnetism, Nature, Vol. 157, page 621, 1946].

Part III

By V. LAURSEN

Since January 1, 1947, a new permanent magnetic observatory has been functioning in Thule, North-West Greenland.

Like the magnetic observatory in Godhavn, the Thule Observatory has also been established by the Greenland Administration under the scientific supervision of the Danish Meteorological Institute, and, as far as the buildings are concerned, the two observatories are nearly identical. Also the recording equipment of the observatories is practically the same. Thus, in Thule, continuous records of the variations in D, H, and Z are obtained by means of two normal speed magnetographs and one quick-run magnetograph. All the variometers are of the la Cour type and so is the instrumental equipment for the control measurements, consisting of two BMZ and three QHM. An ordinary magnetic theodolite, belonging to the equipment of the Rude Skov Observatory, was available during the first months of operation to secure independent determinations of the declination and the horizontal force.

For practical reasons it was impossible to establish the new observatory in exactly the same locality where the temporary magnetic observatory was operated during the Polar Year 1932-33 [Observations faites à Thule. Première partie: Magnétisme terrestre. Institut Météorologique Danois. By V. Laursen, Copenhagen 1943], but control measurements have been carried out at the site of the old observatory to obtain values for the secular variation during the last 15 years.

The data from the Thule Observatory will be published by the Danish Meteorological Institute along with the corresponding results from Godhavn.

During the summer months of 1946 a special magnetic survey was carried out in southern Greenland in the vicinity of the Ivigtut settlement, where a temporary observatory had been established to provide the necessary reduction data. At most of the stations only the vertical force was determined.

Part IV

By JOHANNES OLSEN and V. LAURSEN

The manufacturing of recorders, variometers and field work instruments of the la Cour type has been taken up again after a relative stand-still during the war. New instruments are again available but owing to a great demand and some postwar difficulties in procuring the necessary material the delay of delivery is about one year.

In his last years the late Dr. la Cour devoted much time and skill to the development of a modified type of the field balance known as BM. In the new type, the BMZ [D. la Cour: The magnetometric Zero Balance, the BMZ, Comm. Magn., etc., No. 19, Copenhagen 1942], the balancing monad magnet is placed in a magnetic field, where the vertical force is zero. By this arrangement the position of equilibrium of the balancing magnet is independent of the magnetic moment and therefore of the temperature of this magnet. Further the position is independent of the local gravity, the center of gravity being placed exactly below the axis of rotation.

Instruments of this type have already been distributed to Norway, Finland, Sweden, Latvia, Holland, Belgium, France, Spain, Switzerland, and South Africa. Four instruments, used for field work in Greenland, have been controlled regularly at Rude Skov during several years and have given very satisfactory results, the capital constant of the instruments showing a fair constancy in the course of time. The table below gives the value of this constant for two epochs:

	BMZ 17	BMZ 18	BMZ 19	BMZ 20
Autumn 1941	45505γ	45020γ	45048γ	45183γ
Summer 1945	45508	45020	45057	45190

Supposing the capital constant being invariable during all four years (20 determinations at regular intervals) the standard deviation turns out to be $\pm$ 5γ for each instrument. Upon its return to Rude Skov in October 1947 of the BMZ 19, which has been in use in Greenland for more than a year, a redetermination of the constant has given the value 45065γ.

The BMZ's have been used for field work at the island Bornholm (3000 determinations of the vertical force) and in Jutland, where e.g. 100 stations in a certain region have been measured twice, namely independently by BMZ 19 and BMZ 20. The standard deviation of the differences found was $\pm 3\gamma$.

The examination of the QHM's placed at Rude Skov Observatory has been continued and some of the results have been published [Johannes Olsen: Some investigations on the constancy of the QHM Magnetometer. Comm. Magn., etc., No. 20, Copenhagen 1942].

FINLAND

REPORT OF THE FINNISH NATIONAL COMMITTEE, 1939-1947

By E. SUCKSDORFF

I. Terrestrial Magnetism

Geophysical Observatory, Sodankylä

During the Finnish Winter War 1939-1940 and practically to the end of the second World War the Observatory was able to work in a normal way and in its former extent, in spite of the fact that military operations sometimes approached disagreeably close. During the Winter War the photographic records and other archives were entrusted to the care of the Swedish Hydrographic Service (Kungliga Sjokarteverket), in Stockholm. The geomagnetic elements were recorded with normal (20 mm/h) and quick-run recorders (180 mm/h), using la Cour variometers, and recordings were made completely, with the exception of a few short intervals, until the 15th of September 1944.

In 1941 the Observatory received the new Danish magnetometers QHM 2 and BMZ 15, which were used as observation instruments for a great number of magnetic measurements. During the war a study of magnetic activity on the basis of the records at Sodankylä was completed and published.

In the middle of September 1944 the evacuation of the whole Finnish Lapland took place, and at this time also the personnel of the Observatory had to leave. The observation instruments, a recording set, the photographic records, and manuscripts could be transported away. In October 1944 the German Forces, before their retreat from Lapland, destroyed to the ground the 10 buildings of the Observatory with its instruments, the whole library, etc. This was for the Finnish geophysical research--and also for the international scientific work--naturally a very severe blow.

Immediately after the conclusion of the military operations, the Finnish Academy of Science, the owner of the Observatory, took measures to rebuild the Observatory. But on account of the extremely difficult conditions--as Lapland had been practically turned into a desert--only the most necessary buildings of the

Observatory, the variation house, the absolute house, and a small dwelling house, were completed in the end of the year 1945. A normal magnetic la Cour recorder has been running since the beginning of the year 1946, but in other respects the Observatory works as yet within very modest limits. Observer-in-charge during the years 1946-1947 was Mr. M. Seppänen, M.A., and from the beginning of the year 1948, Mr. T. Hilpelä, M.A.

The magnetic year-books are ready for the press until the year 1944, but because of the printing difficulties their publication is badly delayed. Results of the year 1939 will be printed in the near future.

Geomagnetic Field Work of the Meteorological Office, Helsinki

In the summer of 1939 magnetic observations were made at altogether 95 points on the Gulf of Bothnia in cooperation with the Swedish Hydrographic Service, on board the Swedish magnetic surveyship Kompass. Dr. Gustaf S. Ljungdahl acted as Swedish and I as Finnish observer. This extensive measuring work was not quite completed in 1939, but the outbreak of the war prevented its continuation in the following years. The results are for the present not published.

During the war Dr. J. Keränen made observations of the magnetic declination in 18 points and drew up isogonic maps for the use of the defence forces and the air traffic. After the war I carried out complete magnetic measurements, in 1945 in 6, in 1946 in 30, and in 1947 in 24 secular stations. To get an idea of the homogeneity of the geomagnetic field measurements of the vertical component were made also around each point, and at two different heights on the points themselves. From all secular stations 10 were selected which are situated undisturbed and divided fairly evenly over Finland, and which, if possible, are to be resurveyed every year. As observation instruments in these surveys the theodolite Chasselon No. 82, the QHM No. 84, 85, and 86, and the BMZ No. 25 have been used. These instruments have been compared in 1946 in Copenhagen, Lovö (Stockholm), and Abisko, and in 1947 in Sodankylä with Swedish magnetometers.

During the total solar eclipse on the 9th of July 1945 a temporary recording of the magnetic elements was established near the little town Kokkola 63° 51′ N, 23° 10′ E. There Dr. J. Keränen also made observations of the solar radiation. At the same time a magnetic quick-run recorder was in action in Tammisto, near Helsinki.

Of the other geophysical work performed in the Meteorological Office may be mentioned an investigation of electric currents in the high atmosphere, based on the magnetic records during the second Polar Year. At the present charts of the geomagnetic field in Finland for the epoch 1948.5 (by Dr. J. Keränen) are being completed. Likewise the foundation of a geomagnetic observatory in southern Finland is under consideration.

II. Earth Currents

The record of the two components of the earth currents as well as a normal quick-run recorder continued in Sodankylä--with the exception of a few intervals--until September 1944, at which time the building for the recording of the earth currents was destroyed. These recordings have not yet been reestablished. The results for the years 1935-1943 are in manuscript form ready for print.

III. Atmospheric Electricity

In Sodankylä the recording of atmospheric electric potential-gradient with the Benndorf quadrant electrometer continued until 1943, at which time the electrometer went out of order and could not, because of the war, be repaired. The recording material from the earlier years has for the most part been worked out.

During the solar eclipse of July 9, 1945, observations and records of the atmospheric-electric potential-gradient were made in Kokkola.

IV. Auroral Observations

Only visual observations have been made in Sodankylä and at the climatological stations of our country in connection with meteorological observations. A great part of photographical and older observation material was destroyed in the Observatory Sodankylä.

V. Other Geophysical Work

In Sodankylä observations and registrations of the solar radiation have been continued until 1944. In the Meteorological Office, Helsinki, observations of meteors have been collected and statistically investigated.

VI. Publications

Ergebnisse der magnetischen Beobachtungen des Observatoriums zu Sodankylä im Jahre 1936.

Ergebnisse der magnetischen Beobachtungen des Observatoriums zu Sodankylä im Jahre 1937.

Ergebnisse der magnetischen Beobachtungen des Observatoriums zu Sodankylä im Jahre 1938.

Ergebnisse der magnetischen Beobachtungen des Observatoriums zu Sodankylä im Jahre 1939 (in print).

E. SUCKSDORFF: Die erdmagnetische Aktivität in Sodankylä in den Jahren 1914-1934.

E. SUCKSDORFF: Über den Einfluss der Sonne auf die magnetischen Erscheiningen der Erde im Lichte der Ergebnisse des Observatoriums zu Sodankylä.

J. KERÄNEN: Übersicht über die Tätigkeit des Observatoriums zu Sodankylä in den Jahren 1914-1943.

E. SUCKSDORFF: Atmospheric-electric potential-gradient in Kokkola, Finland, during the Solar Eclipse of July 9, 1945.

E. SUCKSDORFF: Geophysical Observatory Sodankylä.

E. SUCKSDORFF: Diurnal Variations of Computed Electric Currents in the High Atmosphere.

E. SUCKSDORFF: On Geomagnetism and the Aurora Borealis in the Light of Recent Research (Finnish, with English summary).

J. KERÄNEN: Earth Magnetism in Finland (Geographical Handbook of Finland. In print).

Meteorological Office, Helsinki
June 1948.

FRANCE

RAPPORT DE LA SECTION DE MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES SUR LES TRAVAUX DE 1939 À 1948

Par le Secrétaire E. THELLIER

I. Magnétisme Terrestre

Mesures géomagnétiques

Appareils. A l'Institut de Physique du Globe de Paris ont été commencées des recherches sur la mesure du champ terrestre en avion; E. Selzer a étudié des magnétrons en vue de leur utilisation à la mesure des variations rapides du champ terrestre (138, 139); E. Thellier et Mme Thellier ont étudié les corrections de température et d'induction dans les mesures magnétiques (147).

A la Faculté des Sciences de Paris, L. Cagniard qui dirige l'enseignement de géophysique appliquée, de création récente, a entrepris la construction d'un gradiomètre magnétique pour la prospection.

A l'Institut Electrotechnique de Grenoble, L. Néel a construit pour E. Selzer, un multiplicateur de champ, à barres de mu-métal, permettant d'utiliser les magnétrons dans le champ terrestre sans champ auxiliaire.

A l'Observatoire du Pic du Midi, A. Dauvillier a installé un déclinomètre à la fois enregistreur, à lectures directes et avertisseur d'orages magnétiques (46).

A l'Observatoire de Tananarive, L. Cattala a entrepris la construction d'un inclinomètre à rotation à bobine tournante court-circuitée.

Observatoires. En France, l'Observatoire de Chambon-la-Forêt (θ = 48°01′ N, λ = 2°16′ E), qui a remplacé l'Observatoire du Val-Joyeux depuis 1936, a assuré un service continu, sauf une interruption pendant la 2ème quinzaine de Juin 1940 due à l'invasion allemande. Les appareils enregistreurs sont maintenant des La Cour (marche lente et marche rapide), l'appareil Mascart fonctionnant comme appareil de secours. Les appareils électriques ayant été perdus en 1940, les mesures absolues sont faites au moyen d'un théodolite (D et H) et d'un inclinomètre Cambridge. Il est vivement désiré que cette situation s'améliore et les délégués français seront intéressés par toutes les discussions relatives aux appareils étalons et à leur coordination mondiale. Les observations de Chambon-la-Forêt, dépouillées comme par le passé (valeurs horaires aux heures rondes), sont publiées dans les Annales de l'Institut de Physique du Globe de Paris. Le tome 23 de ces Annales est paru avec les observations de 1942, 1943, et 1944, et le tome 24, à l'impression, contiendra les observations de 1945 et 1946. L'Observatoire de Nantes a poursuivi régulièrement ses enregistrements qui sont dépouillés au jour le jour; les résultats qui étaient publiés jusqu'ici par valeurs trihoraires dans les Annales de l'Institut de Physique du Globe de Paris, seront données maintenant sous une forme plus résumée encore.

En Afrique du Nord, l'Institut de Météorologie et de Physique du Globe de l'Algérie a assuré, avec quelque difficulté, le fonctionnement de l'Observatoire de Tamanrasset (θ = 22°42′ N, λ = 5°31′ E) dont une partie des observations a été publiée (40, 41). En même temps ont été créés deux observatoires nouveaux: l'un à El Abiod Sidi Cheikh (θ = 32°54′ N, λ = 0°32′ E) (42) déjà entré en service, l'autre à Beni-Abbès (θ = 30°08′ N, λ = 2°11′ W) qui est en voie d'équipement.

A la Martinique, l'Observatoire dit du Morne des Cadets, rattaché maintenant à l'Institut de Physique du Globe de Paris, vient d'abandonner ses observations magnétiques continues, rendues sans intérêt par les énormes anomalies magnétiques régnant dans toute l'île y compris le voisinage immédiat de la station magnétique.

L'Office de la Recherche scientifique coloniale qui a créé un centre de formation de chercheurs scientifiques coloniaux, à Paris, (2 années d'études pour élèves licenciés ès sciences) procède à la réinstallation de l'Observatoire de Tahiti et à la création d'un observatoire important au Sénégal, à M'Bour, sur la côte, à 90 km au Sud de Dakar.

Les Observatoires privés, dirigés par les Pères de la Compagnie de Jésus, à Tananarive, Zi-Ka-Wei et Ksara ont poursuivi leurs enregistrements magnétiques. Les observations de Zi-Ka-Wei sont publiées in extenso, dans "Observations magnétiques faites à la station de Zo-Sé"; les dernières parues sont celles de 1939 et 1940. Les observations de Ksara, publiées jusqu'en 1937 dans les Annales de cet observatoire, seront résumées dans les Annales de l'Institut de Physique du Globe de Paris; les résultats de 1938 à 1947 paraîtront dans le tome 24 avec des indications sur les observations de Tananarive.

Réseaux magnétiques.

1° Réseau français de répétition. L'Institut de Physique du Globe de Paris a organisé, en collaboration avec l'Institut géographique national, un réseau de 12 stations de répétition placées en des lieux soigneusement choisis et marqués maintenant par une borne géodésique. La première série de mesures (D, H, Z) a été effectuée en 1947 (E. Selzer et E. Thellier). Les résultats ont servi déjà à réviser la carte magnétique de déclinaison en France publiée par l'Institut géographique national pour 1948.0.

2° Réseaux magnétiques généraux. Des campagnes magnétiques limitées ont été effectuées en de nombreuses régions de la France d'outre-mer et à l'étranger: par A. Lasserre et Melle Malbos en Algérie, Tunisie et dans les territoires du Sud (85, 86, 87); par J. Dubief au Sahara, en Tripolitaine, en Afrique équatoriale et en Afrique occidentale francaises (53, 54, 55, 56, 57); par G. Bidault au Maroc (12); par H. Brandstatter et J. Lagrula au Sahara, au Soudan et en Afrique équatoriale (14); par J. Larroque en A.O.F. (84); par A. Savornin à Madagascar (134, 135); par H. Besairie à Madagascar et à la Côte des Somalis (8, 9, 10); enfin, par J. Chevrier en Syrie et au Liban (32). Ces mesures magnétiques, intéressantes parce que faites généralement dans des régions peu étudiées jusqu'ici, n'ont malheureusement pas été "réduites" correctement, en général, faute d'observatoires magnétiques suffisamment proches. Des cartes magnétiques ont été publiées par certains des auteurs précédents (88, 58, 11, 87).

3° Réseaux de prospection. Des campagnes de prospection magnétique, dont les plus importantes sont surtout destinées à l'étude de problèmes de volcanologie, ont été exécutées (ou sont en cours d'exécution) en Auvergne par L. Cattala et J. Rothé (30), par C. Alexanian (1) et par A. Roche; dans les Landes et le pays basque par E. Schneider, E. Thellier et Mme O. Thellier (137); dans l'Ariège par

J. P. Destombes et R. Bollo (52); en Bretagne par E. Le Borgne. A Madagascar Ch. Poisson a poursuivi l'étude des fortes anomalies qu'on recontre dans le voisinage même de l'Observatoire (114). A la Martinique J. Jolivet a repris un réseau de détail exécuté antérieurement par G. Gouault, autour de l'Observatoire, en vue de préciser l'évolution des fortes anomalies qu'on y recontre.

En ce qui concerne l'interprétation des anomalies, V. Baranov a établi un abaque intéressant (2).

Etudes sur les variations du champ terrestre

Variations régulières. H. Labrouste et Mme Labrouste ont étudié le cycle undécennal des composantes diurne et semi-diurne de la variation diurne solaire S (78, 79), et J. Coulomb a établi une prévision générale de l'amplitude de S à partir d'une prévision du nombre de Wolf (38).

P. Rougerie a étudié la variation diurne lunaire de la déclinaison à partir des observations du Val-Joyeux (133).

Ch. Maurain a analysé les variations séculaires des 3 éléments D, I, H, à partir de la série des observations françaises (97) et P. Rougerie, utilisant les résultats de la 2ème Année polaire internationale, a étudié les variations sur le globe de la constante magnétique locale G, de Bauer, en vue surtout de juger des qualités de cette grandeur pour l'étude de la variation séculaire (131, 132).

Variations accidentelles. J. Coulomb et G. Dugast ont cherché à determiner le retard des orages magnétiques sur les "crochets" accompagnant les éruptions chromosphériques (43). Utilisant toute la série des observations françaises, Ch. Maurain et J. Coulomb ont étudié les propriétés des baies magnétiques (99, 100) et Ch. Maurain la répartition diurne et annuelle des perturbations à début brusque (95) et le sens de l'impulsion initiale dans ces perturbations (96). L. Eblé a fait des remarques sur l'agitation magnétique (64) et étudié sa variation diurne (65). Melle Roquet a défini la répartition annuelle des jours calmes (118) et étudié les pulsations géantes (119). J. Dufay et P. Flajolet, utilisant les mesures de declinaison faites à l'observatoire de Lyon, ont étudié les variations undécennale et annuelle de l'agitation magnétique (60, 61, 62). P. Bernard s'est intéressé à l'origine des perturbations magnétiques (4, 5, 6, 7) ainsi que M. Burgaud qui s'est livré à une analyse étendue des observations de Zi-Ka-Wei (20, 21, 22) et E. Thellier qui a établi l'absence de récurrence des orages à début brusque (144).

Géomagnétisme fossile et aimantation des roches

Ch. Poisson a rassemblé des données sur l'aimantation des roches de Madagascar(susceptibilité et aimantation permanente) (113). J. Coulomb a calculé l'aimantation due à des grains magnétiques disséminés dans un corps neutre (35), et Mme Bayard-Duclaux a cherché l'influence d'une altération superficielle de grains ferromagnétiques (3).

Des études sur la direction de l'aimantation de roches volcaniques en place ont été faites par G. Grenet sur diverses coulées d'Auvergne (72), E. Thellier et Mme Thellier sur des laves mexicaines (140) et sur la coulée d'andésite de Volvic (148). L'intensité du champ terrestre au 15ème siècle et à l'époque gallo-romaine a été déterminée par E. Thellier et Mme Thellier (146, 149) en utilisant la méthode proposée par eux (142). Les mêmes auteurs ont poursuivi l'étude des propriétés magnétiques des terres cuites (141, 143, 145); d'autres études sur le sesquioxyde de fer, effectuées d'une part par R. Chevallier et Melle Mathieu (31) et d'autre part par Melle Roquet (120, 121, 122), apportent aussi des matériaux pour une théorie des rémanences des terres cuites et des roches. Une telle théorie est actuellement en voie d'élaboration par L. Néel.

Théories sur l'origine du champ moyen

J. Coulomb a envisagé l'hypothèse d'une aimantation radiale de la croûte terrestre (36) et L. Cagniard a poussé les calculs de Lamb sur l'extinction de courants électriques dans le globe terrestre (27). A. Delaygue a tenté d'établir une théorie s'appuyant sur des courants de convection dus à une séparation ionique par rotation de la Terre (50, 51). J. Mariani a proposé une théorie relativiste du champ terrestre (93, 94) qui, antérieure aux observations de Blackett, serait d'accord avec elles. A. Giaô (68, 69) et A. Dauvillier (47) ont discuté et complété la relation de Blackett. A. Dauvillier avait antérieurement proposé une explication du magnétisme terrestre (45).

II. Courants Telluriques

P. Rougerie s'est livré à une étude étendue des observations telluriques faites jadis à l'observatoire du Parc-Saint-Maur de 1893 à 1898; il s'est intéressé principalement à la variation diurne solaire des différences de potentiel telluriques mais il a étudié aussi leur variation diurne lunaire et leurs relations avec le champ magnétique terrestre (130).

La Compagnie générale de Géophysique a créé une nouvelle méthode de prospection électrique du sous-sol, en utilisant les différences de potentiel telluriques normales (par opposition avec la méthode de polarisation spontanée). Le principe de cette méthode, qui a pris rapidement un développement considérable en France, a été exposé par L. Migaux (102). Les enregistrements obtenus dans les campagnes de prospection constituent un document important dont l'exploitation scientifique est envisagée; quelques résultats ont été exposés par M. Schlumberger et G. Kunetz (136).

III. Électricité Atmosphérique

A l'Observatoire de Chambon-la-Forêt, le champ électrique est enregistré depuis la fondation de l'observatoire en 1936 et les valeurs horaires journalières ont été publiées jusqu'à l'année 1941 dans les Annales de l'Institut de Physique du Globe de Paris. L'enregistrement de la conductibilité électrique de l'air a été effectué de 1938 à 1944 et les valeurs moyennes horaires mensuelles publiées de 1938 à 1941 dans les mêmes annales.

Un résumé de l'ensemble des observations faites sur l'électricité atmosphérique, à l'Observatoire antérieur du Val-Joyeux, a été présenté par Ch. Maurain et ses collaborateurs (101).

Appareils. P. Queney a étudié un compteur donnant le spectre de mobilité des gros ions (115); cette étude est poursuivie actuellement par M. Boussat. A. Dauvillier a construit un nouvel électromètre enregistreur destiné à la mesure du champ électrique terrestre (48). L. Cagniard a discuté les principes des mesures de conductibilité électrique de l'air (24, 25) et avec C. Lévy a construit un nouveau modéle d'appareil de Gerdien (29). R. Lecolazet a proposé un montage électrométrique permettant de mesurer le champ terrestre par une méthode de zéro (89) et il a discuté la théorie des prises de potentiel (90). J. Lacaze a proposé l'emploi de bigrilles électromètres en électricité atmosphérique (81, 82). G. Grenet a construit un électromètre de zéro, à lampes, dans lequel la tension est appliquée à la grille de la première lampe par un condensateur vibrant (73). G. Vassails a exposé sa méthode de détermination des mobilités des gros ions dans l'air d'un vase clos (155).

Mesures et études sur le champ électrique

J. Rouch a donné les résultats des mesures qu'il a effectuées en mer, sur l'Ocean Atlantique et la mer Méditerranée (127), et sur les oceans Atlantique et Pacifique (128, 129). J. Lacaze et P. Molard ont donné les résultats de leurs enregistrements du champ électrique, respectivement à Tamanrasset (Hoggar) (80) et à La Martinique (103).

R. Guizonnier a noté un parallélisme entre les fluctuations du champ électrique moyen et celles de la pression atmosphérique moyenne (74). P. Pluvinage a étudié l'effet de la convection thermique sur le champ électrique au sommet du Puy de Dôme (107). L. Cagniard a étudié l'effet que produisent sur le champ au sol des nuages électrisés (28).

Mesures et études sur l'ionisation de l'air au voisinage du sol

Les résultats de mesures portant sur la conductibilité électrique de l'air, les densités en petits ions et en gros ions et les mobilités de ces ions ont été donnés: par J. Moussiegt pour l'air des Alpes (104); par C. Dauzère pour l'air des grottes (49); par Mme O. Thellier dans un travail étendu sur l'air de Paris et de la campagne (150, 151, 152, 153).

Des études au laboratoire ont été effectuées par H. Le Boiteux et Ouang-Te-Tchao sur les gros ions (13, 105), par G. Reboul et G. Vassails sur le mécanisme des actions ionisantes (116, 117, 157) et sur les mobilités des gros ions (156).

Des études ayant trait à l'équilibre ionique ont été effectuées par P. Langevin sur la recombinaison des ions (83); par L. Cagniard sur l'équilibre électrique dans toute l'atmosphère (23, 26); par Ouang-Te-Tchao et Mme O. Thellier (106) sur l'équilibre ionique; enfin par J. Gilbert (70, 71) qui établirait l'existence de centres neutres dans l'air ne jouant pas le rôle de noyaux de condensation. J. Coulomb a résumé les faits essentiels relatifs à l'électricité atmosphérique (37).

Électricité des nuages et foudre

Sous l'impulsion de J. Coulomb (39), cette étude a fait l'objet d'un nombre important de travaux.

P. Pluvinage a apporté une intéressante contribution à l'étude théorique et expérimentale (au sommet du Puy de Dôme) des propriétés électriques des nuages non orageux (108, 109, 110). R. Lecolazet a étudié la charge électrique des cumulus en déterminant son effet sur le champ au sol d'une part, et d'autre part par mesure directe du champ dans le nuage en le traversant en planeur (91, 92). J. Bricard a recherché le mécanisme de la séparation des charges dans les nuages orageux (15, 16, 17); il a écrit pour les Annales de Géophysique un rapport documenté sur l'électricité des nuages (18). M. Sourdillon a mis au point une technique de photographie des éclairs en plein jour et M. Dufay a étudié le spectre des éclairs dans les régions violette et ultra-violette (63). Récemment Ch. Maurain a publié un ouvrage sur la foudre (98).

Nous abandonnerons dans ce rapport tout ce qui a trait aux deux sujets suivants, étroitement liés aux questions d'électricité atmosphérique, mais qui ressortissent plutôt à la Section de Météorologie:

1° Les noyaux de condensation; la contribution française a été importante avec les travaux de A. Debierne, E. Salles, Mme Thellier, P. Pluvinage et P. Roche, et enfin de H. Dessens qui a mis au point la captation des noyaux au moyen de fils fins d'araignée.

2° La brume et la visibilité; des travaux étendus sur ces questions sont dus à A. Kastler, H. Dessens, J. Duclaux, J. Bricard et H. Grisollet.

IV. Géoradioactivité

Un certain nombre de déterminations de l'intensité du rayonnement pénétrant radioactif ont été effectuées: par J. Bricard et J. Jung en Auvergne (19), par F. Trombe et Melle Henry La Blanchetais dans une rivière souterraine (154) et par E. Rothé et Mme A. Hée en Alsace et dans les Vosges, cette dernière étude étant complétée par des déterminations de la radioactivité d'échantillons de roches (123, 125, 126). D'autre part, H. Garrigue a effectué des mesures de la teneur de l'air extrait du sol en émanations radioactives, dans les Vosges (66), et des mesures combinées de cette teneur et de l'intensité du rayonnement pénétrant, au Pic du Midi, au Puy de Dôme et au Groënland (67).

Mme Hée a étudié le rôle du thorium dans les substances faiblement radioactives (75, 76) et a montré que l'effet d'épaisseur de ce corps dans les roches ne permet pas de le doser (77).

Les possibilités de la prospection radioactive ont été examinées par E. Rothé (124) et, en ce qui concerne l'uranium, par P. Cüer (44) qui a effectué des prospections en France.

Les études menées très activement, en France, sur le rayonnement cosmique, par P. Auger et ses collaborateurs, à l'Ecole Normale Supérieure, et par L. Leprince-Ringuet et ses collaborateurs, à l'Ecole Polytechnique, ne seront pas non plus analysées dans ce rapport.

V. Ionosphère et Atmosphériques

En France s'est developpée, autour de R. Bureau, une école particulièrement active pour l'étude technique et théorique de l'ionosphère et des parasites radioélectriques, ou atmosphériques. Un centre important d'étude de l'ionosphère fonctionne aussi à Fribourg, en Zone française d'occupation.

Les nombreux travaux relatifs à cette branche de la Géophysique ont été analysés chaque année dans le compte-rendu publié par le Secrétaire général du Comité national français de Géodésie et Géophysique (Rapport de la Section de Magnétisme et Electricité terrestres, (33)). Nous n'en ferons pas ici un rapport général qui ferait double emploi avec les rapports plus documentés du Comité francais de radiotélégraphie scientifique (U.R.S.I.).

VI. Phénomènes Optiques de l'Atmosphère

L'étude des phénomènes optiques de l'atmosphère (absorption et surtout émission dans la haute atmosphère) a été très active en France. Elle a été conduite par une pléiade de chercheurs, la plupart élèves de Ch. Fabry, qu'on peut grouper schématiquement suivant leur lieu de travail; à la Faculté des Sciences de Paris: J. Cabannes, D. Kastler, E. Vassy, Mme Vassy, J. Bricard; au Collège de France: J. Duclaux, H. Dauvillier; à l'Institut d'Astrophysique: D. Barbier, D. Chalonge; aux observatoires de Lyon et de St-Michel (Haute-Provence): J. Dufay, J. Gauzit, R. Grandmontagne, M. Dufay, Tcheng Mao Lin; à la Faculté des Sciences de Lyon: G. Déjardin, R. Bernard; à l'Observatoire du Pic du Midi: H. Garrigue, H. Dessens et la plupart des autres chercheurs et de leurs élèves.

L'essentiel sur ces travaux et leur bibliographie pourra être trouvé dans un rapport général de A. Kastler paru dans le tome 2 des Annales de Géophysique pp. 315-328, pour la période 1940-1945 et, pour les années suivantes, dans les rapports annuels de la Section de Magnétisme et Electricité Terrestres du Comité français de Géodésie et Géophysique (33). Quelques notes nouvelles viennent de paraître dans le 6ème rapport de la Commission pour l'étude des relations entre les phénomènes solaires et terrestres (34), en particulier un rapport très documenté de J. Dufay (59), et plusieurs communications présentées au Colloque organisé à Lyon par le Centre national de la Recherche scientifique avec l'aide de la Fondation Rockefeller, en Septembre 1947, paraîtront prochainement dans une publication spéciale du Centre national de la Recherche scientifique.

Bibliographie

1. ALEXANIAN, C., Prospection magnétique à la Grande-Mâcholles. Ann. des Mines et des Carburants, 1944, pp. 171-173.
2. BARANOV, V., Sur un nouvel abaque pour le calcul des couches planes magnétiques minces. Ann. Géoph., 2, 1946, pp. 25-30.
3. BAYARD-DUCLAUX, Mme. F., De l'influence d'un mince dépôt superficiel sur l'aimantation d'une bille d'acier. Application aux propriétés magnétiques des roches. C. R. Acad. Sci., 216, 1943, pp. 727-728.
4. BERNARD, P., Variation, au cours du cycle solaire, de l'intervalle de temps entre les éruptions chromosphériques et les perturbations magnétiques terrestres. C. R. Acad. Sci., 220, 1945, pp. 179-181.
5. BERNARD, P., Répartition des éruptions solaires en relation avec les orages magnétiques. C. R. Acad. Sci., 220, 1945, pp. 506-508.
6. BERNARD, P., Sur la relation de certaines transformations cométaires avec les perturbations du champ magnétique terrestre. C. R. Acad. Sci., 224, 1947, pp. 209-211.
7. BERNARD, P., Effets magnétiques des éruptions solaires visibles. C. R. Acad. Sci., 224, 1947, pp. 1811-1813.
8. BESAIRIE, H., Le réseau magnétique 1939 de la Côte française des Somalis. C. R. Acad. Sci., 208, 1939, pp. 1516-1518.
9. BESAIRIE, H., Le nouveau réseau magnétique de Madagascar (première suite). Annales géologiques du Service des Mines de Madagascar, fasc. X, 1939.
10. BESAIRIE, H., Le nouveau réseau magnétique de Madagascar. Annales géologiques du Service des Mines de Madagascar, fasc. IX, 1938, p. 17.
11. BESAIRIE, H., Cárte de le déclinaison à Madagascar pour 1946, 0 (avec cartes de variation séculaire établies par Ch. Poisson). Service géographique de Madagascar, 1946.
12. BIDAULT, G., Mesures magnétiques au Maroc. Ann. Inst. Physique du Globe, Paris, 21, 1943, pp. 72-80.

13. Le BOITEUX, H., et OUANG-TE-TCHAO, Sur la loi de répartition des mobilités des gros ions. J. Phys., 1938, p. 501.
14. BRANDSTATTER, H., et LAGRULA, J., Déterminations de la déclinaison magnétique au Sahara méridional, au Soudan et en Afrique équatoriale. C. R. Acad. Sci., 209, 1939, pp. 326-327.
15. BRICARD, J., Sur l'application du mécanisme de Wilson aux nuages orageux. C. R. Acad. Sci., 224, 1947, pp. 487-489.
16. BRICARD, J., Le champ électrique dans les nuages orageux et la séparation des charges. La Météorologie, 1946, pp. 419-428.
17. BRICARD, J., L'application du mécanisme de Wilson aux nuages orageux. La Météorologie, 1946, pp. 439-448.
18. BRICARD, J., Rapports et mises au point. Electricité des nuages. Ann. Géophys., 3, 1947, pp. 87-95.
19. BRICARD, J., et JUNG, J., Mesures de l'intensité de la radiation pénétrante tellurique en Auvergne. C. R. Acad. Sci., 209, 1939, pp. 485-488.
20. BURGAUD, M., Relations entre les perturbations magnétiques et les éruptions solaires. C. R. Acad. Sci., 222, 1946, pp. 449-450.
21. BURGAUD, M., Sur les coïncidences des recrudescences de l'activité magnétique à courte période et la naissance des plages faculaires sur le soleil. C. R. Acad. Sci., 222, 1946, pp. 563-564.
22. BURGAUD, M., Activité magnétique et ses causes solaires. Observatoire de Zi-Ka-Wei. Etudes sur le magnétisme terrestre, 11, 1947, études 41 à 49.
23. CAGNIARD, L., Sur l'équilibre électrique de l'atmosphère. C. R. Acad Sci., 216, 1943, pp. 570-572.
24. CAGNIARD, L., Sur le rôle de la ventilation dans les appareils utilisés pour mesurer les conductibilités électriques de l'air atmosphérique. C. R. Acad. Sci., 217, 1943, pp. 574-576.
25. CAGNIARD, L., Sur les principes de la mesure des conductibilités ioniques de l'air à l'aide des appareils de déperdition. Ann. Géophys., 1, 1944, pp. 25-36.
26. CAGNIARD, L., Equilibre électrique d'une atmosphère ionisée (Distribution théorique du champ électrique, des conductibilités et des densités ioniques en altitude. Ann. Phys., 19, 1944, pp. 71-87.
27. CAGNIARD, L., Sur les phénomènes d'induction électromagnétique dans une sphère conductrice. Ann. Fac. Sciences, Toulouse, 1947, pp. 59-88.
28. CAGNIARD, L., Sur les perturbations du champ électrique terrestre provoquées par une éventuelle électrisation des cumulus. Ann. Géophys., Notes de Laboratoire, 3, 1947, pp. 102-103.
29. CAGNIARD, L., et LEVY, C., Un nouvel appareil du type Gerdien pour la mesure correcte et précise des conductibilités électriques de l'air atmosphérique. Ann. Géophys., 2, 1946, pp. 19-24.
30. CATTALA, L., et ROTHE, J., Prospection magnétique sur le minerai de fer de la mine de Puymorens. Ann. Inst. Phys. du Globe Strasbourg, III, 3ème partie, pp. 120-126.
31. CHEVALLIER, R., et MATHIEU Melle S., Propriétés magnétiques des poudres d'hématite. Influence des dimensions des grains. Ann. Phys., 18, 1943, pp. 258-288.
32. CHEVRIER, J., Observations magnétiques en Syrie et au Liban. Ann. Inst. Phys. du Globe Paris, 21, 1943, pp. 81-87.
33. COMITE NATIONAL FRANÇAIS DE GEODESIE ET GEOPHYSIQUE., Compte-rendu annuel publié par le Secrétaire Général. 19 rue Auber, Paris, 9ème.
34. CONSEIL INTERNATIONAL DES UNIONS SCIENTIFIQUES. 6ème rapport de la Commission pour l'étude des relations entre les phénomènes solaires et terrestres. 1948, pp. 144-156.
35. COULOMB, J., Sur l'aimantation des roches due à des grains dispersés. C. R. Acad. Sci., 216, 1943, pp. 351-352.

36. COULOMB, J., Partie principale de l'ensemble du champ magnétique terrestre et composante verticale locale. C. R. Acad. Sci., 216, 1943, pp. 452-453.
37. COULOMB, J., L'Electricité atmosphérique. L'Astronomie, 59, 1945, pp. 145-153.
38. COULOMB, J., Prévision de la variation diurne de la déclinaison magnétique. C. R. Acad. Sci., 224, 1947, pp. 1727-1728.
39. COULOMB, J., L'Electricité des nuages. La Météorologie, 3ème série, 1943, pp. 37-56.
40. COULOMB, J., ARBEY, L., et DUBIEF, J., Observations magnétiques à Tamanrasset (Hoggar) de Janvier 1938 à Mai 1940. Ann. Inst. Phys. du Globe, Paris, 21, 1943, pp. 100-104.
41. COULOMB, J., DUBIEF, J., LASSERRE, A., et QUENEY, P., L'enregistrement du champ magnétique terrestre à l'Observatoire de Tamanrasset, ses résultats de 1934 à 1937. Ann. Inst. Phys. du Globe, Paris, 17, 1939, pp. 67-83.
42. COULOMB, J., LASSERRE, A., et MALBOS, Melle J., Rapport sur les observations magnétiques faites à El Abiod Sidi Cheikh (Algérie) en 1941. Ann. Inst. Phys. du Globe, Paris, 21, 1943, pp. 55-57.
43. COULOMB, J., et DUGAST, G., Sur l'intervalle de temps entre les éruptions solaires et les orages magnétiques. C. R. Acad. Sci., 208, 1939, pp. 1557-1559.
44. CÜER, P., Prospection de l'uranium par ses particules alpha. Ann. Géophys., 2, 1946, pp. 147-159.
45. DAUVILLIER, A., Sur l'origine du magnétisme terrestre. C. R. Acad. Sci., 210, 1940, pp. 177-179.
46. DAUVILLIER, A., Avertisseur d'orages magnétiques. C. R. Acad. Sci., 222, 1946, pp. 1380-1381.
47. DAUVILLIER, A., Sur le magnétisme des corps célestes. C. R. Acad. Sci., 225, 1947, pp. 839-841.
48. DAUVILLIER, A., Sur un nouvel électromètre enregistreur. C. R. Acad. Sci., 216, 1943, pp. 661-663.
49. DAUZERE, C., L'ionisation de l'air dans les grottes. Cahiers de Physique, V, 1941, pp. 27-36.
50. DELAYGUE, A., Avant-propos à une étude sur l'origine du terme principal du champ magnétique terrestre: calcul du champ magnétique que devrait produire une solution électrolytique placée dans un récipient cylindrique en rotation autour de son axe. Cahiers de Physique, XIII, 1943, pp. 41-53.
51. DELAYGUE, A., Essai d'une théorie sur l'origine du champ magnétique terrestre. Ann. Géophys., I, 1944, pp. 121-143.
52. DESTOMBES, J. P., et BOLLO, R., Age triasique supérieur d'une couche ophitique à Ségalas (Ariège). C. R. Sommaire Soc. Géol. France, 3, 1946, pp. 51-52.
53. DUBIEF, J., Mesures magnétiques au Hoggar et dans les régions voisines. Ann. Inst. Phys. du Globe, Paris, 17, 1939, pp. 84-113.
54. DUBIEF, J., Nouvelles mesures magnétiques au Hoggar et dans les régions voisines. Ann. Inst. Phys. du Globe, Paris, 21, 1943, pp. 58-71.
55. DUBIEF, J., Résultats des mesures magnétiques au Sahara (Travaux de l'I.M.P.G.A., Alger, 1, 1943, pp. 1-15.
56. DUBIEF, J., Résultats de mesures magnétiques au Sahara (Algérie et Tripolitaine) en 1943. Travaux de l'I.M.P.G.A., Alger, 6, 1944.
57. DUBIEF, J., Résultats des mesures magnétiques faites au Sahara algérien et en Tripolitaine de Décembre 1943 à Juin 1945. Travaux de l'I.M.P.G.A., Alger, 7, 1945, pp. 3-13.
58. DUBIEF, J., Carte provisoire de la déclinaison magnétique sur la Libye et les pays limitrophes à la date du 1er Janvier 1945. Travaux de l'I.M.P.G.A., Alger, 7, 1945, pp. 1-2.

59. DUFAY, J., Recherches sur les phénomènes optiques de la haute atmosphère effectuées depuis 1940 à l'Observatoire de Lyon et à l'Observatoire de Haute-Provence. 6ème rapport de la Commission pour l'Etude des relations entre les phénomènes solaires et terrestres, 1948, pp. 144-156.
60. DUFAY, J., et FLAJOLET, P., Relations entre l'activité solaire et les perturbations de la déclinaison magnétique à Lyon. C. R. Acad. Sci., 218, 1944, pp. 46-48.
61. DUFAY, J., et FLAJOLET, P., La variation annuelle des perturbations de la déclinaison magnétique à Lyon et ses relations avec l'activité solaire. C. R. Acad. Sci., 218, 1944, pp. 162-164.
62. DUFAY, J., et FLAJOLET, P., Relations entre l'activité solaire et les perturbations de la déclinaison magnétique enregistrées à Saint-Genis-Laval. Ann. Géophys., I, 1945, pp. 264-274.
63. DUFAY, M., Sur le spectre des éclairs dans la région violette et ultraviolette. C. R. Acad. Sci., 225, 1947, pp. 1079-1080.
64. EBLE, L., Différentes sortes d'agitation magnétique. C. R. Acad. Sci., 216, 1943, pp. 305-306.
65. EBLE, L., Variation diurne de l'agitation magnétique. Ann. Inst. Phys. du Globe, Paris, 21, 1943, pp. 88-99.
66. GARRIGUE, H., Campagne de mesures de radioactivité dans les Vosges. Ann. Inst. Phys. du Globe, Strasbourg, 1939, Géophysique, pp. 3-6.
67. GARRIGUE, H., Comparaison des mesures de radioactivité de l'air et de radiation pénétrante d'origine terrestre au pic du Midi, au Puy-de-Dôme et dans la région de l'île Disko, Groënland NW. C. R. Acad. Sci., 214, 1942, pp. 801-802.
68. GIAÔ, A., Sur le magnétisme des masses en rotation. C. R. Acad. Sci., 224, 1947, pp. 1813-1815.
69. GIAÔ, A., Sur la relation entre le moment magnétique et le moment de rotation des masses sphériques. C. R. Acad. Sci., 225, 1947, pp. 924-926.
70. GILBERT, J., Au sujet de l'équilibre ionique dans la basse-atmosphère. C. R. Acad. Sci., 224, 1947, pp. 584-587.
71. GILBERT, J., Au sujet de l'ionisation artificielle des particules en suspension dans un gaz. Ann. Géophysique, Notes de Laboratoire, 3, 1947, pp. 101-102.
72. GRENET, G., Quelques mesures d'aimantation permanente de roches du Massif Central et remarques sur les méthodes de détermination de la valeur du champ magnétique terrestre dans le passé. Ann. Géophysique, 1, 1945, pp. 256-263.
73. GRENET, G., Un électromètre à lampes destiné aux mesures d'électricité atmosphérique. C. R. Acad. Sci., 225, 1947, pp. 585-586.
74. GUIZONNIER, R., Champ électrique terrestre et pression atmosphérique. C. R. Acad. Sci., 213, 1941, pp. 141-143.
75. HEE, Mme A., Le rôle du thorium dans les substances faiblement radioactives. 1ere partie: Particularités du courant d'ionisation produit par les substances thorifères. Cah. Phys., 19, 1944, pp. 59-70.
76. HEE, Mme A., Le rôle du thorium dans les substances faiblement radioactives. 2ème partie: Recherche des causes de l'effet d'épaisseur. Cah. Phys., 20, 1944, pp. 63-71.
77. HEE, Mme A., Effet d'épaisseur du thorium dans les roches. Ann. Géophysique, 2, 1946, pp. 55-67.
78. LABROUSTE, H., et LABROUSTE, Mme Y., Etude statistique du cycle undécennal de la composante diurne de la déclinaison magnétique. C. R. Acad. Sci., 209, 1939, p. 689.
79. LABROUSTE, H., et LABROUSTE, Mme Y., Cycle undécennal des composantes diurne et semi-diurne de la déclinaison magnétique. Cinquième rapport de la Commission pour l'étude des relations entre les phénomènes solaires et terrestres, 1939, pp. 127-129.

80. LACAZE, J., Un an d'enregistrement du gradient de potentiel électrique de l'atmosphére à Tamanrasset (Hoggar). La revue Scientifique, 84, 1946, pp. 286-289.
81. LACAZE, J., Mesure de la conductibilité électrique de l'air à l'aide d'une bigrille électromètre. C. R. Acad. Sci., 222, 1946, pp. 1242-1244.
82. LACAZE, J., Sur l'utilisation des bigrilles électromètres à grille isolée et à plaque fortement négative en électricité atmosphérique. C. R. Acad. Sci., 223, 1946, pp. 101-102.
83. LANGEVIN, P., Sur la recombinaison des ions. J. Phys., VIII, 6, 1945, pp. 1-5.
84. LARROQUE, J., Observations magnétiques en A.O.F. C. R. Acad. Sci., 210, 1940, pp. 221-222.
85. LASSERRE, A., et MALBOS, Melle J., Note sur la déclinaison magnétique en Tunisie. Annu. Inst. Météorologie et Phys. du Globe de l'Algérie, 1938.
86. LASSERRE, A., et MALBOS, Melle J., Mesures magnétiques dans les territoires du Sud de l'Algérie. Annu. Inst. Météorologie et Phys. du Globe Algérie-Sahara, 1939.
87. LASSERRE, A., et MALBOS, Melle J., Inclinaison magnétique en Algérie-Tunisie au 1er Janvier 1938. Ann. Inst. Phys. du Globe, Paris, 23, 1948, pp. 71-82.
88. LASSERRE, A., et DUBIEF, J., préface de COULOMB, J., Carte de la déclinaison magnétique sur le Sahara pour 1938, 0. Inst. de recherche Sahariennes, Alger, Publ. hors série, No. 1, 1940.
89. LECOLAZET, R., Sur un montage électrométrique pour la mesure du champ électrique terrestre par une méthode de zéro. C. R. Acad. Sci., 220, 1945, pp. 531-533.
90. LECOLAZET, R., Sur la définition et la théorie des prises de potentiel en électricité atmosphérique. C. R. Acad. Sci., 222, 1946, pp. 331-332.
91. LECOLAZET, R., Sur le champ électrique à l'intérieur et au voisinage des cumulus. C. R. Acad. Sci., 225, 1947, pp. 1085-1086.
92. LECOLAZET, R., Résultats d'une étude préliminaire de l'effet des cumulus sur le champ électrique terrestre. La Météorologie, 1946, pp. 429-433.
93. MARIANI, J., Une interprétation théorique du magnétisme terrestre. C. R. Acad. Sci., 218, 1944, pp. 585-586.
94. MARIANI, J., Electromagnétisme et radioactivité. Le magnétisme terrestre comme conséquence de la relativité générale. Cah. Phys., 28, 1945, pp. 23-54.
95. MAURAIN, C., Sur les perturbations magnétiques à début brusque dans la région parisienne. Répartition annuelle et diurne des débuts brusques. C. R. Acad. Sci., 217, 1943, pp. 8-10.
96. MAURAIN, C., Sur les perturbations magnétiques à début brusque. Sens des débuts brusques. C. R. Acad. Sci., 217, 1943, pp. 57-59.
97. MAURAIN, C., Variations séculaires du champ magnétique terrestre près de Paris de 1883 à 1941. Ann. Inst. Phys. du Globe, Paris, 22, 1944, pp. 61-69.
98. MAURAIN, C., La Foudre. Collection Armand Colin, No. 248, Paris, 1948.
99. MAURAIN, C., et COULOMB, J., Sur les perturbations magnétiques en baies. C. R. Acad. Sci., 216, 1943, pp. 273-276.
100. MAURAIN, C., et COULOMB, J., Propriétés des perturbations magnétiques en baies. C. R. Acad. Sci., 216, 1943, pp. 327-329.
101. MAURAIN, C., SALLES, E., SALLES-HOMERY, Mme G., GIBAULT, G., et CHARCZENKO, P., Sur les phénomènes électriques terrestres à l'observatoire du Val-Joyeux (d'après 12 ans d'observations). Ann. Inst. Phys. du Globe, Paris, 17, p. 49.
102. MIGAUX, L., Une méthode nouvelle de géophysique appliquée: la prospection par courants telluriques. Ann. Géophysique, 2, 1946, pp. 131-146.

103. MOLARD, P., Variation du champ électrique à l'Observatoire du Morne des Cadets (La Martinique). Ann. Géophysique, 2, 1946, pp. 339-342.
104. MOUSSIEGT, J., Mesures de la conductibilité et de l'ionisation de l'air dans les Alpes. Ann. Inst. Hydrologie et Climatologie, 12, pp. 157-168.
105. OUANG-TE-TCHAO et LE BOITEUX, H., Sur le coefficient d'absorption des petits ions par les particules neutres en suspension dans l'air. C. R. Acad. Sci., 208, 1939, pp. 1288-1289.
106. OUANG-TE-TCHAO et THELLIER, Mme O., Sur l'équilibre ionique dans l'atmosphère. C. R. Acad. Sci., 211, 1940, pp. 799-801.
107. PLUVINAGE, P., Influence de la convection thermique sur le champ électrique terrestre. C. R. Acad. Sci., 216, 1943, pp. 303-304.
108. PLUVINAGE, P., Le régime de l'ionisation à l'intérieur d'un nuage électriquement neutre. C. R. Acad. Sci., 218, 1944, pp. 48-50.
109. PLUVINAGE, P., Le régime de l'ionisation à l'intérieur d'un nuage faiblement électrisé. C. R. Acad. Sci., 218, 1944, pp. 1000-1002.
110. PLUVINAGE, P., Etude théorique et expérimentale de la conductibilité électrique dans les nuages non orageux. Première partie: Etude théorique. Ann. Géophysique, 2, 1946, pp. 30-54.
111. PLUVINAGE, P., Etude théorique et expérimentale de la conductibilité électrique dans les nuages non orageux. Deuxième partie: Etude expérimentale. Ann. Géophysique, 2, 1946, pp. 160-178.
112. PLUVINAGE, P., Sur les propriétés électriques internes des nuages bas non orageux. La Météorologie, 1946, pp. 434-438.
113. POISSON, C., Quelques données numériques sur le magnétisme des roches de Madagascar. Ann. géologiques du Service des Mines de Madagascar, fasc. IX, 1938, p. 7.
114. POISSON, C., Roches métamorphisées et magnétisme terrestre sur la ligne des crêtes Ambohidempona-Ambatofotsikely. Bull. de l'Acad. malgache; nouvelle série 26, 1944-1945, Tananarive, 1947.
115. QUENEY, P., Compteur de gros ions donnant directement le spectre des mobilités. C. R. Acad. Sci., 208, 1939, pp. 1521-1523.
116. REBOUL, G., Sur la formation des petits ions, des gros ions et des centres neutres. C. R. Acad. Sci., 220, 1945, pp. 267-268.
117. REBOULS, G. et VASSAILS, G., Sur une anomalie présentée par les gaz soumis à l'action de diverses causes ionisantes. C. R. Acad. Sci., 220, 1945, pp. 157-158.
118. ROQUET, Melle J., Sur la variation annuelle de la fréquence des jours magnétiquement calmes. Rev. Sci. ill., 81, 1943, pp. 279-282.
119. ROQUET, Melle J., Pulsations géantes. La Revue Scient., 3214-3215, 1942, pp. 433-435.
120. ROQUET, Melle J., Sur les propriétés magnétiques du sesquioxyde de fer faiblement magnétique. C. R. Acad. Sci., 222, 1946, pp. 727-729.
121. ROQUET, Melle J., Sur l'aimantation rémanente isotherme du sesquioxyde de fer. C. R. Acad. Sci., 224, 1947, pp. 1418-1420.
122. ROQUET, Melle J., et THELLIER, E., Sur des lois numériques simples relatives à l'aimantation thermorémanente du sesquioxyde de fer. C. R. Acad. Sci., 222, 1946, pp. 1288-1290.
123. ROTHE, E., Sur quelques phénomènes de concentration de la radioactivité des roches. C. R. Acad. Sci., 211, 1940, pp. 753-756.
124. ROTHE, E., Sur la méthode de prospection des couches géologiques par les radiations pénétrantes. C. R. Acad. Sci., 212, 1941, pp. 212-215.
125. ROTHE, E., et HEE, Mme A., Sur une méthode d'étude de la radioactivité des roches. C. R. Acad. Sci., 210, 1940, pp. 30-32.
126. ROTHE, E., et HEE, Mme A., Etude géoradiologique sur les roches d'Alsace et des Vosges. Ann. Inst. Phys. du Globe, Strasbourg, 1939, Géophysique, pp. 7-24.

127. ROUCH, J., Observations du champ électrique de l'atmosphère en mer dans l'Océan Atlantique et dans la Méditerranée. Ann. Inst. Phys. du Globe, Paris, 17, 1939, pp. 57-63.
128. ROUCH, J., Observations du champ électrique de l'atmosphère dans l'Océan Atlantique et dans l'Océan Pacifique. C. R. Acad. Sci., 209, 1939, pp. 564-568.
129. ROUCH, J., Observations du champ électrique de l'atmosphère dans l'Océan Atlantique et dans l'Océan Pacifique. Ann. Inst. Phys. du Globe, Paris, 19, 1941, pp. 96-106.
130. ROUGERIE, P., Contribution à l'étude des courants telluriques. Ann. Inst. Phys. du Globe, Paris, 20, 1942, pp. 60-111.
131. ROUGERIE, P., Sur la distribution et la variation séculaire de l'aimantation terrestre. C. R. Acad. Sci., 216, 1943, pp. 416-418.
132. ROUGERIE, P., Sur la direction de l'aimantation terrestre. C. R. Acad. Sci., 216, 1943, pp. 451-452.
133. ROUGERIE, P., Variation diurne lunaire de la déclinaison magnétique au Val-Joyeux. C. R. Acad. Sci., 225, 1947, pp. 67-68.
134. SAVORNIN, A., Mesures magnétiques effectuées à Madagascar de 1935 à 1937. Ann. Géologiques du Service des Mines de Madagascar, fasc. IX, 1938, p. 49.
135. SAVORNIN, A., Prospection magnétique à Ambohidranomoro (Ouest de Madagascar). Ann. Géologiques du Service des Mines de Madagascar, fasc. X, 1939.
136. SCHLUMBERGER, M., et KUNETZ, G., Variations rapides simultanées du champ tellurique en France et à Madagascar. C. R. Acad. Sci., 223, 1946, pp. 551-553.
137. SCHNEIDER, E., THELLIER, E., et THELLIER, Mme O., Contribution géophysique à l'étude du trias ophitique pyrénéen. Ann. Géophysique, 1948 (sous presse).
138. SELZER, E., Réalisation de magnétrons à anode non fendue, de grande symétrie. Etude de leurs propriétés statiques. C. R. Acad. Sci., 218, 1944, pp. 499-501.
139. SELZER, E., Bruit de fond et oscillations à fréquences musicales observés dans les magnétrons. C. R. Acad. Sci., 218, 1944, pp. 589-591.
140. THELLIER, E., Sur l'aimantation permanente de quelques échantillons de lave mexicaine. C. R. Acad. Sci., 211, 1940, pp. 110-112.
141. THELLIER, E., Sur les propriétés de l'aimantation thermorémanente des terres cuites. C. R. Acad. Sci., 213, 1941, pp. 1019-1022.
142. THELLIER, E., Sur la vérification d'une méthode permettant de déterminer l'intensité du champ magnétique terrestre dans le passé. C. R. Acad. Sci., 212, 1941, pp. 281-283.
143. THELLIER, E., Sur la thermorémanence et la théorie du métamagnétisme. C. R. Acad. Sci., 223, 1946, pp. 319-321.
144. THELLIER, E., Eruptions chromosphériques, orages magnétiques à début brusque et récurrence de 27 jours. Communication au Colloque de Lyon, Septembre 1947 (sous presse).
145. THELLIER, E., et THELLIER, Mme O., Sur les variations thermiques de l'aimantation thermorémanente des terres cuites. C. R. Acad. Sci., 213, 1941, pp. 59-61.
146. THELLIER, E., et THELLIER, Mme O., Sur l'intensité du champ magnétique terrestre, en France, trois siècles avant les premières mesures directes. Application au problème de la désaimantation du Globe. C. R. Acad. Sci., 214, 1942, pp. 382-384.
147. THELLIER, E., et THELLIER, Mme O., Sur les corrections d'aimantation induite et de température dans les mesures magnétiques. Ann. Inst. Phys. du Globe, Paris, 22, 1944, pp. 82-90.

148. THELLIER, E., et THELLIER, Mme O., Recherches géomagnétiques sur des coulées volcaniques d'Auvergne. Ann. Géophysique, 1, 1944, pp. 37-52.
149. THELLIER, E., et THELLIER, Mme O., Sur l'intensité du champ magnétique terrestre, en France, à l'époque gallo-romaine. C. R. Acad. Sci., 222, 1946, pp. 905-907.
150. THELLIER, Mme O., Sur l'ionisation de l'air dans une atmosphère pure (campagne) et polluée (grande ville). Ann. Inst. Phys. du Globe, Paris, 19, 1941, pp. 107-179.
151. THELLIER, Mme O., Sur l'ionisation et la pollution actuelle de l'atmosphère parisienne. C. R. Acad. Sci., 216, 1943, pp. 589-591.
152. THELLIER, Mme O., Sur la variation diurne de l'ionisation de l'air à Paris. Ann. Géophysique, 1, 1944, pp. 97-99.
153. THELLIER, Mme O., Sur l'état électrique de la basse-atmosphère et ses modifications dans les lieux habités. La Météorologie, 1945, pp. 163-174.
154. TROMBE, F., et HENRY LA BLANCHETAIS, Melle C., Ionisation. Sur la présence de radiations pénétrantes telluriques dans la rivière souterraine de St-Paul (Haute-Garonne). C. R. Acad. Sci., 224, 1947, pp. 207-209.
155. VASSAILS, G., Sur la détermination des mobilités de gros ions dans un gaz au repos. C. R. Acad. Sci., 222, 1946, pp. 724-725.
156. VASSAILS, G., Détermination des mobilités des gros ions en suspension dans un gaz au repos. C. R. Acad. Sci., 224, 1947, pp. 1820-1822.
157. VASSAILS, G., Aérosols de barbotage et moment électrique moléculaire du liquide. C. R. Acad. Sci., 225, 1947, pp. 53-55.

GERMANY

FIAT REVIEW OF GERMAN SCIENCE, 1939-1946

An account of German work in the fields of the International Association of Terrestrial Magnetism and Electricity is given in the FIAT Review of German Science 1939-1946: Geophysics, Parts I and II, edited by J. Bartels. These two volumes belong to a series of 88 similar reports sponsored by the three western occupational powers in Germany. Titles and tables of contents are in English; the text is in German. There are two editions: The official edition, limited to 1100 copies, has been distributed by the Governments concerned; another edition has been published under the general title "Naturforschung und Medizin in Deutschland, 1939-1946", by Dieterichsche Verlagsbuchhandlung, Wiesbaden, Germany, 1948. Geophysics Vol. I contains: Geomagnetism I--Instruments, methods, surveys, by Fr. Errulat (pp. 27-38); Geomagnetism II--Time-variations, relations to solar physics, aurora, ionosphere, by J. Bartels (pp. 39-92); Ionosphere, by Dieminger (pp. 93-164); Atmospheric Electricity, by H. Israel (pp. 165-184). A review of the whole volumes on Geophysics has appeared in the Journal of Terrestrial Magnetism and Atmospheric Electricity, volume 53, pages 462-464 (1948).

ERDMAGNETISCHES OBSERVATORIUM FURSTENFELDBRUCK (OBERBAYERN)

von F. Burmeister

Das im Jahre 1938 in Fürstenfeldbruck (25 km westlich von München) erbaute Erdmagnetische Observatorium ist von Beschädigungen infolge des Krieges verschont geblieben und hat während der ganzen Zeit seine Tätigkeit forsetzen können. Die Jahresmittel der erdmagnetischen Elemente von 1939 bis 1947 liegen berechnet vor, ebenso sind die magnetischen Charakterzahlen laufend ermittelt worden. Zwei Variometer-Systeme sind in Betrieb, ein modernes System von G.

Schulze, Potsdam und ein älteres System von M. Th. Edelmann, München, mit geringerer Empfindlichkeit. Die Vermessungstätigkeit des Instituts umfasst Bayern, Baden, Württemberg, die Rheinpfalz und Hessen, also im wesentlichen die Gebiete der amerikanischen und der französischen Besatzungszonen. In den Jahren 1938-41 wurden in Württemberg 24 Punkte I. Ordnung zur Ergänzung der Reichsvermessung 1934/35 vermessen, ferner wurde die Deklination in Württemberg, Baden, an 611, in der Rheinpfalz an 95 Punkten beobachtet. Die Beobachtungspunkte sind fast ausschliesslich trigonometrisch bestimmte und durch Vermarkung versicherte Punkte der Landesvermessung. Eine grosse Anzahl dieser Punkte sind identisch mit Punkten der älteren Vermessungen von K. Haussmann, A. Nippoldt und G. v. Neumayer, so dass die Säkularvariation in diesen Gebieten abgeleitet werden konnte. Die Ergebnisse wurden in magnetischen Karten verarbeitet. Zu den zukünftigen Aufgaben des Observatoriums gehört in erster Linie eine Neuvermessung Bayerns, deren Ausführung in den letzten Kriegsjahren unmöglich war. Sie ist auch jetzt wegen der wirtschaftlichen Verhältnisse, darunter vor allem Mangel an Benzin und Reifen für den Kraftwagen, in Frage gestellt.

Ab 1948 wird fortlaufend der Erdstrom registriert werden. Die erforderlichen Instrumente werden jetzt justiert.

Die früher in München befindliche Erdbebenwarte wurde durch Bombenschaden im Juni 1944 ausser Betrieb gesetzt, doch konnte das Instrumentarium und die Bibliothek gerettet werden. Auch die luftelektrischen Messungen mussten abgebrochen werden. Der Leiter der Warte, Prof. Dr. C. W. Lutz ist im Oktober 1946 gestorben. Die Erdbebenwarte wird 1948 auf dem Gelände des Erdmagnetischen Observatoriums in Fürstenfeldbruck neu gebaut werden.

GREAT BRITAIN

BRITISH NATIONAL REPORT ON TERRESTRIAL MAGNETISM AND ELECTRICITY

(A) Terrestrial Magnetism.

(1) Report on the Magnetic Work Undertaken by the Royal Observatory since 1939.

Inasmuch as the period from 1939 coincides, practically, with the war years and the difficult months succeeding them, magnetic work at Abinger has been confined almost entirely to routine observation and continuous recording of the elements declination, horizontal intensity, and vertical intensity.

With negligible interruption photographic records have been maintained by means of Copenhagen (la Cour) magnetographs throughout the period, at ordinary time-speed (15 mm to the hour) and also at a speed twelve times as great. In June 1940 a magnetograph which records declination and horizontal intensity on a scale approximately one-quarter that of the ordinary scale was installed. This has proved very useful for verification, in doubtful cases, of the range of the large rapid changes occurring in great storms.

The magnetographs are maintained at constant temperature. The temperature coefficients were investigated and compensated when the magnetographs were installed. In order to economize in electric power consumption, the practice has been to use a lower control temperature during the winter months than during the summer months. The base-line values, as determined before and after a change of control temperature, provide a check on the temperature compensation.

The orientations of the magnets are tested at intervals. The frequent absolute observations, their small probable errors, and the remarkable stability of the base-line values serve as checks on the stability of the adjustments.

The torsion of the declinometer suspension and the collimation error of the optical system of the magnet are determined monthly.

Absolute observations of D, H, and Z are generally made each week day. The standard instruments used for absolute observation of H and Z are the two coil-magnetometers--Schuster-Smith and Dye--lent to the Royal Observatory by the National Physical Laboratory, Teddington; but a considerable number of observations of inclination with an earth inductor and of horizontal intensity with a Kew-pattern unifilar magnetometer are made in addition, and serve as a check on the electric methods.

The reduction of the observations and the tabulation of the results have been kept closely up to date, but no results have been published since 1938. Approval has now been obtained to resume publication and it is hoped gradually to reduce the arrears.

The three-hourly K indices of magnetic activity according to the plan recommended at the Washington Meeting in 1939 have been estimated to date and have been communicated quarterly to the Director of the Carnegie Institution from January 1, 1940, onwards.

It is intended that the methoa shall be applied retrospectively to past records; and at the date of this report the K indices have been assessed for the period 1939-1936 inclusive.

A few instruments, used principally in geophysical prospecting, have been tested for the manufacturers and examined for the determination of their constants.

At Greenwich, a revision of all the Admiralty Magnetic Charts was undertaken in connection with an issue for the epoch 1942.5. In addition to charts of declination, inclination, and horizontal intensity, a new chart was constructed showing vertical intensity.

These charts have formed the basis of an investigation of the earth's general magnetic field by spherical harmonic analysis, which was completed in 1944 but has not yet been published. A further revision of the Admiralty chart of magnetic declination with reduction to epoch 1947.5 has just been completed.

Much interference is now being experienced at Abinger from stray magnetic fields originating in the current used for electric traction. Plans are under consideration for the removal of the magnetic station of the Royal Observatory from Abinger to a site in north Devonshire where permanent freedom from such interference is to be expected.

Three papers on solar-geomagnetic relationships have been communicated by the Astronomer Royal to the Royal Astronomical Society, as follows:

(a) "Solar Flares and Magnetic Storms", 1st paper Monthly Notices, vol. 103, 244, 1943; 2nd paper, vol. 104, 4, 1944.
(b) "Sudden Commencements" in the Greenwich Magnetic Records (1879-1944)". In course of printing in Geophysical Supplement, 1947.
(c) "Geomagnetic 'Crochet' Occurrence at Abinger, and Allied Solar and Radio Data". To be published in Geophysical Supplement, 1947.

Papers (a) and (b) have been summarized as observational data in the report by Ferraro and Price, on British theoretical research in geomagnetism. Besides the marked diurnal variation in sudden commencement (SC) occurrence found at Greenwich, attention may also be drawn here to a remarkable similarity of small or even tiny detail in synchronous traces (more especially in H) at Abinger and Lerwick, more than 600 miles apart. This feature, which sometimes persists for hours but is apparently obliterated during disturbance, seems worth fuller investigation.

The results of paper (c) are summarized as follows:

The rather infrequent occurrence at Abinger of geomagnetic "crochets" (ultraviolet solar radiation effect) has been studied over 11 years, in conjunction with data of solar flares and radio fade-outs. The trace movements in H, D, and V of 23 examples are reproduced, in addition to tabulated data for these and for 32 other cases of less certain identification. The general synchronization of flare, fade-out, and crochet (when present) is noteworthy.

Comparison is made of the amplitude ΔH and direction ΔD of the crochets with the normal diurnal inequality of H and D. A striking feature is the change in direction from east to west in D at about 10.7^h apparent solar time, in conformity with the diurnal inequality in D. The correlation with the diurnal inequality in H is less obvious, but ΔH is of the correct sign (negative) over the range of daylight hours in which crochets occurred. There are indications of other diurnal and seasonal factors (other than a simple dependence upon the sun's zenith distance) in the occurrence of crochets at Abinger. Some crochets in 1946 have synchronized with reported bursts of "solar noise"

(2) Work in Terrestrial Magnetism and Atmospheric Electricity at Observatories of the Meteorological Office, from 1939 to 1947.

Terrestrial Magnetism and Atmospheric Electricity at Eskdalemuir and Lerwick

From the date of the last report on February 20, 1939, to the onset of the second World War in September 1939 the observatories at Eskdalemuir and Lerwick continued their normal program. Investigational work at the Edinburgh Meteorological Office, however, came to a standstill with the transfers of staff. During the war the departmental policy was to maintain the routine magnetic and electrical work and prepare the material for the Observatories' Year Book as far as practicable. The war brought no large changes at Eskdalemuir, but Lerwick Observatory was transformed into a very predominantly radio-meteorological station with a staff four or five times its prewar establishment.

The standard instruments at Eskdalemuir throughout were the Schuster-Smith coil for H, the Kew magnetometer for D, and the Schulze inductor for V. At Lerwick a portable Schuster-Smith coil constructed at Eskdalemuir from a portable Smith coil (as mentioned in the last report) replaced the Kew magnetometer in October 1939 as the standard for H, and la Cour's B.M. magnetometer replaced the inductor in March 1940 as the standard for V. Local check observations of the coils continued to be made at regular intervals with the Kew magnetometers, and of the B.M. magnetometer at Lerwick with the inductor.

The general control of variometers and absolute instruments is in accord with the resolutions passed at the Washington Assembly of 1939, but the Year Books have not in the past contained all the information asked for on these points.

The la Cour and auxiliary variometers continued to provide recordings (with few breaks) of the three elements. Schmidt mirrors were fitted to the auxiliary instruments at both observatories in 1941 to give supplementary small-scale records and so ensure complete registration of the most intense disturbances. The range recording capacity at Lerwick was increased to $\pm 4500\gamma$ in H, $\pm 2400\gamma$ in D, and $\pm 2800\gamma$ in V. Oblique oscillation of the reflected light in the la Cour variometers with accompanying decrease of illumination and loss of record was partially compensated by tilting the totally reflecting prisms.

The large horizontal coil and galvanometer system at Eskdalemuir for recording rates of change of V was maintained in working order, but was not actually in use.

Apart from the observational work and the maintenance of instruments it was found possible to keep up to date the preparation of the Year Book material for Eskdalemuir in so far as the lists of international quiet and disturbed days were available. Staff difficulties at Lerwick, however, led to much inaccuracy and arrears in the latter part of the war. These shortcomings have now been rectified. Routine reports of magnetic character figures and (from 1940) of Bartels' three-hourly range (K) indices of magnetic disturbance were sent to the Carnegie Institution, Washington, U.S.A. at first quarterly, and, later on, monthly. Character figures were sent quarterly also to the International Meteorological Organization at Lausanne, Switzerland, until that Office was closed after the war. Various telegraphic warnings of strong aurora and incipient magnetic disturbance were issued on a temporary basis in the course of the war, and some assistance was given in geological magnetic surveys at Lerwick.

The auroral watch at Lerwick was maintained throughout. Arrangements were made in November 1938 for cooperation in auroral photography with a number of stations organized by the University of Edinburgh. No suitable aurora occurred, however, during the remainder of the 1938-39 season, and when the following season arrived the war had dislocated the scheme.

In atmospheric electricity the routine of maintaining and standardizing the electrograph, determination of the site factor and preparation of the data for the Observatories' Year Book was continued at both observatories without interruption. No significant changes were made in the work.

The only note published during the war was "Potential Gradient and Atmospheric Opacity at Lerwick 1927-39", by O. M. Ashford in the Quarterly Journal of the Royal Meteorological Society (Vol. 67, No. 288, 1941). The Geophysical Memoir on Hourly Ranges during the Polar Year, by F. E. Dixon, mentioned in this report for 1939, is still in the press. A small unpublished investigation of the scale-value effect due to the curved-face prism of the la Cour D variometer was made jointly by Lerwick and Edinburgh in 1941. It accounted satisfactorily for previously unexplained slight discrepancies ($1'.03$ instead of $1'.00$ per mm) in the scale value.

(3) R.R.S. Research.

The vessel is lying at moorings in the River Dart in a state of care and maintenance. She still lacks her main and auxiliary machinery which is incomplete. Instructions have been given by the Board of Admiralty to prepare an estimate of the cost required to complete her for sea and the annual cost of running her.

Owing to the difficulty of obtaining the necessary material and labor to complete the main engines at the present time, it has been proposed that, should approval be given to proceed, the ship shall make her first voyage under sail only, and that the main engines be subsequently installed.

It is expected that, should approval be given, about two years would be occupied in getting the ship ready, owing to the scarcity of almost every essential (e.g., canvas for sails).

(4) Theoretical Researches.

Theories of Magnetic Storms and Diurnal Variations

S. Chapman and V. C. A. Ferraro have continued their theoretical studies of geomagnetic storms. In a first paper (Terr. Mag., Vol. 45, 245, 1940) they considered an idealised two-dimensional problem which partly illustrates the first phase of a magnetic storm and, in particular, the sudden increase in the horizontal force during a few minutes (sudden commencements). They showed clearly that during the advance of a neutral ionized stream into regions of increasing magnetic intensity, the electrostatic attraction between the ions and electrons can carry the electrons far beyond the distances they could attain alone, thus removing certain difficulties which had been envisaged in their original discussion of the theory of the first phase, connected with the reduction of the electrical conductivity when collisions between ions and electrons become very rare. [As T. G. Cowling has pointed out in another connection, the effect of this electrostatic field is to leave the apparent conductivity unaltered by the magnetic field. (M.N.R.A.S., Vol. 93, 90, 1933).]

The problem of the induction of electric currents in a neutral ionized stream when the flow is assumed to take place without resistance, i.e. when no collisions take place between the charges in the stream, was discussed in greater detail than hitherto by Ferraro (Proc. Lond. Math. Soc., Ser. 2, Vol. 49, 77, 1946) who showed that, as in the case when the flow is according to Ohm's law, the currents induced in this stream are confined to a surface layer the thickness of which, in this case, depends solely on the electron density in the stream, and varies inversely as the square root of this density. Chapman and Ferraro's original quantitative discussion of the theory of the first phase is thus largely substantiated, and it is hoped to give a more complete development in a later paper.

A first attempt has also been made by Chapman and Ferraro to reconsider the problems associated with the theory of the geomagnetic ring-current, to which they attribute the magnetic storm variations in middle and low latitudes during the main phase of a magnetic storm. In a paper (Terr. Mag., Vol. 46, 1, 1941) dealing with the radial stability of the ring, they considered an ideal two-dimensional case in which the ring is replaced by a cylindrical current-sheet whose axis is parallel to the geomagnetic axis; it was concluded that under certain conditions this model ring would be stable for radial oscillations. They also suggested that similar oscillations of the geomagnetic ring-current might account for some of the world-wide fluctuations of the earth's magnetic field during magnetic storms. A more accurate solution of the same problem, taking account of displacement currents, has been given by Ferraro (Terr. Mag., Vol. 51, 547, 1946). He shows that while the conclusions reached in the earlier paper are substantiated, the cylindrical current-sheet is in effect unstable and would inevitably break up at a rate which is, moreover, comparable with the rate of decrease of intense and moderate storms.

T. L. Eckersley has suggested (Nature, 150, 177, 1942, Terr. Mag., 52, 305, 433, 1947) that there may be two types of Magnetic Storms, both due to the approach of a neutral stream of particles to the Earth, one caused by slowly moving particles (Chapman and Ferraro's theory), the other due to faster particles which penetrate the ionosphere. In the latter case a vertical electric field is set up by a process of differential penetration of the ions and electrons. By considering the motion of the charges in this field in conjunction with the Earth's magnetic field, Eckersley is able to explain--qualitatively at least--many ionospheric changes during a magnetic storm, as well as the concomitant magnetic variations.

Cowling (Terr. Mag., Vol. 47, 209, 1942) has criticised Alfvén's theory of magnetic storms and aurorae on the ground that the particles in a rare ionized gas are subjected to a diamagnetic repulsion from the regions of greatest magnetic intensity; this prevents the particles from reaching the earth's atmosphere in the way imagined by Alfvén. Cowling also shows that too little account was taken of the electrostatic forces, which in any case will prevent more than a slight separation of the ions from the electrons.

The suggestion first made by Chapman in 1929 (M.N.R.A.S., 89, 456, 1929) that a solar corpuscular stream responsible for geomagnetic storms might be detected by the observation of a faint absorption line on the violet side of the Fraunhofer lines has been tentatively confirmed, following Richardson, by H. A. Brück and F. Rutllant (M.N.R.A.S., 106, 130, 1946) from their observations of the H and K lines in the solar spectrum during the magnetic storm of February 7, 1946.

The effect of tidal motion in the ionosphere has been considered by Cowling (Proc. Roy. Soc., A, Vol. 183, 453, 1945) with reference to the 'dynamo' theory of the lunar variation of the earth's magnetic field. From the values of the integrated conductivities of the E and F regions estimated there, Cowling shows that the tidal oscillations in these layers must be between 100 and 1000 times as large as those on the ground. He also suggests that the 'dynamo' currents due to tidal action are not unlikely to flow mainly in the F layer. Cowling also considered the electrical conductivity in the solar atmosphere and the ionosphere, and shows that a correction must be applied to the simple approximate free-path methods used in the derivation of the conductivity. Exact formulae are derived by the methods of Chapman and Enskog for the electrical conductivity of the solar atmosphere and the ionosphere. The integrated conductivity of the ionosphere is found to be of the order of 10^{-7} e.m.u., which is much smaller than earlier estimates.

In this paper, Cowling has also discussed the effects of diamagnetism and drift-currents in the earth's atmosphere, to which the solar and diurnal variations of the earth's field have been ascribed. He shows that these effects cannot produce a diurnal variation of this field much greater than 2γ, while semi-diurnal changes are much smaller. This provides further reasons why these effects are inadequate to explain the observed variations.

Solar Magnetism

The mechanical effects associated with the non-uniform rotation of the sun in the presence of its magnetic field have been discussed by Ferraro (M.N.R.A.S. Vol. 97, 458, 1937). The electrical conductivity of the solar material is so large that motion of the solar gases relative to the lines of magnetic force can take place only if the gas is polarized and if an electrostatic field is set up which neutralizes the electromotive force induced by the motion. This fact implies that the angular velocity of the sun, if not constant, must vary so that it is constant over a surface traced out by the revolution of a magnetic line of force about the solar magnetic axis. Further, only local departures from this steady state are likely to exist. The same result was later derived independently by Alfvén, who has termed the surfaces of constant angular velocity "isorotational surfaces". Ferraro also suggested that the sun's general magnetic field was unlikely to be limited radially to the extent supposed by Hale, as in this case the isorotational surfaces would have to be nearly spherical and the motion of the sun's surface uniform--in contradiction with observation.

Hartmann and Thiessen have recently advanced fairly definite evidence that the magnetic field does not fall off rapidly with increasing height. (See Observatory, 66, 229, 1946)

Cowling has also expressed doubts as to whether the sun's general magnetic field does fall off rapidly with increasing height. In a paper (M.N.R.A.S., Vol. 105, 166, 1945) dealing with the sun's magnetic field he shows that the time of electromagnetic decay of this field is of the order of 10^{10} years, so that this field could be a relic from a different primeval state. He also discussed in detail various hypotheses ascribing the field to thermal effects. Thus, ordinary thermo-electric currents can be ignored as these would produce a field directed in circles round the axis. Thermal effects due to convection in the rotating sun gives a field of the correct sign but 10^{-7} times too small, and modification of this hypothesis in which the field produced by thermal currents is magnified by dynamo action is shown to require over 10^{18} years for the field to grow to its present size. Other possible explanations of the sun's field are suggested and examined briefly; it is suggested that the field could be intensified by more efficient use of lines of force already existing or, a less likely hypothesis, that the material in the far interior of the sun is capable of magnetization.

The fact that lines of magnetic force are effectively "frozen" into the highly conducting solar material has been shown by Cowling (M.N.R.A.S., Vol. 106, 1947, p. 218) to imply that a sunspot magnetic field grows or decays because a magnetic field is convected up to the surface, or is sucked back. It may also be important in considering solar disturbances, for the convected material may generate electric fields producing electric discharges, which have been suggested by Waldmeier and Giovanelli as possible causes of solar flares, and by Alfvén and others as causes of prominences.

In his presidential address to the Royal Astronomical Society in 1943, S. Chapman (M.N.R.A.S., 103, 117, 1943) discusses various important questions relating to solar magnetism. He gives estimates of sunspot dipole moments and of sunspot magnetic flux. He derives an expression for the surface Poisson distribution of magnetic matter for a sunspot, which agrees well with Nicholson's observed variation of the inclination of the spot field with the radial distance from the center of the spot. He also draws attention to the large magnetic forces between the spots of a bipolar group and the force exerted by the general magnetic field of the sun.

He considers, for the first time, the important question of the electromagnetic growth and decay of a spot field.

Subsequently, T. G. Cowling considered this same question of the growth and decay of the spot field at greater length (M.N.R.A.S., 106, 218, 1946). From a study of the diagrams given in the Mount Wilson "Magnetic Observations of Sunspots", 1916-1924, and of the Greenwich curves showing the variation in area of 30-day and 60-day spots, Cowling shows that if the magnetic field is due to the darkening of the spot, a time of the order of one day at most is needed to establish the field. Electromagnetic decay or growth, on the other hand, would take 300 years. Cowling therefore concludes that the sunspot magnetic field must exist before and after the visible lifetime of the spot, and that the growth and decay of a spot is probably the result of mass motion of the solar atmosphere.

Cowling has also criticised Alfvén's theory of sunspots (M.N.R.A.S., 106, 446, 1946), though he thinks certain parts of the theory may be of permanent value.

Cosmic Magnetism

In 1892 Schuster first suggested that every massive rotating body might be the seat of a magnetic field as well as a gravitational field. Shortly after the discovery by Babcock (1947) that the star 78 Virginis possesses a magnetic field, P. M. S. Blackett in an important study (Nature, 159, 658, 1947) inferred that the ratio of the magnetic moment, P, to the angular momentum, U, for the case of the Earth, the Sun, and 78 Virginis is fairly well constant. He suggested that the formula

$$P = \beta G^{1/2} U/c,$$

where G is the constant of gravitation, c the velocity of light, and β a constant of order unity, may possibly be a fundamental law of nature, and may provide the long-sought connection between electromagnetism and gravitation.

A. L. Hales and D. I. Gough (Nature, 160, 746, 1947), following upon a suggestion of E. C. Bullard, compared their measurement of the horizontal intensity of the Earth's magnetic field in the Witwatersrand at a depth of 4800 feet with formulae derived from Blackett's theory by S. K. Runcorn and from core theories. They concluded that the results differ appreciably from both formulae.

S. Chapman (Nature, 161, 52, 1948) corrected Runcorn's formula and concluded that, while the observations of Hales and Gough are not in accord with the formula derived from core theories, it remains uncertain to what extent they agree with the correct formula derived for the variation of the horizontal magnetic intensity with depth on the Blackett theory.

Ionospheric Researches

1. Ionization and radiative equilibrium--The basic reactions in the ionosphere depend largely on its constitution and temperature; from radio measurement of the heights and electron densities, Martyn and Pulley (Proc. Roy. Soc., A, Vol. 154, 455, 1936) found that the temperature rises from almost 180°K at 80 km to values which in the F layer are of the order of 1000°K, and put forward the hypothesis that this high temperature persisted all the year round. Temperatures of the same order were derived theoretically by Godfrey and Price (Proc. Roy. Soc., A, Vol. 163, 228, 1937) from considerations of radiative equilibrium.

No reliable estimates of the molecular density of the upper atmosphere above the E layer are available as yet. There is good evidence, e.g. from meteors, that in this layer the molecular density is of the order of 6×10^{12} mol. per cc. In the F_1 and F_2 layers the daytime values are usually supposed to be of the order of 10^{11} and 10^{10} mol. per cc respectively. Ferraro has shown (Terr. Mag., Vol. 50, 215, 1945; Vol. 51, 427, 1946) that if the density in the F_2 layer were much smaller than 10^{10} mol. per cc, downward diffusion of ions would become pronounced. As the daily variation of the maximum electron density calculated in this case is markedly different from the observed variation, Ferraro concludes that the molecular density in the F_2 layer can scarcely be less than this estimate.

Martyn and Pulley suggested (loc. cit.) that the attachment of electrons to neutral oxygen atoms was likely to be the main process by which electrons disappear from the ionized regions. In a first investigation of the collision processes occurring in the ionosphere, Massey (Proc. Roy. Soc., A, Vol. 163, 542, 1937) concluded, in agreement with Martyn and Pulley, that negative ion phenomena were likely to play an important part in the disappearance of electrons in the ionized layers. In a later paper Bates, Buckingham, Massey, and Unwin (Proc. Roy. Soc., A, Vol. 170, 322, 1939) calculated by quantum theory methods the coefficient of recombinations between positive ions and electrons and found it quite inadequate to account for the observed recombination coefficient for electrons; they suggested that a dynamical equilibrium of electrons and negative ions existed, in which the proportion of negative ions to electrons was of the order of 100. In a more recent paper, Bates and Massey (Proc. Roy. Soc., A, Vol. 187, 261, 1946) express doubts as to the validity of this suggestion and they reconsider the whole problem of the equilibrium theory of the ionized layers. They point out that in their earlier work they had underestimated the importance of photo-detachment of electrons from negative ions during the daytime, which reduces the negative ion density below the electron density. In consequence, they consider that the problem of explaining the rate of disappearance of electrons in the ionized layers remains outstanding.

The marked reduction in the negative ion concentration due to photo-ionization has been pointed out also by Ta-You Wu (Terr. Mag., Vol. 50, 57, 1945), who suggested that the high value of the coefficient of recombination might be explained by assuming a preponderance of positive ions in the ionized regions. Ferraro has shown, however, that this hypothesis is untenable (Terr. Mag., Vol. 50, 223, 1945).

The radiative equilibrium in the ionosphere has been reexamined by R.v.d.R. Woolley (Proc. Roy. Soc., A, Vol. 189, 218, 1947) with special reference to the high temperature resulting from a radiation balance between strong ultraviolet absorption and relatively weak infra-red emission. Woolley suggests that while molecular oxygen is the principal cause of ultraviolet absorption at heights less than 250 km, at greater heights the absorption is mainly due to atomic oxygen. He also suggests that water vapor is the principal infra-red radiator at a height of 100 km, but that at greater heights there is no water vapor and that negative ions control the temperature there.

In a recent paper, R.v.d.R. Woolley (Proc. Roy. Soc., 187, 102, 1946) has examined whether it is possible to account for the observed electron densities in the ionosphere without assuming that the sun emits far more energy in the remote ultraviolet spectrum than would be emitted by a black-body at 6000°. He concludes that this could be done by supposing a low recombination rate in the F2-layer and by appealing to ionization from metastable states as a cause of the ionized layers.

2. Ionized layer formation--Chapman (Proc. Phys. Soc., Vol. 51, 93, 1939) has extended his study of the vertical distribution of ionization to the case when the ionizing radiation is not monochromatic, but is spread over a range of wave length, corresponding to an absorption band for some atmospheric constituent. He finds that the height of maximum absorption is somewhat lower than the level of maximum absorption for monochromatic radiation, and that the layer of absorption is more extended, mainly below the level of maximum absorption, than in the case of monochromatic absorption.

Chapman and M. Mian (Terr. Mag., Vol. 47, 31, 1942) have shown that the world-wide distribution of the rate of ion-production by monochromatic radiation at any level may be analyzed in a series of Legendre Functions, and that the rate of ion-production at any level in any latitude at any season may likewise be analyzed in the form of a Fourier Series.

M. V. Wilkes (Proc. Camb. Phil. Soc., Vol. 36, 479, 1940) has also considered, on the basis of Chapman's formula for the rate of ion-production, the layer formation in the ionosphere, on the assumption that electrons disappear, not according to the quadratic law, but by attachment to oxygen atoms at a rate proportional to the product of the numbers of oxygen atoms and electrons present.

Sir Edward Appleton (Nature, 157, 691, 1946) has drawn attention to two important effects recently discovered by him in the F2-layer. The first is a longitude effect in the electron density at places in approximately the same latitude and the second relates to a geomagnetic control of the ionization in this layer for low values of the sun's zenith distance.

3. Atmospheric tides in the ionosphere--Martyn (Proc. Roy. Soc., A, Vol. 189, 241, 1947) has advanced a theory whereby he seeks to explain the anomalous seasonal, diurnal and geographical variations of the F_2-region ionization by considering the solar tides in this region. The influence of the earth's magnetic field is shown to be important in this connection. Martyn finds that the F_2-region becomes greatly distorted and that a longitude effect arises by reason of the asymmetry of the earth's field. He uses the theory to explain the high F_2 ionization in low latitudes, the high values of h'_{F_2} at noon near the equator, and the afternoon and night time increase in ionization found at certain stations, and suggests that the effective coefficient of recombination in the F_2-region is much smaller than the generally accepted values.

4. Aurora, night-sky light, cosmic rays--From an analysis of simultaneous auroral and geomagnetic events at Fort Rae, for the 2nd International Polar Year, Stagg and Paton (Nature, Vol. 143, 941, 1939) suggest that in high magnetic latitudes there may be a closer spatial connection than has hitherto been supposed between the currents producing the major short-period geomagnetic perturbations and the concomitant auroral currents existing at heights of about 100 km.

Bates and Massey (Proc. Roy. Soc., A, Vol. 187, 261, 1946) have critically studied current theories on the origins of the night-sky light, and conclude that they are still far from certain. The oxygen recombination theory may possibly account for the intensity of the green line and the intensities of some of the red lines, while the ionized layer theory accounts for the remainder of the intensity of the red lines and of the nitrogen band systems. The sodium oxide theory may account for the intensity of the D lines.

D. R. Barber (Nature, Vol. 148, 88, 1941) gives some evidence of the reality of the connection between the frequent irregular variations of the night-sky light and the concomitant geomagnetic variations.

A. Duperier (Nature, Vol. 149, 579, 1942) has given an account of the remarkable changes of cosmic ray intensity associated with the magnetic storm of March 1, 1941, and shows that there was no simple proportionality between geomagnetic and cosmic ray disturbances. Its recovery was slow and not completed until the sixth day.

5. Solar-terrestrial relationships--H. W. Newton (M.N.R.A.S., Vol. 103, 244, 1943) has described relationships found between intense solar flares and magnetic disturbance, additional to the small synchronous perturbations of the earth's field. An investigation of all available data (up to 1943) on solar flares reveals that very intense flares have special distinguishing features, and shows the desirability of future observations including some quantitative data which might serve as an index of intensity. A selection of 37 flares was made as being specially intense (designated 3+), and the characteristics of these flares described. Examination of the magnetic storm records at Greenwich reveals that a very intense solar flare is frequently followed about one day later by a great magnetic storm ($\Delta H > 300\gamma$), provided that the flare is not farther than 45° from the center of the sun's disk. Very intense solar flares and great magnetic storms are both rare occurrences, and the degree of association revealed by the analysis is much higher than pure coincidence would account for. The results suggest that the associated magnetic storms are of the nascent-stream type described by Bartels, and indicate a time of travel of the stream from sun to earth of about 26 hours or rather less for the most intense storms. The distribution on the sun's disk of the flares preceding great storms also suggests that the semi-angle of the cone of the solar stream may sometimes be as great as 45°.

In a second paper (M.N.R.A.S., Vol. 104, 4, 1944), Newton has examined solar flares of intensities 3 and 2 to see if a similar relationship exists between them and subsequent magnetic disturbance; 118 flares of intensity 3 and 332 of intensity 2, for the period 1934-1942, were considered, and compared with (a) magnetic storms recorded at Greenwich, (b) the daily international magnetic character figures. For flares of intensity 3, there is a small statistical rise of magnetic disturbance within a few days of the flare; the disturbance is less intense and decidedly less probable in occurrence than for flares 3+. There is no significant rise of geomagnetic activity for flares of intensity 2. Radio fade-out data confirm these results but are less definite than the solar flare data.

A statistical study of the relation between magnetic disturbance and solar phenomena has also been made by C. W. Allen (M.N.R.A.S., Vol. 104, 13, 1944). The data used relate to the 2800 disturbed days during the period 1906-1942. The disturbances were classified on the basis of their 27-day recurrence tendency into four groups, depending on whether the disturbance was within a sequence, started a sequence, ended a sequence, or was non-recurrent. The results tend to confirm the view that storms are of two distinct types: In the first they are intense, have sudden commencements, are associated with sunspots and follow a solar flare after about one day; in the second they are less intense, have less sudden commencements, are not closely related to sunspots or solar flares, but show a definite 27-day recurrence tendency. Although the storms considered by Allen are not generally as great as those considered by Newton, there is again evidence that great storms are caused by particles from solar flares, these particles taking about 1-1/2 days to reach the earth. The less intense storms appear to be caused by streams of particles issuing from "M-regions" on the sun, these particles taking about 3 days to reach the earth. M-regions tend to avoid the area within 40° of sunspot groups but have a maximum frequency just outside this area. Allen suggests the identification of M-regions with the source of coronal streamers and thus explains some of the characteristics of M-regions including their maximum development two years before sunspot minimum.

6. Sudden Commencements--The Greenwich magnetic records have been examined by H. W. Newton (M.N.R.A.S., Geophys. Sup., Vol. 5, in press) to discover the characteristics of the sudden commencements recorded there, and any periodic variations in the frequency of their occurrence. For the six solar cycles covered, 681 sudden commencements were found; these were divided into four groups, A, B, C, D according to the intensity of the following disturbance, ranging from great storms to slight or no disturbance. In rather more than half the S.C.s found, there was a small preliminary impulse of opposite sign from the main impulse; these are denoted by S.C.* . The main impulse in H was positive in 91 per cent cases, and ranged from 10γ to 180γ, the mean amplitudes for the four groups A, B, C, D being 78, 49, 37, 30γ. The duration of the main impulse was about 3 minutes, and that of the preliminary impulse (when it could be measured from quick-run records) about 1/2 minute.

The hourly frequency of occurrence of S.C.s at Greenwich appears to show a diurnal variation with a minimum centered at 8 a.m., with a sharp rise about noon to an afternoon maximum. The S.C.* s show this variation most distinctly. There also appears to be a daily variation of the ratio preliminary impulse/main impulse from about 0.1 to 0.4, the greatest values occurring at 7 a.m. and 10 a.m., but the intervening period showing a discontinuity with no S.C.* s. The "inverted" S.C.* s occur mainly during this period, suggesting some change in conditions for the production of S.C.s at about 8 hours local time. This apparent dependence on local time evidently requires further elucidation, as it seems at first sight inconsistent with the known synchronous world-wide occurrence of many S.C.s.

The monthly frequencies also appear to show a seasonal variation with a minimum in winter and a general maximum from about March to September. This contrasts with the frequency of occurrence of small disturbances not associated with S.C.s which have sharp peaks at both equinoxes and deep minima in summer and winter.

By superposing the data for the six solar cycles, frequency graphs of S.C.s were obtained which agree well with the 11-year sunspot curves. A significant difference was again found in the frequency distribution over the solar cycle between small storms having S.C.s (which closely parallels the sunspot curve) and small storms without S.C.s.

7. Analysis of Observations--S. Chapman and J. C. P. Miller have outlined (M.N.R.A.S., Vol. 4, 649, 1940) the mathematical theory and described the essentials of the method they have developed for the determination of lunar daily harmonic component variations in meteorological and geomagnetic elements, from series of hourly or bi-hourly values covering long periods of time. A somewhat different treatment from that used in sea-tidal analysis is necessary owing to the data being overlaid by much larger solar daily and irregular fluctuations. The method involves first a harmonic analysis of average solar daily inequalities for "lunar" groups of days chosen according to the hour angle of the mean moon at Greenwich mean noon; this analysis allows for the presence of a non-cyclic element, mainly irregular, in the inequality, but otherwise is made as if the only

components present were periodic in the mean solar day. From these primary harmonic coefficients for the different lunar groups of days the true solar daily variation is obtained, and by eliminating that, the lunar daily variation is also found. This involves a second process of harmonic analysis in which the terms of the sequences analyzed are (a) the "primary" harmonic coefficients for the different lunar groups of days, and (b) the numbers of days in each of these groups. A general theory of the analysis of a function containing "non-integral" harmonics is described, the theoretical formulae being expressed, for brevity and convenience of manipulation, in terms of complex plane vectors. This theory is illustrated by obtaining the detailed formulae required in the determination of lunar daily harmonic components.

The method used and described by Chapman and Miller in the above paper may be described as the "fixed-age" method, in contrast to the "fixed-hour" method recently adopted by others, notably by J. Bartels and H. F. Johnston in discussing the geomagnetic tide at Huancayo. A comprehensive review of the different methods of computing the lunar geomagnetic tide, L, and of its various mathematical and graphical representations has been made by S. Chapman (Terr. Mag., Vol. 47, 249, 1942). This paper reveals how important the dynamo theory of L has been, in that it has indicated the type of relationship to be expected between the phases of the harmonic constituents of L, and has thus proved an indispensable guide in analyzing the observed variations of the magnetic elements for lunar effects. Chapman shows how each harmonic lunar atmospheric tide ("Q-tide") may be regarded as generating a part L(Q) of the L-field, and develops a convenient notation depending on this for dealing with the complex phenomena involved. The various possible modes of describing and representing mathematically the partial geomagnetic tides L(Q,U,P) for any element U and station P are examined and compared, and a new mode of representing L throughout half a lunation or any greater interval (ignoring seasonal changes) is described. This representation is by means of a surface, or by plane contour lines representing the surface. The relations between the various aspects of L hitherto considered by Chambers, Figee, Bartels, Johnston, Chapman, and Miller, are elucidated with reference to this surface.

In a paper entitled Greenwich frequency-statistics of geomagnetic disturbance (Terr. Mag., Vol. 46, 385, 1941), S. Chapman has continued and elaborated his discussion of the statistics of the frequency of magnetically disturbed days at Greenwich, begun in an earlier paper (Phil. Trans. Roy. Soc., A, Vol. 225, 49, 1925). The former discussion was based on hourly values of the declination (D), this later discussion is based on hourly values of the horizontal intensity (H). The sum of the hour-to-hour changes of H from one Greenwich noon to the next is denoted by v_H. This has been determined for 21,323 days covering the period 1848-1913, omitting 1864-67. Frequency tables and graphs are given showing the proportion of days on which v_H lies within assigned ranges, (i) for the mean of the year, (ii) for the mean of each calendar month, (iii) for each of the three seasons in five groups of years of different mean sunspot number, and (iv) for two groups of years of similar sunspot number taken from ascending and descending parts of the sunspot-cycle. The results are compared with similar tables and graphs for R_D, the daily range of declination D after the monthly mean S has been removed. The frequency distributions for v_H and R_D, especially as regards their dependence on season and sunspot epoch, are shown to be similar. A method of correcting the v_H-statistics for the influence of S_q is devised; an attempt is also made to correct the R_D-statistics for the influence of the day-to-day variability of S_q. The corrected frequency-graphs are in notably good agreement. The numerical measure v_H is shown to be fairly closely correlated with the international daily magnetic character figure C throughout the year.

In a series of eight papers entitled "Notes on Isomagnetic Charts" (Terr. Mag., Vol. 45, 433, 443; Vol. 46, 7, 15, 163; Vol. 47, 1, 115, 139, 1940-1942) S. Chapman has developed the fundamental theory underlying the construction of isomagnetic charts. The geometry of isomagnetic and other contour lines on a sphere is first considered; the nature of their singular points (foci and nodes) is elucidated and all the possible forms of the isomagnetic lines near these points are examined. An exact mathematical treatment is then given of the isogonic and X- and Y-charts for the field of the centered magnetic dipole. In the fourth and fifth papers the nature and occurrence of geomagnetic dip-poles is discussed, and the forms of the various isomagnetic lines and of the magnetic meridians in the neighborhood of these poles are examined in detail. The sixth paper deals with the methods of evaluation of the earth-air current (i) from the isomagnetic charts for D and H. A new method is given of evaluating the current by calculating the curl directly from the D- and H-charts. The error of estimation of the curl and hence of i is examined, and it appears that the non-zero values of i are mainly due to errors in one or both charts. It is suggested that when new charts of D and H are constructed, the value of i should be taken as zero (on the atmospheric-electric evidence) and the mutual consistency of the charts should be tested and adjusted by methods which are indicated. The seventh paper deals with isoporic charts, and in particular with the character of the D-, H-, and I-isopors near the dip-poles and other singular points. In the last paper the mutual consistency of the D- and H-isoporic charts is considered by methods similar to those described for the isomagnetic charts. It is shown that the inferred values of di/dt indicate considerable error in the isoporic charts.

8. Electromagnetic induction problems associated with geomagnetism--The theory of the induction of currents in non-uniform sheets and spherical shells has been studied by A. T. Price. This has been undertaken to obtain, if possible, a more accurate appraisal of the influence of the oceans on magnetic variations, and also to obtain a clearer understanding of the shielding effect of the non-uniform ionospheric layers, particularly in relation to Chapman and Ferraro's theory of magnetic storms. A. Ashour and A. T. Price have made calculations of the magnetic field inside a non-uniform spherical shell when the magnetic field outside varies (i) suddenly, (ii) periodically, (iii) aperiodically. Apart from the applications referred to above, it is hoped that these calculations will throw some light on the results of the analysis by Newton (referred to above) of the sudden commencements at Greenwich.

(B) Atmospheric Electricity.

In 1939 the results of three investigations were published which were discussed in the last report. These related to the field changes due to lightning flashes (T. W. Wormell, Phil. Trans. Roy. Soc. A., 238, p. 249, 1939), the intermediate ions of the atmosphere (A. R. Hogg, Proc. Phys., 51, p. 1014, 1939), and the conductivity close to the earth's surface (A. R. Hogg, Commonwealth Solar Observatory Mem., 7, 1939).

(1) Kew Observatory.

Measurements and Recordings

During the war years the resources of the Observatory were directed to urgent work for the national war effort, so that work in atmospheric electricity was largely limited to maintaining the measurements and recordings of those atmospheric electrical elements near the surface which had formed the basic program of work before the war.

Continuous autographic records have been maintained of the following elements:

(1) Potential gradient
  (a) by Kelvin photographic equipment
  (b) by auxiliary Benndorf electrograph (since 1942), with half the sensitivity of the Kelvin instrument
(2) Point discharge from artificial point (Geophysical Memoirs No. 68, 1936)
(3) Electrical charge on rain (Geophysical Memoirs No. 75, 1938)

Measurements of the earth's field have been made regularly for standardizing the autographic records, and air-earth current and conductivity have been measured when conditions were suitable.

Values of potential gradient, air-earth current and conductivity have been published up to 1937 in the Observatories Year Books; data for the years 1938 to 1946 are ready for publication.

Investigational Work

A further batch of alti-electrograph ascents were made and the results discussed by Simpson and Robinson. The conclusions reached by Simpson and Scrase were in general confirmed. Higher levels were reached in the later soundings, most of which showed no detectable field at the highest point. The uppermost charge was in all cases positive. A more complete analysis of the locations of charges in a few storms was made possible by the use of a greater number of instruments. The traces obtained below the cloud base did not show the increase in field expected from the usual theories of space charge in high fields.

Sir George Simpson has completed an analysis of the records obtained from the rainfall electrograph during the years 1942-46, with particular reference to the simultaneous variation of rain charge and rain current, potential gradient and discharge current from the artificial point. By concentrating attention on those (fairly frequent) periods which show a "mirror image" relationship on point discharge current and rain current, he has derived empirical relationships connecting rate of rainfall, net charge on rain and point discharge current. He has proposed an explanation of these relationships which enables him to confirm Whipple and Scrase's estimate of the natural point discharge currents at Kew. The fact that the alti-electrograph traces did not show the space charges due to these currents, remains unexplained.

Sir George Simpson has also examined certain regular repetitions of pattern in the variations of potential gradient during disturbed conditions.

In recent months an attempt has been made to measure the electrical current flowing up and down a living tree. It is found that discharge occurs from the tree at the same time as from the artificial point but is normally smaller; there is probably a seasonal variation in the threshold value of the field necessary to produce discharge from the tree.

Bibliography

Sir GEORGE SIMPSON and G. D. ROBINSON. The distribution of electricity in thunderclouds, II. Proc. Roy. Soc., A, Vol. 177, 1941, pp. 281-329.

G. D. ROBINSON. The distribution of electricity in thunderclouds. Q. J. Roy. Met. Soc., Vol. 67, 1941, pp. 332-340.
A. J. DRUMMOND. A century of progress in atmospheric electricity at Kew Observatory. Q. J. Roy. Met. Soc., Vol. 70, 1944, pp. 49-60.
Sir GEORGE SIMPSON. The electricity of cloud and rain. Q. J. Roy. Met. Soc., Vol. 68, 1942, pp. 1-33.

(2) The Distribution of Charge in Thunder Clouds.

Sir G. C. Simpson and G. D. Robinson (Proc. Roy. Soc. A., 177, p. 281, 1941) have published further results with the alti-electrograph, continuing the work of Sir G. C. Simpson and F. J. Scrase (Proc. Roy. Soc. A, 161, p. 309, 1937). The alti-electrograph consists of a device for recording the sign of the electric field during the ascent of a free balloon. Results for eight thunderstorms are given, in many cases with simultaneous records of the field at the earth's surface and the electric current due to rain; the previous conclusions are confirmed. Simpson and Robinson gave a detailed analysis of the kinds of record to be expected in various ascents through a typical thundercloud and found that all their records could be fitted into such a scheme. The distribution of charge consists of an upper positive and lower negative region, while still lower, in a localised region, there is a concentration of positive charge; the presence of this lowest charge was certainly proved in many of the thunderstorms investigated, and probably exists in all. But the South African measurements, by Schonland, show no sign of a lower positive charge. The presence, in English thunderstorms, of two distinct regions of positive charge argues two distinct processes of separation of charge, and Simpson and Robinson have shown that the upper separation occurs at temperatures below the freezing point, while the lower separation occurs above the freezing point. This later work supports the theory of Simpson and Scrase, that the cause of the upper separation is friction between ice particles, while that of the lower separation is the breaking of rain drops in ascending currents of air.

(3) The Electric Charge on Rain.

Sir G. C. Simpson, in his Presidential Address to the Royal Meteorological Society (Q. J. Roy. Met. Soc., Vol. 68, p. 1, 1942), in addition to referring to earlier work, mentions results obtained at Kew in which light steady rain showed an inverse relationship between the rain charge and the field. A particular example of the same phenomenon has been discussed by J. A. Chalmers and E. W. R. Little (Terr. Mag., Vol. 45, p. 451, 1940), who have shown that the results can be interpreted either in terms of a bipolar cloud, with positive charge uppermost, or in terms of a wholly negative cloud, depending upon the effective separation of trees, etc., which give rise to point discharge; the problem of this effective separation has been further discussed by J. A. Chalmers (Phil. Mag., Vol. 31, p. 363, 1941). J. A. Chalmers and E. W. R. Little (Terr. Mag., in course of publication) have described measurements on the current received by a completely exposed area of ground, and the point discharge currents to an exposed point, the paper referred to above being an account of a single day's observations. In addition to results in agreement with previous observations, two points of interest emerge; it was found that the inverse relation of rain charge and field for steady rain during the winter and spring gives place in summer to a direct relation. And a number of occasions have been observed in which there was a negative field without precipitation, but with light mist; similar recent observations by J. A. Chalmers during periods of "sea-fret" have not yet been published; the importance of this phenomenon lies in the fact that there must be separation of charge to give the negative field, and yet neither ice-friction nor the breaking of drops is likely to be occurring.

Work has been commenced at Durham to measure simultaneously the charges and masses of rain drops, with simultaneous measurement of the field. For the measurement of field, J. A. Chalmers has devised a new method, in which a rolling steel ball carries off some of the "bound" charge on an earth-connected conductor and this charge is used to measure the field; this work has not yet been published.

(4) Ionization in the Atmosphere.

J. A. Chalmers (Q. J. Roy. Met. Soc., Vol. 72, p. 199, 1946) has carried a stage further the investigation of A. R. Hogg (Commonwealth Solar Observatory Mem. 7, 1939) by showing, theoretically, that the type of variation of conductivity with height found by Hogg is consistent with an increase in the rate of production of ions as the surface of the earth is approached.

(5) Absorption of Ions by Falling Particles.

By the death of F. J. W. Whipple, the subject of atmospheric electricity has lost one of its foremost workers. In a posthumous paper of Whipple's with J. A. Chalmers (Q. J. Roy. Met. Soc., Vol. 70, p. 103, 1944) there is a detailed discussion of the process suggested by C. T. R. Wilson (J. Frank. Inst., Vol. 208, p. 1, 1929) for the capture of ions by falling drops, polarized in an electric field. The results have been applied by Chalmers and Little (Terr. Mag., Vol. 45, p. 451, 1940) to the acquisition of charge by rain drops. More recently, J. A. Chalmers (Q. J. Roy. Met. Soc., in course of publication) has extended the theory to the capture of ions by falling ice particles and has shown that, weight for weight, ice particles should be more effective than water drops in capturing ions; he has given reasons for rejecting the idea that Wilson's process is the main agent for the separation of charge in thunderclouds, but it may be of major importance in the question of the charges on rain drops.

(6) Fields Below Clouds.

When point discharge occurs, there must be a space charge between the cloud and the earth, and hence a larger field just below the cloud than lower down. But the interpretation of the widths of the alti-electrograph traces in terms of field strengths (Simpson and Scrase, Proc. Roy. Soc. A, Vol. 161, p. 309, 1937) show no such increase on rising. J. A. Chalmers (Q. J. Roy. Met. Soc., Vol. 70, p. 121, 1944) has shown that neither the effect of rain charges, nor of vertical air currents can account for this discrepancy. The possibility remains that the width of the alti-electrograph trace does not measure the actual field strength, but some other quantity, perhaps the vertical current density.

(7) Lightning.

J. M. Meek and F. R. Perry (Phys. Soc. Rep. on Progress in Physics, Vol. 10, p. 314, 1944-45) have given an extensive report on the lightning discharge, covering both British and foreign work. Of the recent British work, mention may be made of theories of the stepped leader; C. E. R. Bruce (Nature, Vol. 147, p. 805, 1941, and Proc. Roy. Soc. A, Vol. 183, p. 228, 1944) has attempted to account for the "step" process by corona loss from the leader channel and transition from glow to arc conditions. C. E. R. Bruce and R. H. Golde (J. Inst. Elec. Eng., Vol. 88, Pt. II, p. 487, 1942) have analyzed various properties of lightning discharges and have pointed out distinctions between discharges in tropical and temperate zones.

T. W. Wormell has recommenced work on the electric field changes due to lightning discharges, using a capillary electrometer and cathode-ray equipment. No results have yet been published.

(C) Electric Currents in the Sea and English Channel.

The Admiralty has pursued some research on terrestrial magnetism in connection with the method used for detecting enemy ships by their magnetic field. It has been shown that the natural short period variations in the earth's magnetic field are often very different at different points near an estuary or sea channel. It has been shown that this is due to a fluctuating electric current flowing in the waters of the channel, and that this electric current is of the nature of a natural earth current. The electric current in the Clyde estuary has been observed to produce electric potential gradients of the order of a few millivolts per kilometer, and associated magnetic fields of the order of a few gammas.

Experiments have also been made off Plymouth. Continuous records were made there, during September, 1946, of the potential gradients in the sea, and it has been possible to distinguish two causes of the potential gradient. The first is an electromagnetic induction due to the tidal motion of the water in the presence of the earth's magnetic field; this potential gradient amounts to some 15 millivolts per kilometer directed approximately N-S at right angles to the tidal stream and fluctuating with tidal period. The second cause is an earth current flowing approximately E-W along the length of the English Channel and fluctuating with time in an irregular way. This electric current can almost always be observed by the small fluctuating potential gradient which it produces, but it is most active at times when the magnetic observatories register general geomagnetic activity. At the sudden onset of a magnetic storm, potential gradients as high as 50 millivolts per kilometer have been measured. There is little doubt that the earth current in the Channel produces a magnetic field affecting the magnetic records at the observatory at Abinger.

The earth-current activity is mainly confined to short-period fluctuations of duration 20 minutes or less.

Accounts of this work were given at a Geophysical Discussion of the Royal Astronomical Society and will probably be published by the Society.

(D) Auroral Work. [Supplied October 14, 1947, by J. Paton, of the University of Edinburgh, the initiator and originator of the work.]

Stations equipped with Stormer-Krogness auroral cameras were established in September 1946 at

	Latitude	Longitude	Observers
A. Newburgh, Fife	56°21′03″	3°13′50″	J. Paton and D. A. Thomson (Schoolmaster)
B. Blairgowrie, Perth	56 34 50	3 20 36	J. McKellican (Road Surveyor)
C. Newton Stewart, Wigton	54 57 37	4 29 6	H. W. Geddie, Rector, High School and his staff

Base lines AB = 26.5 km AC = 173.7 km BC = 194.1 km.

The observers are all voluntary and took part in regular practices throughout the winter.

During this winter of sunspot maximum, in order that all aurora visible here may be covered, I am residing at Abernethy, traveling to the laboratory in Edinburgh each day. The station A at Newburgh has therefore been shifted three miles west to my home at Abernethy (56°20′01″, 3°18′38″). In addition, thanks to the loan of another camera from Professor Störmer, a new station D has been established at Bridlington School, Yorks (54°5′10″, 0°12′43″), the observers being the science masters, Messrs. Reeve and Lewis. Invaluable help has been given by G.P.O. telephones. Their night supervisor, at Perth, becomes virtually one of the team during photography.

Detailed instructions on the photography of aurora, meteors, mother-of-pearl clouds and luminous night clouds, including notes on the photography of quiet arcs according to Professor Störmer's International Scheme, have been supplied to each observer.

Few aurora were visible during the winter of 1946-47 and parallactic photographs were secured only on the nights of March 2nd - 3rd (A and B) and April 17th - 18th (A, B and C). Since the beginning of August, auroral activity has been great, but most of the displays have been confined to elevations of less than 20° above the N horizon, even observed from the northern stations A and B. The reputedly fine display of 15th - 16th August 1947 was visible only at Station B for some minutes, low stratus obscuring the sky completely. On this night a few photographs of a corona were obtained at B during the few minutes that cloud conditions permitted photography. Photographs of low aurora were taken at A and B simultaneously during the nights of 17th - 18th, 22nd - 23rd September and 9th - 10th October. Photography of a quiet arc according to the International Scheme took place on the night of 22nd - 23rd September. Rather diffuse luminous night clouds were photographed from A and B on the night of 25th - 26th August. Measurement of the plates is proceeding.

This work has been made possible through the grants of (a) £100 from the Royal Society (Government Grant) for general expenses, and (b) £100 from the Department of Scientific and Industrial Research for telephone expenses. Both are likely to be expended by the end of the present auroral season.

(E) Ordnance Survey.

No magnetic survey work has been done since 1939.

(F) Irish Survey of Vertical Magnetic Force, 1944-46.

The earliest magnetic survey of Ireland was carried out during the years 1834-38 and reduced to epoch 1837 by Sabine and Lloyd. A second survey epoch 1857 was made in 1857-62 by the same workers. In 1890-96 Rücker and Thorpe carried out a much more extensive survey which was reduced to the epoch 1891.

In 1944 it was decided to expand some local observations made with a vertical force variometer into a general survey of the country related to geological conditions. It was intended to reoccupy Rücker and Thorpe's stations of which there were 44, but most of these were situated near towns, and owing to new constructions and the presence of magnetic materials most of these proved unsuitable and this practice was discontinued. These stations were only a small fraction of the total number (1183).

The field work of the survey was carried out between August 1944 and August 1946. The instrument used was a Watts vertical force variometer No. 21885 and transport was by car. Readings were taken at intervals of about five miles along the routes followed but the interval varied as the geological structure or magnetic gradient demanded more detail. Stations were selected beside main roads and to facilitate accurate fixing usually close to road intersections. Positions were noted on 1/2″ topographical maps and later transferred to 6″ geological maps (duplicate series).

The readings at each station were taken by two observers working independently with different tripods. The procedure was as follows. The tripods were set up about 20 yards apart and the instrument read six times on each tripod. If the values for the two positions agreed within 10γ the average was accepted. Usually they agreed to 5γ. If, however, they disagreed by more than 10γ two further positions were chosen to form a square. This usually revealed whether the disturbance was due to a nearby magnetic object or to a steep gradient in the neighborhood. In the former case the average of the readings in agreement was taken, but in the latter a new station was selected.

On the whole the instrument behaved satisfactorily. There was a gradual drift in both sensitivity and zero reading due apparently to vibration and shock in transport and use. Tests for sensitivity by use of the auxiliary magnets were made every few days and the zero reading was checked by frequent visits to the subsidiary base station Phoenix Park and other previously read stations. As the survey progressed it was possible to revisit a few of these stations daily as besides being a check on the instrument this proved a convenient means of detecting magnetic storms. Minor errors which could not otherwise be accounted for were attributed to magnetic pulsations, temperature effects and personal errors.

Of the 1183 observation stations chosen in an area (excluding Northern Ireland) of approximately 26,000 square miles, 53 were rejected and 118 duplicated, so that the total number of stations accepted is 1012. Final values have been worked out for 892 of these. A small amount of field work is still necessary in order to clear up some irregularities revealed in the plotting of results. The stations that had to be discarded were on locally disturbed ground or else observations were made during magnetic storms.

The instrument readings converted to gammas were corrected for diurnal variation by reference to the mean hourly values as supplied by Abinger Observatory. A simple deduction was made without regard to the latitude or intensity of the station. Corrections for altitude or temperature were not considered necessary. Tables were prepared listing the positions, times and values of the field readings and the reading corrected for diurnal variation. The final figure "x" gives the vertical intensity in relation to that of the base station Valencia Observatory. The absolute value of the base station was on August 24, 1944, found to be 44220γ and all intensities are therefore 44220$\pm$ "x" γ.

For the various field trips different reductions had to be made to bring all readings to this datum. These reductions were arrived at from the differences in repeat readings at many stations and it is assumed that they both correct for drift in the instrument constants and at the same time make allowances for secular variation.

The results of the survey are presented as two tracings on a scale of 10 miles to the inch. One sheet shows the vertical magnetic intensity by contours drawn at 50γ intervals, the zero being the value at Valencia Observatory on August 24, 1944, i.e. 44220γ. In preparing this map certain readings were omitted as being on small localized anomalies due to known minor igneous intrusions, on steep irregular gradients in regions of igneous or metamorphic rocks or as being single isolated abnormal readings of unknown origin. The other map shows lines of equal anomaly of vertical intensity also at 50γ intervals. In the preparation of this the value of the normal field was arrived at by a process of trial and error. The Valencia base has been accepted as being normal and a normal increase of 6γ per mile along the magnetic meridian (N 14-1/2 W) has been assumed. Though this map clearly defines all the major anomalies it would probably be more correct if the base were treated as being about 50γ above normal and the increase about 5.6γ per mile.

It is hoped to publish the magnetic map as soon as conditions permit. There have been difficulties in this work owing to shortage of equipment, and we have been greatly indebted to H.M. Royal Observatory at Abinger for supplying mean hourly values of the vertical component from continuous trace records. Athlone, however, at the center of Ireland, is approximately 350 miles from Abinger, and 8° west of Greenwich. Owing to its extreme westerly position beyond meridian 10° W, the Valencia locality is of great importance for magnetic observations, and it is hoped that this station will be re-equipped and fully modernized at an early date.

The extension of the magnetic survey into Northern Ireland is much to be desired, although the large basaltic areas will no doubt introduce anomalies and problems of their own.

HUNGARY

REPORT OF THE HUNGARIAN NATIONAL COMMITTEE OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

Abstract

By Karoly Kántás

The Hungarian National Committee of the International Union of Geodesy and Geophysics held its after-war reforming meeting on November 17, 1947.

The first regular meeting was held on January 19, 1948. The work of the Committee and sections actually began after this date. The result of work by the Committee is this report which comprises magnetic work carried out up to 1948 by Baron Roland Eötvös Institute of Geophysics, Hungarian Institute for Meteorology and Terrestrial Magnetism, Hungarian-American Oil Industrial Company, Limited, Hungarian Institute of Cartography, Hungarian Institute of Militarial Technics, and also a summarization of magnetic works published in Hungary between 1939-1947.

The report, of course, due to war losses, is not complete. The most extensive work was carried out by the Hungarian-American Oil Industrial Company, Limited, on an area of approximately 38,000 km^2 (40 per cent of the whole territory of Hungary), and determined the vertical component of the earth's magnetic field at 16,000 stations.

The State Institute of Geophysics, for solving special geological problems, executed minor magnetic surveys.

The Institute for Meteorology and Terrestrial Magnetism was principally confined to observations in the Observatory, and determined the horizontal components and inclination of the earth's magnetic field at 31 stations.

The Hungarian Institute of Cartography and the Institute of Militarial Technics determined the magnetic declination at 72 stations.

Our report is merely a modest one, as permitted by the circumstances. It is a sign of our revival. The contents are all what we have salvaged from the ruins of the war.

Budapest, Hungary
May 20, 1948

REPORT ON MAGNETIC SURVEYS MADE FROM 1939 TO 1947 BY THE HUNGARIAN "BARON ROLAND EÖTVÖS" STATE INSTITUTE OF GEOPHYSICS

By János Renner, Director

1. Introduction--Terrestrial magnetic surveys have always been important in the work program of the "Roland Eötvös" Institute. During the life of Roland Eötvös, the excellent scientist, all geophysicsl surveys under his direction had been connected with terrestrial magnetic surveys. The Institute resumed these surveys later, partly with absolute, but mostly with relative measurements. The relative measurements were executed with a horizontal variometer (Kohlrausch system), and with a horizontal and a vertical magnetic variometer (Schmidt system). When determining daily variations the terrestrial magnetic data of the observatory were partly used, and partly the results of our own registrations have been adopted. Our terrestrial magnetic surveys performed in the field were carried out mostly for the purpose of studying questions of the earth-crust structure.

The research work of the Institute of Geophysics until the first half of 1943 was directed by Dr. Jenő Fekete. His sudden death in March of that year was a great loss to the Institute and to the entire scientific world. Imre Bassó succeeded him as Director until 1945; he was followed by Tibor Dombai who directed the field surveys.

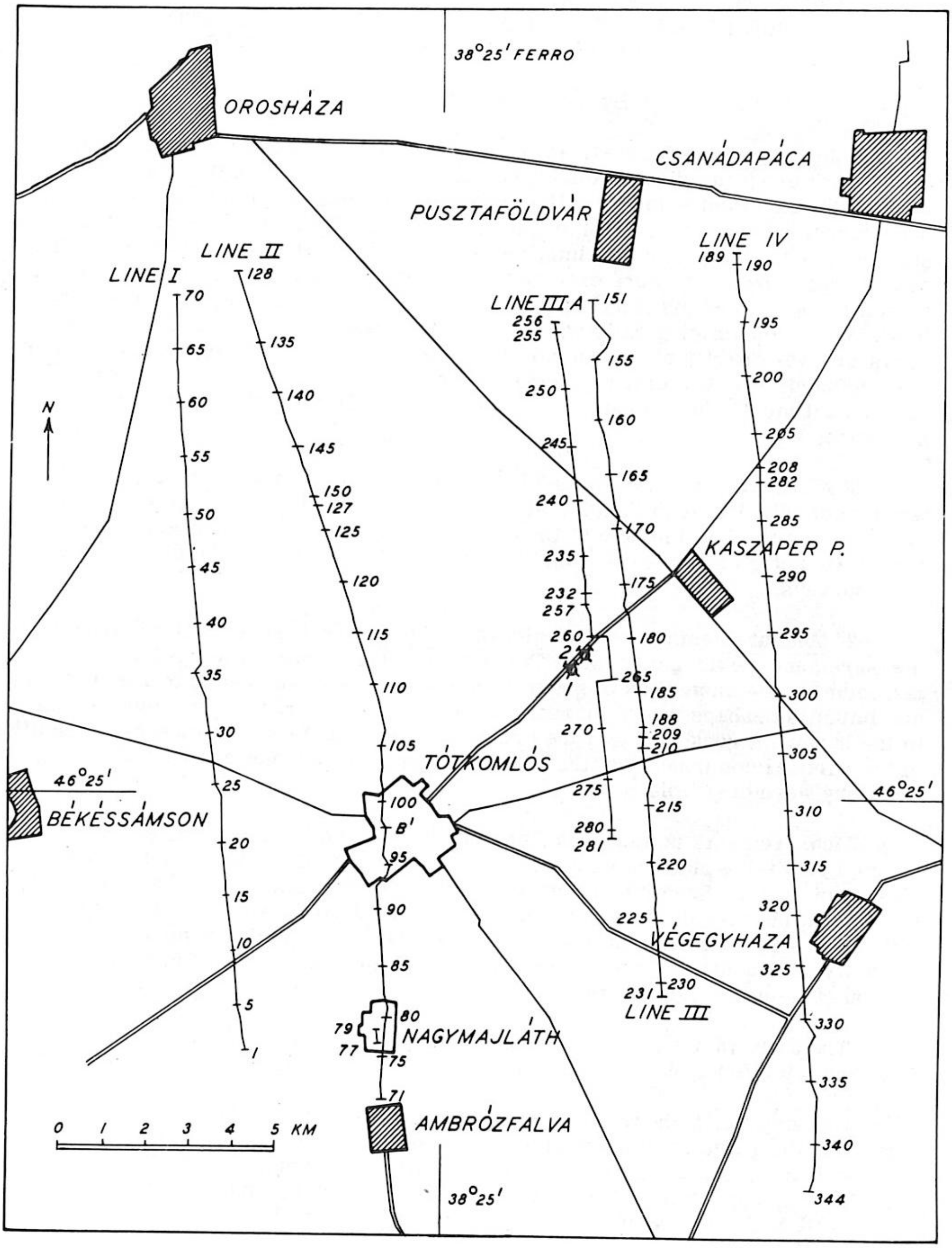
2. Measurements in the vicinity of Tótkomlós in 1941--Torsion-balance measurements performed east of Tótkomlós in 1940 showed a well-determined maximum in the anomalies of gravity. Since it could have been supposed that this maximum is perhaps due to increase in density derived from a volcanic intrusion in the basement rock, and that the eruptive rocks might cause noticeable anomalies in the vertical components of the earth's magnetism, magnetic surveys in this territory were desirable.

Measurements lasted from October 29 to November 19, 1941, and were carried out at 344 stations with a vertical variometer (Schmidt system). With the use of another Schmidt variometer at the registering station, observations for determining the daily variations were executed every half hour during the field work. For the elimination of probable changes in the instrument, vertical intensity measurements were taken daily at a base station before and after completion of field measurements.

The daily variations were first taken from the values of our own registration, and later from the data of the Observatory of Ógyalla.

Drawing No. 1 shows location of stations observed in about a north-south direction along five sections with distances of 200 meters between stations. Line "a" on drawing No. 2 shows vertical anomalies corrected with the data of our registration, while line "b" shows them adjusted with the data obtained by Ógyalla. The result of the two kinds of reduction are practically identical. The anomalies of all sections are referred to the base station.

No well-determined maximum value was observed along either section; the variations are insignificant, and no conclusion may be arrived at from the terrestrial magnetic anomalies as to the presence of greater subsurface magnetic masses. These measurements were performed by Gyula Banai.



38°25' FERRO
OROSHÁZA
CSANÁDAPÁCA
PUSZTAFÖLDVÁR
LINE I
LINE II
LINE III A
LINE IV
LINE III
KASZAPER P.
TÓTKOMLÓS
BÉKÉSSÁMSON
46°25'
VÉGEGYHÁZA
NAGYMAJLÁTH
AMBRÓZFALVA
38°25'
N
0 1 2 3 4 5 KM

Figure 1

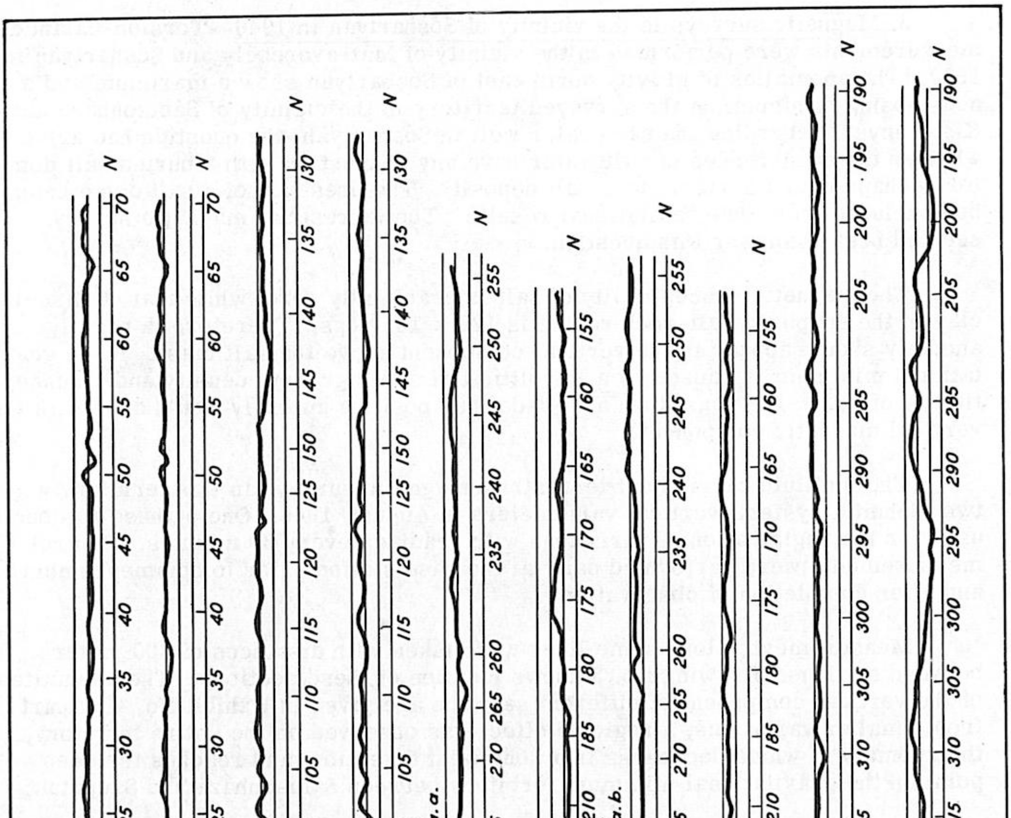

LINE I.a.
LINE I.b.
LINE II.a.
LINE II.b.
LINE III/a.a.
LINE III.a.
LINE III/a.b.
LINE III.b.
LINE IV.a.
LINE IV.b.
40γ
S
N

Figure 2

3. Magnetic surveys in the vicinity of Sóshartyán in 1946--Torsion-balance measurements were performed in the vicinity of Mátraverebély and Sóshartyán in 1937. The anomalies of gravity north east of Sóshartyán show a maximum and a non-closing minimum on the surveyed territory in the vicinity of Sámsonháza and Kisterenye. Regarding the salt-water well in Sóshartyán, the question had arisen whether the occurrences of salt water have any connection with a buried salt dome (or perhaps with a subterranean salt deposit). The presence of a salt dome cannot be concluded from the gravitational results. The terrestrial magnetic survey seemed best to answer this question.

The magnetic susceptibility of salt is practically zero, while that of Kiscell clay in the supposed salt-rock region is 120×10^{-6} cgs. Therefore, a negative anomaly should appear in the vertical component above the salt mass. If the gravitational minimum is caused by a Rhyolitic tuff of 1.8 gr/cm^3 density and a susceptibility of 742×10^{-6} cgs, then a well-defined positive anomaly would appear in the vertical magnetic component.

The Institute carried out terrestrial magnetic surveys in this territory with two (Schmidt system) vertical variometers in August, 1946. One of these has been used for the registration of variations with readings every 30 minutes. Control measurements were performed daily at the base station prior to commencement, and after completion of observations.

Measurements along some lines were taken with distances of 200 meters between stations. Drawing No. 3 shows location of these sections. The anomalies of the vertical component of different sections are given in Exhibit No. 4. Apart from smaller variations, a regional effect was observed on the entire territory, the anomaly of which decreases in a southwest direction, and reaches the deep point on the gravitational minimum territory between Sámsonháza and Szupatak.

The smaller local anomalies observed in the AA' and BB' sections are perhaps caused by Piroxenandesitic dikes which at some places outcrop. The major local anomaly observed in the FF' section may be attributed to the magnetic effect of the Várhegy hill near Sámsonháza, formed by erupted material.

Since comparatively few local anomalies had been encountered in the entire territory, the formations lying nearer the surface may almost be considered magnetically homogeneous. Therefore, the regional anomalies at greater depths are perhaps due to the effect of the crystalline basement. Anomalies attributable to the effect of salt rocks were nowhere observed, or could the effect of Rhyolitic tuff be shown, so it is probable that a geosyncline lies below the gravitational minimum territory mentioned.

The surveys were carried out by Gyula Banai, under the direction of Tibor Dombai; the stations were staked out by János Ország.

4. Magnetic surveys in the vicinity of Szécsény in 1947--Torsion-balance measurements were performed in the vicinity of Szécsény in 1946 and 1947 for the purpose of studying the folds and faults geologically indicated. During these gravitational measurements a terrestrial magnetic survey was also done along the main highway running east and west. A Schmidt-system vertical variometer was used for these surveys while the daily variations were registered by another like instrument.

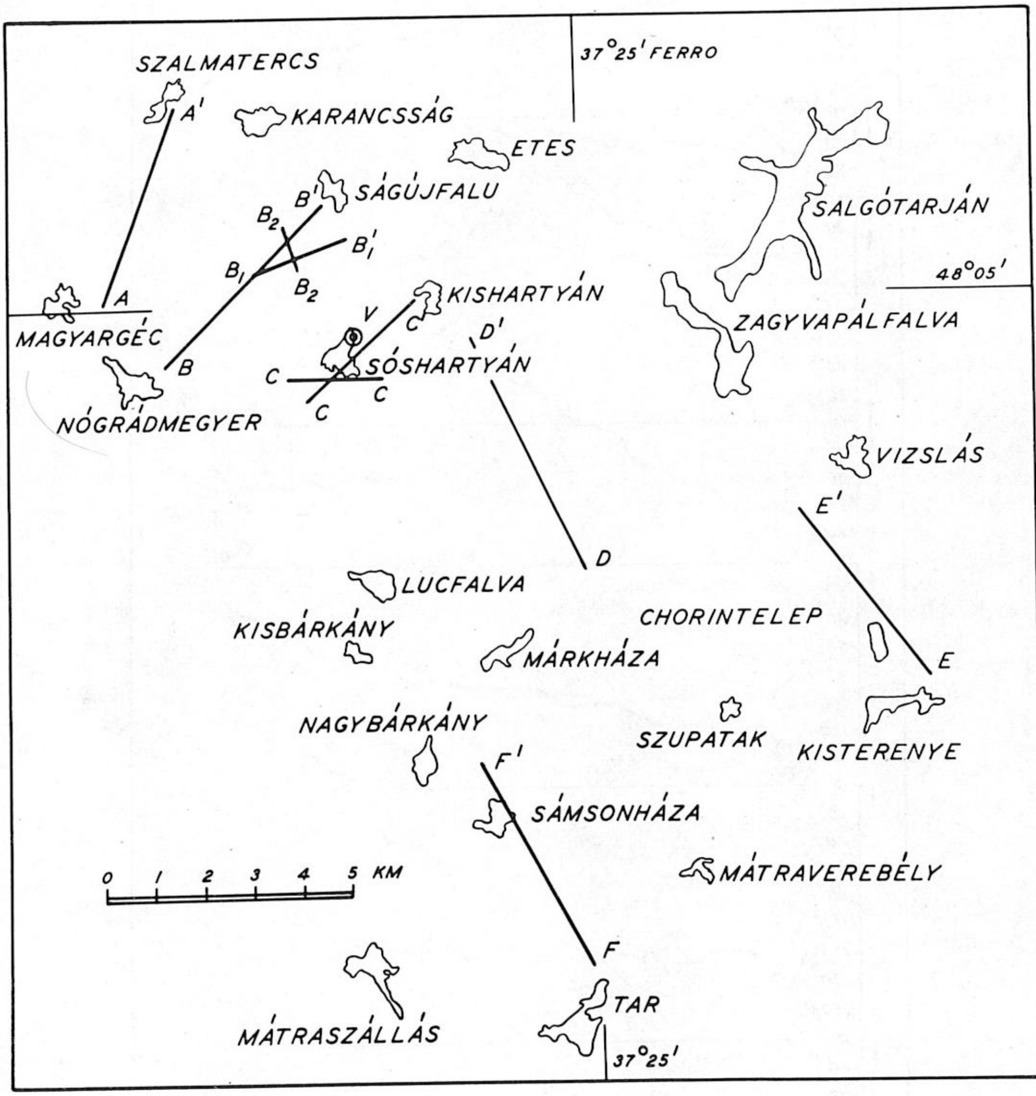

37°25' FERRO
SZALMATERCS
A'
KARANCSSÁG
ETES
B'
SÁGÚJFALU
SALGÓTARJÁN
B_2
B_1'
B_1
B_2
48°05'
A
KISHARTYÁN
MAGYARGÉC
V
C'
D'
ZAGYVAPÁLFALVA
B
SÓSHARTYÁN
C
C
C
NÓGRÁDMEGYER
VIZSLÁS
E'
D
LUCFALVA
CHORINTELEP
KISBÁRKÁNY
MÁRKHÁZA
E
NAGYBÁRKÁNY
SZUPATAK
KISTERENYE
F'
SÁMSONHÁZA
0 1 2 3 4 5 KM
MÁTRAVEREBÉLY
F
TAR
MÁTRASZÁLLÁS
37°25'

Figure 3

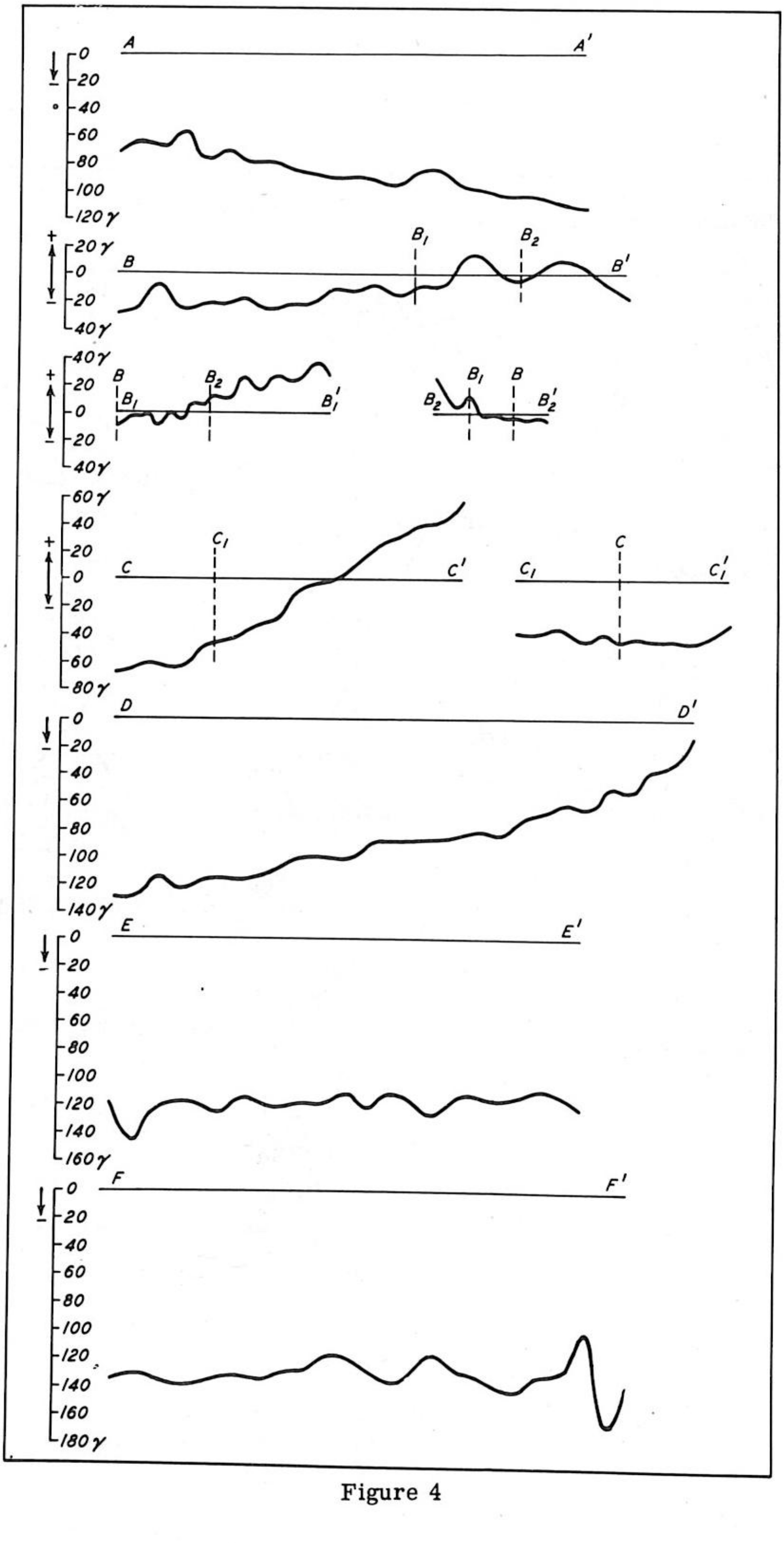

A
A'
0
-20
-40
-60
-80
-100
120 γ
B
B'
B_1
B_2
20 γ
0
20
40 γ
40 γ
20
0
20
40 γ
C
C'
C_1
C_1'
60 γ
80 γ
D
D'
140 γ
E
E'
160 γ
F
F'
180 γ

Figure 4

Exhibit No. 5 discloses the location of the survey, and Exhibit No. 6 shows the vertical magnetic anomalies adjusted with the daily variations. It is surprising that a major negative anomaly appears in the vicinity of Balasagyarmat but at Mária-puszta it turns positive. The rest of the territory has smaller variations in the vertical component. The data at disposal are insufficient for describing these anomalies.

5. Magnetic surveys in the vicinity of Pálháza in 1947--Terrestrial magnetic surveys, together with torsion-balance measurements, were carried out also in 1947 in the vicinity of Pálháza, north of Sátoraljaujhely in the extreme northeast part of Hungary. The same instruments were used as in the vicinity of Szécsény. We especially surveyed the gravitational minimum found near Alsóregnec and studied it from aspects of magnetism as well, but no substantial amount of terrestrial magnetic anomalies were found. A detailed elaboration of the observations made is still in progress.

6. Comparison of the instruments in Ógyalla in 1939--Absolute terrestrial magnetic measurements were also carried out formerly by the Institute at places of gravity stations. The magnetic declination and horizontal intensity were measured partly with Moureaux, and partly with Wild-Edelmann magnetic theodolites. The constants of these two instruments were determined in Ógyalla; those of the Moureaux, in 1902, and those of the Wild-Edelmann unit in 1909. These instruments since then, until the end of World War I had several times been checked with the Wild instrument of the Observatory of Ógyalla.

Comparison was made again in Ógyalla in 1939, namely with the three quartz filament horizontal magnetometers placed at disposal by Dan la Cour, Director of the Institute of Terrestrial Magnetism in Copenhagen (QHM).

According to results of the comparison:

$$H_{QHM} - H_{Mour.} = +61\gamma$$

$$H_{QHM} - H_{Bp.\ Wild} = +26\gamma$$

The difference fairly corresponds to the old comparisons.

The relative magnetic variometers of the Institute of Geophysics were then also checked with the Dan la Cour QHM instrument, and the adding constants of these relative instruments were controlled.

Magnetic declinations were also determined with the Moureaux, as well as with the Wild-Edelmann theodolites and the values obtained were compared with the declination value given by the Lamont instrument of the Observatory of Ógyalla. The differences were the following:

$$D_{Lamont} - D_{Moureaux} = +3.0'$$

$$D_{Lamont} - D_{Wild} = +3.9'$$

The comparisons were made by György Marczell, pensioned Director of the Institute of Meteorology, and by István Béla Haáz and Ernő Ács, observers.

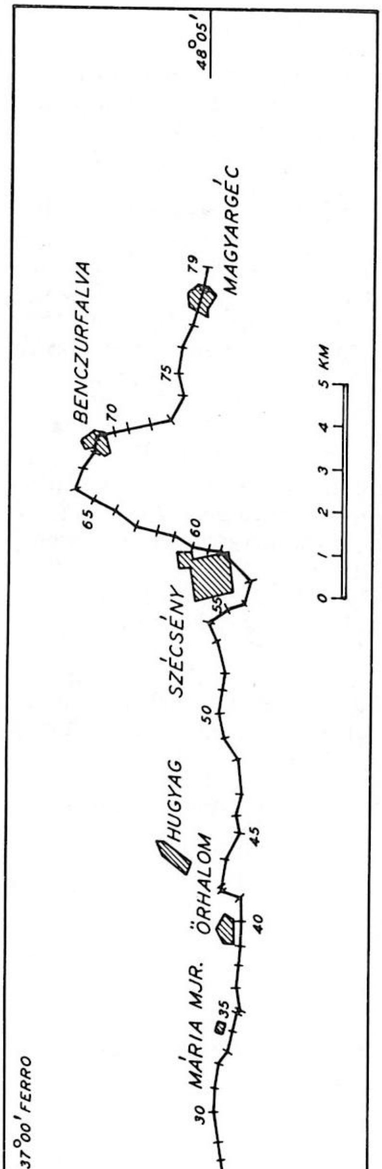


Figure 5

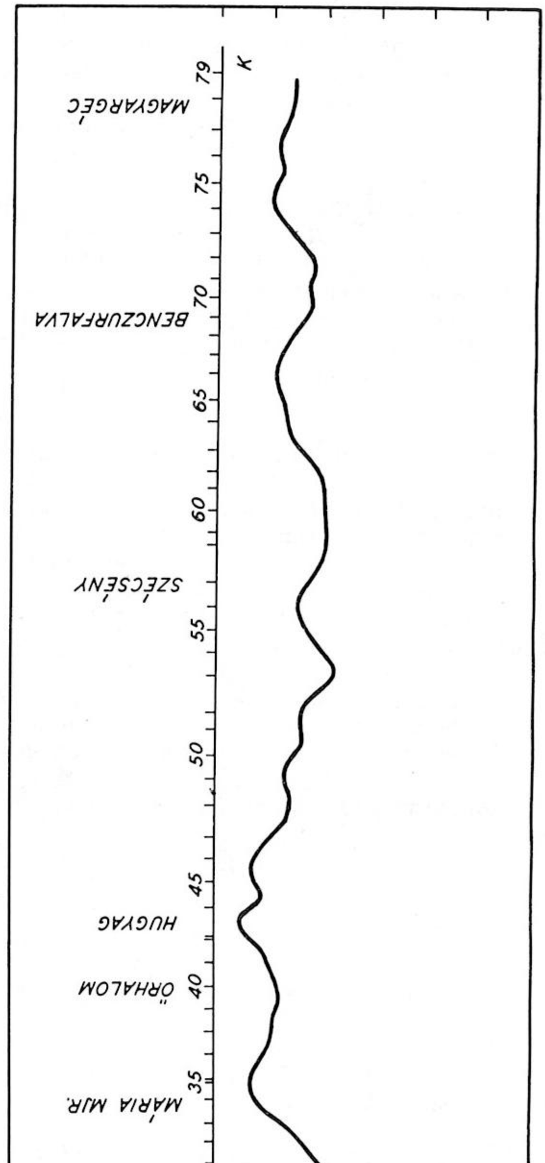


Figure 6

REPORT BY THE HUNGARIAN INSTITUTE OF METEOROLOGY AND TERRESTRIAL MAGNETISM ON WORK DONE BETWEEN 1939-1948

By Antal Réthly, Director

On November 7, 1938, the Observatory of Ógyalla was returned to Hungary. Under Czechoslovakian rule, from 1919 to 1924, no observations were performed and from 1924 to 1938 only declination was recorded. Thus the complete magnetic measurements carried on for 26 years, from 1893 to 1918, were interrupted. We continued to record the declination immediately, beginning its publication at the same time.

In spite of war difficulties, coping with lack of instruments, we published the hourly values of each magnetic component (D, H, Z) from January 1, 1941, up to December 31, 1944. These data appeared in Part II of the Yearbook of the Hungarian Institute for Meteorology and Terrestrial Magnetism (observations made by the Observatory of Ógyalla).

We handed over the Observatory with full equipment in work on May 31, 1945, to the delegate of the Czechoslovakian state; since then we have no information about the measurements and of their being worked up.

With the loss of the Observatory of Ógyalla the magnetic observations of Hungary stopped owing to lack of instruments. In March, 1948, we equipped temporarily a magnetic observatory with borrowed instruments and with these observations were resumed.

We began the survey of Hungary in 1943 and carried out measurements in North-Transylvania. The results were published in 1947. Difficulties due to the war interrupted this survey also.

In 1944, still at Ógyalla, Dr. György Barta began to design a new type differential magnetometer. With this instrument we hope to be able to measure the spatial variation of the magnetic field at an accuracy of 0.01 $\gamma/m = 10^{-9}$ cgs. The manufacture of the instrument is in progress. Its description follows this paper.

The magnetic data of Hungary were published in Part II of the Yearbook of the Hungarian Institute for Meteorology and Terrestrial Magnetism. The papers also appeared here concerning the magnetic observations carried out in the Observatory of Ógyalla; these are listed as follows:

J. Bucsy. Work done by the Observatory for Terrestrial Magnetism of Ógyalla in 1941. Ann. 1941, pp. 3-10. Hungarian and German texts.

Dr. Gy. Barta. Work done by the Observatory for Terrestrial Magnetism of Ógyalla in 1942. Ann. 1942, pp. 12-13. Hungarian and German texts.

J. Bucsy. Magnetic disturbances in Ógyalla on 5th July, 1941. Ann. 1942, pp. 14-16. Hungarian and German texts.

Dr. Gy. Barta. Work done by the Observatory for Terrestrial Magnetism of Ógyalla in 1943. Ann. 1943, pp. 8-10. Hungarian and English texts.

Dr. Gy. Barta. Magnetic surveys in Transylvania (autumn 1943). Ann. 1943, pp. 10-12. Hungarian and English texts.

Dr. Gy. Barta. Differential magnetometer.

Differential magnetometer

During practical magnetic surveys we generally determine the components of the magnetic field, though in many cases it would be more appropriate to determine the spatial variation of same. The variation falling on a 1-cm is the gradient expressed in cgs units; consequently the gradient gives the rate of variation of the magnetic field. In the following we shall submit the theory of an instrument determining the magnetic gradient. Our aim is to obtain the gradient with the precision of 0.01 γ/m. Considering that 0.01 $\gamma = 10^{-7}\Gamma$, then 0.01 $\gamma/m = 10^{-9}$ cgs = 1 Eötvös difference is to be indicated by the instrument.

Let us take two completely uniform coils mounted on an axis so that the normals of their windings be of opposite directions and perpendicular to the axis. Rotating the coils around the common main axis, the magnetic field induces current in them. If the field is homogeneous, and the windings of the coils are completely of equal dimensions and of opposite directions, then the induced electromotive forces nullify one another. If the magnetic field is not equal at the places of the two coils, then the induced electromotive force

$$\Delta E = \Delta M.F.\omega \sin \omega t$$

where ΔM is the difference of the field intensity, F is the surface of the windings of the coils, ω is the angular speed of rotation.

Let us set up two coils of ~10 cm radius on an axis in a distance of 1 m. The surface of a winding is 314 cm^2, the circumference 62.8 cm. Let the weight of the coils be 2.5 kg and the diameter of the wire wound on them be 0.1 mm. The coils have about 45,000 turns; therefore, the whole surface of the turns is 1.5 - 10 cm^2. The inner resistance of the coil system is 150,000Ω. Let us turn the system at an angular speed of $2\pi/t = \omega \approx 100$ (16 turns per second) then the electromotive force to be indicated is

$$\Delta E = 150 \sin \omega t \text{ el.magn.u.} = 1.5 \times 10^{-6} \sin \omega t \text{ volt.}$$

Such a fluctuation of the tension is generally detectable.

The great accuracy desired needs the measuring of an alternate tension of about 10^{-6} volt. Naturally, there is no need to measure the value of this tension; only its existence is to be indicated. The measurement can be carried out most simply by compensating the field difference by a magnetic field of opposite directions and of adequate dimensions so that the electromotive force vanishes.

We can carry out the compensation with two electric compensation coils having their planes perpendicular to one another. Let the intersection of the planes of the two coils be in the direction of the main axis of the instrument. Having the main axis horizontal, let the plane of one of the coils be horizontal, the other vertical. A steady current flowing in the coils of known dimensions can produce any desired magnetic vector in a plane perpendicular to the main axis.

Thus the measurement is carried out by introducing a current of known intensity in the two compensation coils until the electromotive force induced in the main coils vanishes. The two components of the difference-field perpendicular to the direction of the main axis will be proportional to the intensity of the current flowing in the compensating coils.

The 0.01 γ/m accuracy is quite a great requirement for in this case the ratio of the field difference is about 2 × 10-7. To attain such an accuracy the coils must be of equal dimensions and of opposite directions. Both requirements can be attained by placing smaller turnable adjusting coils inside the coils. Let the direction of one of these coils be the same as that of the main axis, the other perpendicular to that. With the former we can continually vary the normal of the coil and with the latter the surface of the windings. Thus with this instrument we can measure the spatial variations of the magnetic field with the accuracy of 0.01 γ/m.

MAGNETIC SURVEYS CARRIED OUT BY THE HUNGARIAN-AMERICAN OIL INDUSTRIAL COMPANY, LIMITED, UP TO 1948

By Károly Kántás

In 1933 the European Gas and Electric Company, predecessor of the Hungarian-American Oil Industrial Company, Limited, won a concession for the search of gas and oil in the western part of Hungary, Transdanubia.

Magnetic surveys had an important role all through the research work which was directed by Professor Simon Papp, Chief Geologist. At first the reconnaissance surveys served the purpose of solving tectonic problems of the territory, and the determination of the striking direction of the basement rocks; later for solving special geological problems.

Results given in our report are from the following surveys:

1. Magnetic surveys on the Hungarian Little Plain, carried out by Dr. Miklós Kretzói in 1934.
2. Magnetic surveys in southwest Hungary, carried out by Viktor Scheffer in 1935.
3. Magnetic surveys in the vicinity of Mihályi, carried out by Viktor Scheffer in 1936.
4. Reconnaissance magnetic surveys in the vicinity of Szekszárd, Mohács and Villány, carried out by Viktor Scheffer in 1936.
5. Detailed magnetic surveys on the Hungarian Little Plain, carried out by Viktor Scheffer in 1937.
6. Magnetic surveys in the vicinity of Kurd and Döbrököz, carried out by Viktor Scheffer in 1937.
7. Magnetic surveys in the vicinity of Inke and Kaposvár, carried out by Viktor Scheffer in 1937.
8. Detailed magnetic surveys in the vicinity of Salomvár, Gerse, Nádasd, Olaszka, Nagytilaj, carried out by Dr. Miklós Kretzói in 1939.
9. Reconnaissance magnetic surveys between Lake Balaton and Lake Velence, carried out by Dr. Miklós Kretzói in 1939.
10. Detailed magnetic surveys in the vicinity of Répcelak, carried out by Dr. Károly Kántás in 1940.
11. Magnetic surveys in the vicinity of Fertőszentmiklós, Nagylózs, Pinnye, carried out by Dr. Károly Kántás in 1940.

12. Detailed magnetic surveys on the structure of Igal, carried out by Dr. Károly Kántás in 1941.
13. Supplementary magnetic surveys in the vicinity of Csurgó, carried out by Dr. Károly Kántás in 1941.
14. Magnetic surveys in the vicinity of Görgeteg, carried out by Dr. Károly Kántás in 1942.
15. Detailed magnetic surveys in the vicinity of Salomvár, carried out by Dr. Károly Kántás in 1942.
16. Detailed magnetic surveys in the vicinity of Hahot and Pusztaszentlászló, carried out by Dr. Károly Kántás in 1942-43.
17. Supplementary magnetic surveys in the vicinity of Nádasd and Nagymákfa, carried out by Dr. Károly Kántás in 1940.
18. Supplementary magnetic surveys in the vicinity of Inke, carried out by Dr. Károly Kántás in 1944.

Surveys from 1-15 and 17 were performed with the Askania No. 113,831 vertical magnetometer.

Survey 16 was carried out with the Askania No. 113,831 vertical, and Askania No. 363,826 horizontal magnetometers.

The supplementary survey 18 was performed with the Askania No. 363,826 horizontal magnetometer.

The value of the vertical intensity was determined at 16,089 stations, and that of the horizontal intensity at 1884 stations.

During surveys of 1-7, the magnetic system of the vertical instrument was not compensated for temperature variations; the mean error of these surveys, therefore, is $\pm 5\ \gamma$, while that of the other surveys with compensated magnetic systems is $\pm 3.5\ \gamma$.

The mean error of the horizontal intensity measurements was $\pm 4\ \gamma$.

The distance between stations of reconnaissance surveys was 2-3 km; that of detailed surveys was 500 meters.

The diurnal variations up to the end of 1940 were subtracted on the basis of data of the Magnetic Observatory of Vienna. Beginning with 1941, these data were given by the Observatory of Ógyalla.

We used the Eötvös normal value up to the end of 1941, which is the following:

$$\Delta Z = 646.97\ \Delta\phi + 22.98\ \Delta\lambda$$

We then deducted a new normal value from our own survey results which, for the epoch of 1941.5, is the following:

$$\Delta Z = 623.2\ \Delta\phi + 35.06\ \Delta\lambda + 0.725\ \Delta\phi\ \Delta\lambda - 11.1\ \Delta\phi^2 + 2.3\ \Delta\lambda^2$$

and with this we recalculated the old results as well. We used this correction also in the following years, taking into consideration the annual variations of the $\Delta\phi$ and $\Delta\lambda$ coefficients as well: -0.68 +0.34

(See lit.: Normal value of vertical intensity of the earth's magnetic field in the Transdanubian District.)

We were obliged to use the old Eötvös formula for the normal values of the horizontal intensity, for our surveys were insufficient for the deduction of new normal values from them.

The anomalies have been mainly caused by the magnetic effect of the basement rocks, and give valuable information for understanding the tectonics of the area.

The extreme values of the anomaly on the territory being relatively small, are due to surveys not being carried out at locations where basement rocks have come to the surface, especially volcanic rocks, for the simple reason that these territories as an oil promising region are hopeless. We therefore prepared a less dense network of the Bakony, Vértes and Mecsek mountain region.

The greatest anomaly encountered was +2700 γ in the vicinity of Várkesző, caused by basalt rocks near the surface.

As something interesting, we give section 2 of the surveys carried out in the vicinity of Pusztaszentlászló. We figured out the depth of the effecting mass from our results to be 1600-1900 meters. By drilling we reached the rock at two points, at 1770 and 1790 meters, in 1947.

From calculations, the susceptibility of the rocks was 1000×10^{-6} cgs. As per sample, which was not at all homogeneous, $900\text{-}1500 \times 10^{-6}$ cgs was obtained from several cores with approximate measurements. The material of the effecting mass is andesit.

In 1944 we intended to measure the susceptibility of the rocks also, but were obstructed by the oncoming war, and our instruments were ruined, which to date could not be replaced.

The Aurora Borealis was seen in Hungary on September 18-19, 1941, due to which the magnetic field showed such disturbance on the above two days that no field work was possible then. A variation of 20-100 γ was observed at certain stations.

MEASUREMENTS OF THE MAGNETIC DECLINATION IN HUNGARY

By Jenő Hofhauser

Furnishing topographic maps with magnetic data necessitated the new establishment of the values of the declination in Hungary. Surveys covering the whole country were last made by Ignac Kurlander at the time of the Austro-Hungarian monarchy in the latter part of the previous century. The results of these were elaborated and published by Liznar for the epoch 1890. No regular measurements were carried out from this time until 1935.

In 1935 the Hungarian Institute of Cartography entrusted Dr. Jenő Hofhauser with carrying out new measurements. The measurements were executed with a Wild T_0 compass-theodolite, the index error of which, according to comparisor made with the instruments of the State Institute of Geophysics before and after the period of measurements, remained 70′. The mean error of the orientation is ±0.91′.

During the new measurements the declination was not measured directly on account of difficulties encountered in the astronomical north measurements, but the angle τ, closed by the magnetic north and the north which was deducted from the network of the triangulation. For determination of this, the angle of any geodetic direction (a straight line connecting two triangular points) should be measured which is closed by the magnetic north; the north direction of the network is derived from the coordinates of the two triangular points. δ can be figured out from τ with the aid of the meridian convergence, μ :

$$\delta = \tau + \mu.$$

$\mu = (\lambda - \lambda_0) \sin \phi$, λ_0 is the length of the network base point.

According to the above, the angle of a geodetic direction PA closed with the network north, is:

$$(PA) = \text{arc tg} \frac{Y_A - Y_P}{X_A - X_P}$$

where $X_A Y_A$, $X_P Y_P$ are the coordinates of the triangular points. If 1_{PA} is the angle of the (PA) geodetic direction which is closed by the magnetic north, and 1_{PM} is the index error of the theodolite, then

$$\tau = (PA) - 1_{PA} + 1_{PM}.$$

Measurements of the declination in 1935-36 were executed at 26 points on the territory of Hungary, then being of smaller size due to the Peace Treaty of Trianon. Calculating from these 26 points, the normal value of the magnetic declination, referred to the base point of $\phi = 47° 26'$, $\lambda = 36° 37'$ (east of Ferro) is for the epoch of 1936.0:

$$\delta = -2° 05' -1.237' + 0.443802\, \Delta\lambda - 0.004248\, \Delta\phi - 0.0000703\, \Delta\phi\, \Delta\lambda$$
$$-0.00088542\, \Delta\phi^2 - 0.0003425\, \Delta\lambda^2$$

(The negative sign means western declination.)

For purposes of checking the correctness of these normal values, measurement of the declination was carried out at four old points and four new points in 1937. These control measurements gave entirely corresponding results with those of the previous year.

Measurements of the declination were performed at seven points in 1941, and at 35 points in 1943 on the added territory of north Transylvania. The results of our measurements, together with those of Cechura, Procopiu and the older ones, are given in the following table. All results were reduced to the epoch of 1943.5. The observers are the following: C = Cechura; H = Hofhauser; HM = Hepites and Murat; K = Kurlander; P = Procopiu.

No.	Station	Latitude	Long. from Ferro	Elevation	Year	Observer	Value	Difference	Epoch 1943.5
1	Zágráb	45° 49.'0	33° 39.'0		1890.0	K	-569′	+415′	-154′
2	Sziszek	45 29.0	34 03.0		1890.0	K	-560	+415	-145
3	Lentihegy	46 36.0	34 13.0	259	1936.0	H	-197	+ 55	-142
4	Szombathely	47 13.0	34 17.0	216	1936.0	H	-200	+ 55	-145
5	Sopron 603HP	47 40.5	34 17.5	227	1936.0	H	-192	+ 55	-137
6	Malacka	48 28.3	34 40.7	155	1932.0	C	-217	+ 92	-125
7	Pozsony	48 10.7	34 43.6	218	1932.0	C	-212	+ 92	-120
8	7 mérés közepe	46 52.5	34 45.0		1936.0	H	-178	+ 55	-123
9	Bos. Gradiska	45 08.0	34 55.0		1890.0	K	-528	+415	-113
10	Köorra	46 51.8	35 00.0	400	1936.0	H	-334	+ 55	-279
11	Jablánc	48 37.1	35 05.1		1932.0	C	-212	+ 92	-120
12	Nagyszombat	48 22.7	35 11.4	161	1932.0	C	-198	+ 92	-106
13	2 mérés közepe	46 52.5	35 15.0	135	1936.0	H	-165	+ 55	-110
14	Dunaszerdahely	47 59.3	35 15.2	115	1932.0	C	-200	+ 92	-108
15	Győr 178HP	47 42.3	35 19.3	118	1936.0	H	-162	+ 55	-107
16	Galánta	48 11.8	35 20.9	120	1932.0	C	-194	+ 92	-102
17	Halomtető	46 56.0	35 22.4	399	1936.0	H	-375	+ 55	-320
18	Cserfőhegy	46 05.0	35 28.0	193	1936.0	H	-164	+ 55	-109
19	Galgócz	48 27.2	35 28.9	183	1932.0	C	-185	+ 92	- 93
20	Pöstyén	48 37.2	35 30.0	163	1932.0	C	-192	+ 92	-100
21	Veszprém	47 05.0	35 35.0		1890.0	K	-511	+415	- 96
22	Bród	45 09.0	35 41.0		1890.0	K	-514	+415	- 99
23	Trencsén	48 52.7	35 42.9		1932.0	C	-187	+ 92	- 95
24	6 mérés közepe	46 52.5	35 45.0		1936.0	H	-152	+ 55	- 97
25	4 mérés közepe	47 07.5	35 45.0	260	1936.0	H	-145	+ 55	- 90
26	Nyitra	48 19.4	35 47.0		1932.0	C	-186	+ 92	- 94
27	Nagysurány	48 05.5	35 49.6		1932.0	C	-178	+ 92	- 86
28	Komárom	47 47.1	35 49.9		1932.0	C	-182	+ 92	- 90
29	Ógyalla	47 52.5	35 51.4	113	1932.0	C	-185	+ 92	- 93
30	Nagytapolcsány	48 33.6	35 51.9	164	1932.0	C	-183	+ 92	- 91
31	Pécs	46 04.0	35 54.0		1890.0	K	-499	+415	- 84
32	Bellus	49 04.3	36 01.4		1932.0	C	-176	+ 92	- 84
33	Némethprona	48 53.7	36 08.9		1932.0	C	-166	+ 92	- 74
34	Léva	48 14.4	36 15.7	161	1932.0	C	-149	+ 92	- 57
35	Zsolna	49 13.4	36 22.5	451	1932.0	C	-164	+ 92	- 72
36	Párkány	47 48.4	36 22.6	110	1932.0	C	-169	+ 92	- 77
37	Eszék	45 33.0	36 23.0		1890.0	K	-498	+415	- 83
38	Nyitrabánya	48 43.4	36 24.8	579	1932.0	C	-173	+ 92	- 81
39	Selmecbánya	48 28.2	36 33.3	799	1932.0	C	-165	+ 92	- 73
40	Tétényi legelő	47 25.7	36 37.2	230	1936.0	H	-125	+ 55	- 70
41	Turócsztmárton	49 03.4	36 37.4	419	1932.0	C	-157	+ 92	- 65
42	Baja 79HP	46 11.7	36 38.3	115	1936.0	H	-125	+ 55	- 70
43	Ipolyság	48 04.4	36 38.7	128	1932.0	C	-155	+ 92	- 63
44	Drégelypalánk	48 02.2	36 43.5	224	1936.0	H	-122	+ 55	- 67
45	4 mérés közepe	47 05.1	36 45.5		1936.0	H	-130	+ 55	- 75
46	Zólyom	48 34.9	36 46.7		1932.0	C	-160	+ 92	- 68
47	Besztercebánya	48 44.7	36 47.8	455	1932.0	C	-156	+ 92	- 64
48	Litva	48 17.7	36 50.6	480	1932.0	C	-143	+ 92	- 51
49	Rózsahegy	49 03.2	36 59.3	643	1932.0	C	-148	+ 92	- 56
50	Gyetva	48 33.8	37 05.8		1932.0	C	-162	+ 92	- 70
51	3 mérés közepe	47 22.5	37 15.0		1936.0	H	-105	+ 55	- 50

No.	Station	Latitude	Long. from Ferro	Elevation	Year	Observer	Value	Difference	Epoch 1943.5
52	Turdosin	49°20.'8	37°15.'4	632	1932.0	C	-141'	+ 92'	- 49'
53	Lipótsztmiklós	49 05.5	37 18.1	690	1932.0	C	-140	+ 92	- 48
54	Breznóbánya	48 48.4	37 19.7		1932.0	C	-139	+ 92	- 47
55	Losonc	48 18.0	37 20.4	204	1932.0	C	-142	+ 92	- 50
56	Piszkéstető	47 55.0	37 33.7	942	1936.0	H	-110	+ 55	- 55
57	Tiszolcz	48 40.6	37 36.4		1932.0	C	-129	+ 92	- 37
58	Ajnácskő	48 13.5	37 37.4		1932.0	C	-147	+ 92	- 55
59	Parád	47 55.7	37 41.9	255	1936.0	H	- 95	+ 55	- 40
60	Rimaszombat	48 23.5	37 42.6	278	1932.0	C	-131	+ 92	- 39
61	Csorba	49 04.2	37 43.7		1932.0	C	-128	+ 92	- 36
62	Szeged Öthalom	46 17.2	37 46.5	90	1936.0	H	- 98	+ 55	- 43
63	Királyhegyalja	48 50.3	37 47.7		1932.0	C	-126	+ 92	- 34
64	Szolnok	47 13.2	37 48.0		1936.0	H	-105	+ 55	- 50
65	Pelsőc	48 32.1	38 04.9	325	1932.0	C	-184	+ 92	- 92
66	Rozsnyó	48 40.2	38 12.6		1932.0	C	-121	+ 92	- 29
67	Podolin	49 16.0	38 12.8		1932.0	C	-115	+ 92	- 23
68	Igló	48 57.1	38 15.1	483	1932.0	C	-113	+ 92	- 21
69	3 mérés közepe	47 21.2	38 17.8		1936.0	H	- 86	+ 55	- 31
70	3 mérés közepe	47 36.5	38 18.3		1936.0	H	- 86	+ 55	- 31
71	Szin	48 30.0	38 19.0	179	1936.0	H	- 81	+ 55	- 26
72	Tarkő	49 10.2	38 34.5	428	1932.0	C	-106	+ 92	- 14
73	Torna	48 35.2	38 34.9		1932.0	C	-107	+ 92	- 15
74		47 11.2	38 37.5		1936.0	H	- 76	+ 55	- 21
75	4 mérés közepe	47 22.5	38 45.0		1936.0	H	- 75	+ 55	- 20
76	4 mérés közepe	47 37.5	38 45.0		1936.0	H	- 72	+ 55	- 14
77	4 mérés közepe	47 52.5	38 45.0		1936.0	H	- 70	+ 55	- 15
78	Temesvár	45 45.0	38 54.0		1890.0	K	-426	+405	- 21
79	Eperjes	49 00.7	38 55.5	245	1932.0	C	- 97	+ 92	- 5
80	Bártfa	48 18.5	38 57.8	270	1932.0	C	- 91	+ 92	- 1
81	Kassa	48 43.5	38 58.0	252	1932.0	C	- 93	+ 92	- 1
82	Alsókéked	48 32.5	39 00.2	210	1936.0	H	- 76	+ 55	- 21
83	Fehértemplom	44 52.0	39 06.0		1890.0	K	-426	+405	- 21
84	Sarkad 115HP	46 45.8	39 07.5	91	1936.0	H	- 72	+ 55	- 17
85	Varanno	48 52.8	39 19.9	143	1932.0	C	- 84	+ 92	+ 8
86	Sátoraljaujhely	48 24.1	39 21.3	104	1932.0	C	- 85	+ 92	+ 7
87	Nagy Mihály	48 44.6	39 34.0	113	1932.0	C	- 80	+ 92	+ 12
88	Mezőlaborc	49 16.8	39 34.5	328	1932.0	C	- 70	+ 92	+ 22
89	Pecesztmárton	47 00.9	39 38.1	140	1942.0	H	- 15	+ 11	- 4
90	Székelyhid 404	47 20.3	39 47.1	150	1942.0	H	- 11	+ 11	- 0
91	Csap	48 25.9	39 50.6	104	1932.0	C	- 72	+ 92	+ 20
92	Karánsebes	45 24.0	39 53.0		1890.0	K	-397	+395	- 2
93	Takcsány	49 00.0	39 54.4		1932.0	C	- 63	+ 92	+ 29
94	Ungvár	48 38.6	39 56.4	137	1932.0	C	- 73	+ 92	+ 19
95	Mátészalka	47 56.3	39 59.0		1936.0	H	- 50	+ 55	+ 5
96	Orsova	44 42.0	40 04.0		1890.0	K	-399	+395	- 4
97	Élesd HP.kő	47 03.9	40 04.2	287	1942.0	H	- 1	+ 11	+ 12
98	Nagyberezna	48 53.8	40 06.8	205	1932.0	C	- 56	+ 92	- 36
99	Beregszász	48 11.9	40 17.2	115	1932.0	C	- 59	+ 92	- 33
100	Munkács	48 27.2	40 22.7	120	1932.0	C	- 44	+ 92	- 48
101	Szilágysomlyó	47 12.1	40 23.0	309	1942.0	H	- 4	+ 11	+ 15
102	Alsószopor	47 27.7	40 25.9	180	1942.0	H	+ 1	+ 11	+ 12

No.	Station	Latitude	Long. from Ferro	Elevation	Year	Observer	Value	Difference	Epoch 1943.5
103	Csusca	46°55ʹ.9	40°28ʹ.9	700	1942.0	H	+ 2′	+ 11′	+ 13′
104	Uzsok	48 59.2	40 31.9	560	1932.0	C	- 47	+ 92	+ 45
105	Kraszna 132HP	47 10.7	40 34.9	240	1942.0	H	+ 9	+ 11	+ 20
106	Szatmárnémeti	47 46.0	40 35.0		1940.5	P	+ 2	+ 22	+ 24
107	Szolyva	48 32.5	40 40.2	120	1932.0	C	- 46	+ 92	+ 46
108	Nagyszőlős	48 07.7	40 41.5		1932.0	C	- 51	+ 92	+ 41
109	Zilah	47 11.0	40 44.0		1940.5	P	+ 1	+ 22	+ 23
110	Volóc	48 43.2	40 51.6	700	1932.0	C	- 36	+ 92	+ 56
111	Avasfelsőfalu	47 53.1	41 06.8	300	9/22/43	H	+ 39	+ 1	+ 40
112	Herecsény	48 16.5	41 06.8	232	1932.0	C	- 37	+ 92	+ 55
113	Diós 15.P.T.kö	46 53.7	41 11.4	520	9/20/43	H	+ 25	+ 3	+ 28
114	Récekeresztur	47 03.7	41 11.4	520	9/20/43	H	+ 30	+ 2	+ 31
115	Jóháza gula	47 24.1	41 12.8	565	9/21/43	H	+ 28	+ 1	+ 29
116	Nagybánya	47 38.7	41 14.5	228	9/21/43	H	+ 29	+ 2	+ 31
117	Técső	48 00.4	41 14.5	216	9/22/43	H	+ 64	- 0	+ 64
118	Técső	48 00.4	41 14.7	215	1932.0	C	- 28	+ 92	+ 64
119	Gyulafehérvár	46 03.0	41 15.0	250	1940.5	P	+ 20	+ 24	+ 44
120	Kolozsvár	46 45.3	41 15.7	346	10/10/43	H	+ 31	- 3	+ 28
121	Torda	46 33.0	41 27.0	325	1940.5	P	+ 20	+ 24	+ 44
122	Crajova	44 19.0	41 28.0	110	1901.0	HM	-301	+312	+ 11
123	Aknaszlatina	47 58.2	41 32.8	240	1932.0	C	- 30	+ 92	+ 62
124	Mármarossziget	47 55.0	41 34.0	270	1940.5	P	+ 27	+ 24	+ 51
125	Tarackraszna	48 13.4	41 36.0	430	1932.0	C	- 20	+ 92	+ 72
126	Petrovai csucs	47 50.8	41 48.8	664	9/23/43	H	+ 54	- 0	+ 54
127	Felsőilosva	47 23.3	41 50.7	363	9/9/43	H	+ 54	- 3	+ 51
128	Nagyszeben	45 48.0	41 51.0	405	1940.5	P	+ 21	+ 24	+ 45
129	Apanagyfalu	47 06.0	41 52.7	300	9/27/43	H	+ 54	+ 2	+ 56
130	Rahó	48 03.2	41 53.1	440	1932.0	C	- 14	+ 92	+ 78
131	Izakonyha	47 42.0	41 55.0	400	1940.5	P	+ 23	+ 24	+ 47
132	Budatelke	46 53.1	41 55.2	500	9/27/43	H	+ 35	+ 2	+ 37
133	Zavideni	44 45.0	41 56.0	230	1940.5	P	-292	+312	+ 20
134	Calimanesti	45 15.0	42 01.0	280	1940.5	P	-290	+312	+ 22
135	Kőrösmező	48 15.6	42 01.1	650	1932.0	C	- 2	+ 92	+ 90
136	Felsővisó	47 43.0	42 07.0	510	1940.5	P	+ 42	+ 24	+ 66
137	Beszterce	47 08.1	42 07.3	448	10/9/43	H	+ 43	- 2	+ 41
138	Havasmező	47 30.5	42 07.7	963	9/23/43	H	+ 55	+ 2	+ 57
139	Marosvásárhely	46 33.5	42 13.0	310	9/29/43	H	+ 17	- 2	+ 15
140	Curtea d'Arges	45 10.0	42 21.0	450	1940.5	P	-292	+312	+ 20
141	Borsa	47 39.7	42 21.2	957	9/24/43	H	+ 68	+ 1	+ 69
142	Szászrégen	46 47.1	42 22.4		10/8/43	H	+ 41	- 2	+ 39
143	Segesvár	46 14.0	42 30.0	370	1940.5	P	- 11	+ 24	+ 13
144	Csikfalva	46 28.3	42 31.7		10/1/43	H	+ 35	+ 2	+ 37
145	Potesti	44 51.0	42 33.0	270	1940.5	P	-292	+312	+ 20
146	Mirosi	44 24.0	42 36.0	200	1940.5	P	-293	+312	+ 19
147	Fogaras	45 50.0	42 40.0	430	1940.5	P	+ 21	+ 24	+ 45
148	Székelykeresztur	46 18.7	42 40.0	523	10/5/43	H	+ 39	- 2	+ 37
149	Tiszakő	46 46.3	42 41.5	958	10/8/43	H	+ 27	+ 0	+ 27
150	Lóhavas	47 15.7	42 41.5	1229	9/28/43	H	+ 70	+ 3	+ 73
151	Borzai hágó	47 34.7	42 41.8	1489	9/26/43	H	+ 74	+ 1	+ 75
152	Szováta	46 35.7	42 44.7	450	9/29/43	H	+ 55	- 7	+ 48
153	Palotai Mikola	46 56.4	42 45.9	908	10/8/43	H	+ 90	- 4	+ 86

No.	Station	Latitude	Long. from Ferro	Elevation	Year	Observer	Value	Difference	Epoch 1943.5
154	Carlibaba	47°35′.0	42°48′.0	940	1940.5	P	+ 54′	+ 24′	+ 78′
155	Campulung	45 18.0	42 54.0	595	1940.5	P	+ 27	+ 24	+ 51
156	Jacobeni	47 26.0	42 59.0	835	1940.5	P	+ 55	+ 24	+ 79
157	Bélborlába	47 04.3	43 08.5	1092	10/7/43	H	+ 63	+ 3	+ 66
158	Kápolnásfalu	46 22.3	43 11.0	980	10/6/43	H	+ 92	- 4	+ 88
159	Felsőrákos	46 04.3	43 11.4	482	10/5/43	H	+ 57	- 0	+ 57
160	Ditró	46 50.5	43 11.7		10/7/43	H	+ 50	- 3	+ 47
161	Cimpulung	47 31.0	43 14.0	750	1940.5	P	+ 66	+ 24	+ 90
162	Suceava	47 39.0	43 14.0	360	1940.5	P	+ 58	+ 24	+ 82
163	Szotyor	45 49.3	43 14.4	528	10/5/43	H	+ 71	- 4	+ 67
164	Brassó	45 39.0	43 18.0	590	1940.5	P	+ 30	+ 24	+ 54
165	Garádos	46 34.9	43 21.4	948	10/2/43	H	+ 66	- 1	+ 65
166	Gyergyóbékás	46 49.3	43 27.8	1850	10/6/43	H	+ 72	+ 0	+ 72
167	Gura Homorului	47 30.0	43 32.0	480	1940.5	P	+ 48	+ 24	+ 72
168	Pogányhavas	46 28.4	43 34.3		10/2/43	H	+ 94	- 14	+ 80
169	Ploesti	44 56.0	43 42.0	150	1901.0	HM	-261	+312	+ 51
170	Veleniida Monte	45 12.0	43 42.0	360	1901.0	HM	-256	+312	+ 56
171	Palanca	46 31.0	43 44.0	720	1901.0	HM	-238	+312	+ 74
172	Torja	46 03.2	43 44.5	693	10/4/43	H	+ 79	- 4	+ 75
173	Otoponi	44 34.0	43 45.0	100	1940.5	P	+ 42	+ 24	+ 66
174	Radauti	47 51.0	43 45.0	360	1940.5	P	+ 47	+ 24	+ 71
175	Aklosbérc	46 18.3	43 45.5	1165	10/9/43	H	+ 72	+ 1	+ 73
176	Cernauti	48 15.0	43 46.0	245	1940.5	P	+ 26	+ 24	+ 50
177	Kovászna	45 50.2	43 49.6	568	10/4/43	H	+ 79	- 1	+ 78
178	Falticeni	47 28.0	43 57.0	300	1940.5	P	+ 60	+ 24	+ 84
179	Targu Neamtui	47 15.0	44 01.0	375	1940.5	P	+ 69	+ 24	+ 93
180	Burdujeni	47 40.0	44 02.0	380	1901.0	HM	-218	+312	+ 94
181	Ojtoz hágó	46 08.8	44 02.2	865	10/4/43	H	+ 86	- 3	+ 83
182	Mizil	45 00.0	44 04.0	85	1901.0	HM	-244	+312	+ 68
183	Dorohoin	47 59.0	44 05.0	180	1901.0	HM	-207	+312	+105
184	Hotin	48 30.0	44 11.0	250	1940.5	P	+114	+ 24	+138
185	Dolhasca	47 27.0	44 16.0	260	1940.5	P	+ 86	+ 24	+110
186	Targu Ocna	47 13.0	44 19.0	270	1940.5	P	+ 81	+ 24	+105
187	Botosani	47 44.0	44 21.0	180	1940.5	P	+115	+ 24	+139
188	Pasceni	47 15.0	44 25.0	220	1940.5	P	+ 81	+ 24	+105
189	Buzau	45 09.0	44 30.0	105	1901.0	HM	-232	+312	+ 80

The annual mean values of the magnetic declination in Ógyalla between 1893-1943 are:

1893	-8°03′		1905	-7°03′		1917	-5°30′		1934	-2°43′	
		5			5			9			12
1894	-7 58		1906	6 58		1918	21		1935	31	
		6			3						2
1895	52		1907	55		1924	4 20		1936	29	
		4			5			12			12
1896	48		1908	50		1925	08		1937	17	
		4			6			10			6
1897	44		1909	44		1926	3 58		1938	11	
		6			9			12			7
1898	38		1910	35		1927	46		1939	04	
		4			10			8			9
1899	34		1911	25		1928	38		1940	1 55	
		5			8			11			7
1900	29		1912	17		1929	27		1941	48	
		6			9			7			7
1901	23		1913	08		1930	20		1942	41	
		5			9			9			8
1902	18		1914	5 59		1931	11		1943	33	
		4			10			9			
1903	14		1915	49		1932	02				
		6			9			11			
1904	08		1916	40		1933	2 51				
		5			10			8			

Map "A" shows the reduced isogons for the epoch of 1943.5; map "B" shows together the isogons of the epochs of 1850.0, 1890.0, and 1943.5; map "C" gives explanation regarding the anomalies of the isogons, disclosing the geological conditions.

LIST OF TECHNICAL PAPERS ON EARTH'S MAGNETISM PUBLISHED IN HUNGARY BETWEEN 1939-1948

By K. Kántás

Barnóthy, J. The problem of elementary particles and the origin of the geomagnetic field. Papers of the terrestrial magnetism, No. 2, Budapest, 1947.

Barta, Gy. On the theory of Z balances of Dan la Cour's system. "Az Időjárás" 1940, juliusaugusztusi szám, 163-170 old., Budapest. (In Hungarian with German summary.)

Barta, Gy. Supplement to "On the theory of Z balances of Dan la Cour's system". "Az Időjárás" 1941, március-áprilisi szám, Budapest. (Hungarian-German)

Barta, Gy. Temperature compensation of Dan la Cour's Z balances. "Az Időjárás" 1941, szeptember-oktőberi szám, 197-203 old., Budapest. (In Hungarian with German summary.)

Barta, Gy. On the changes of the horizontal intensity and inclination of the earth's magnetism in Transylvania. Papers of the terrestrial magnetism, No. 1, Budapest, 1947. (In Hungarian with English summary.)

Berkes, Z. Phenomena of Aurora Borealis in Hungary. "Az Időjárás" 1943, január-februári szám, 14-20 old., Budapest. (In Hungarian with German summary.)

Egyed, L. Interpretation of the magnetic anomalies on the basis of vertical and horizontal intensity curves. "Az Időjárás" 1943, november-decemberi száma, 185-188 old., Budapest. (In Hungarian with German summary.)

Faragó, P. Measurement of terrestrial magnetic field intensity by means of a cathode ray tube. Matematikai és Fizikai Lapok, XLVII, köt, Budapest, 1940. (In Hungarian with English summary.)

Kántás, K. Interpretation of the magnetic anomalies on the basis of the vertical intensity curve. "Az Időjárás" 1942, március-áprilisi szám, 57-60 old., Budapest. (In Hungarian with German summary.)

Kántás, K. Measurement of the magnetic susceptibility of rocks in the electrical tuning circuit. Publications of the Mining and Metallurgical Department of Palatine-Joseph University of Technical Sciences, vol. XV, pp. 265-283, 1943, Sopron, Hungary. (In German with English summary.)

Kántás, K. Normal value of the vertical intensity of the earth's magnetic field in the Transdanubian District. Publications of the Mining and Metallurgical Department of Palatine-Joseph University of Technical Sciences, vol. XVI, pp. 171-175, Sopron, Hungary, 1944-47.

INDIA

NOTE ON ACTIVITY IN INDIA IN GEOMAGNETISM, ATMOSPHERIC ELECTRICITY, AND IONOSPHERE DURING 1939-1947

Geomagnetism

Continuous photographic registration of H, D, and Z was maintained with the Watson magnetographs which have been in operation at the Alibag Observatory since 1904. Absolute observations of H and D were carried out regularly once every week with the observatory standard magnetometer, and of I with two inductors on all days except Sundays and public holidays. Besides these, absolute observations of H and D were also made with two other magnetometers and three pairs of magnets for the purpose of comparison.

A la Cour declination variometer (scale value 2.′25/cm) which was in continuous operation since March 1937 was discontinued in April 1942, but was restarted in July 1946 after making some adjustments in the variometer as well as in the recording unit. A la Cour H variometer (scale value 36.0 γ/cm) and a la Cour Z variometer (scale value 16.8 γ/cm) were installed inside the variometer building in August 1946 and continuous records are being taken with them since then. Both the H and Z records are taken on the same paper. Arrangements have been made to insure against loss of records during magnetic storms by suitably arranging additional specks of light which automatically begin to fall on the photographic paper of the recording unit when the specks for normal traces go out of the paper. The records are being studied and compared with those taken with the Watson instruments which, however, continue to be used for routine tabulation and analysis.

In addition to assigning the international character figures C to every day, K-indices are also being assigned to every three hour interval since January 1, 1946, and the data are being regularly communicated to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington for the determination of the International Quiet and Disturbed Days. Short notes on magnetic storms as recorded at Alibag were published regularly in the Journal of Terrestrial Magnetism and Atmospheric Electricity up to March 1942 and again from January 1, 1946. Close cooperation was maintained with the Solar Physics Observatory, Kodaikanal and the All India Radio, New Delhi. Telegrams reporting magnetic storms were sent to them regularly, thereby providing facilities to carry on special observations during such storms. Information regarding magnetic disturbances was also supplied to different scientific institutions.

During the war, short-term forecasts of geomagnetic disturbances affecting transmission of radio waves via the ionosphere were issued regularly to Air Headquarters, New Delhi, from January 1943 to December 1945. These forecasts were based primarily upon the geomagnetic activity 27 days before the forecast period, supplemented by an estimate of disturbance based on the location of sunspots and degree of activity of the sun as reported by the Solar Physics Observatory, Kodaikanal.

The publication of the observatory data subsequent to 1939 was held up on account of the war. The data for 1940-1944 are already in the press and are expected to be published soon and will be followed shortly by the data for the years 1945-46. The published data includes information regarding performance of variometers, absolute observations and base-line determinations, scale-value determinations and temperature coefficients.

The variometers of the Dehra Dun Observatory of the Survey of India ceased to operate from August 18, 1943. To bring up to date the declination maps, a number of repeat stations (67) were reoccupied in 1943-1944, but the results were of lower precision than formerly, as full correction for diurnal change and disturbance could not be applied, for want of observatory cover. Stations depending on Alibag and Dehra Dun were reduced for Alibag alone and others were not reduced at all.

Theoretical researches on various problems on geomagnetism were continued and the list of works published are given in the appendix.

Atmospheric Electricity

Atmospheric electric potential gradient was continuously recorded during the period under review with the help of Dolzelek electrometers at Bombay and Poona. The potential gradient at four different hours of each day, hourly means (from positive and negative values) for each month, hourly means for each month (derived from ten quiet days), the electrical character of each day and approximate daily duration of negative potential gradient at Bombay are being regularly tabulated from the Bombay electrograms and published in the observatory annual entitled "Magnetical, meteorological, atmospheric electric and seismographic observations made at the Government Observatories Bombay and Alibag". Poona electrograms are, however, not being tabulated and are preserved for special studies.

Researches on various problems on atmospheric electricity were continued and the list of works published is given in the appendix.

Ionosphere

Ionospheric recorders have been installed by the All India Radio at Peshawar (latitude 34°N, longitude 71° 30′ E), Delhi (latitude 28° 35′ N, longitude 77° 5′ E), Bombay (latitude 19° .9′ N, longitude 73° .0′ E), and Madras (latitude 13° N, longitude 80° 15′ E). Measurements of the critical frequencies of the F and E layers and the virtual heights of the F layer are made within an interval of five minutes centered at each full hour of local mean time. The data thus collected together with some analysis based on them are being regularly published by the Research Department of the All India Radio in their publication "Ionospheric Data", since September 1945. Besides these, problems on the ionosphere have been studied in different universities and institutions. The list of works published during the period under review is given in the appendix.

The India Meteorological Department is taking steps to set up a Magnetic, Earth Current, and Ionospheric Observatory in South India, near the magnetic equator.

Appendix

List of Papers on Geomagnetism, Atmospheric Electricity, and Ionosphere Published during 1938-1947

1. S. K. BANERJI. Does thunderstorm rain play any part in the replenishment of earth's negative charge? Q.J.R. Met. Soc., vol. 64 (1938), pp. 293-299.
2. S. K. BANERJI. Potential gradient inside thunder clouds. Q.J.R. Met. Soc., vol. 64 (1938), pp. 221-222.
3. S. K. BANERJI. On the interchange of electricity between solids, liquids and gases in mechanical actions. Ind. J. Phys., vol. 12, Pt. VI (1938), pp. 409-436.
4. J. N. BHAR. Ionosphere at Calcutta. Ind. J. Phys., vol. 13, p. 253 (1939).
5. S. K. CHAKRABARTY. Geomagnetic time variations and their relations to ionospheric conditions. Curr. Sci., vol. 15, p. 246 (1946).
6. S. K. CHAKRABARTY. Frequency of micropulsations and their variation at Alibag. Scientific notes of India Met. Department, vol. 10, No. 126 (1947).
7. S. K. CHAKRABARTY. Solar streams of corpuscles and their relations to geomagnetic storms. Mon. Not. R. Astr. Soc., London, 106 (1947).
8. S. P. CHAKRAVARTY. A note on field strength of Delhi 3 and Delhi 4 at Calcutta during solar eclipse of September 21, 1941. Proc. Inst. Radio Engrs., New York, vol. 31, p. 269 (1943).
9. CHAMANLAL and K. VENKATARAMAN. Whistling meteors--a Doppler effect produced by meteors entering the ionosphere. Electronics, vol. 14, p. 28 (1941).
10. A. S. CHAUBAL and M. R. RANGASWAMI. The severe magnetic storm of September 18, 1941. Curr. Sci., vol. 10, p. 432 (1941).
11. M. W. CHIPLONKAR and M. S. HATTIANGADI. On the reflection of atmospherics from the ionosphere at night. Proc. Ind. Acad. Sci., vol. A-21, p. 265 (1945).
12. M. W. CHIPLONKAR. Measurement of point discharge current during disturbed weather at Colaba. Ind. Acad. Sc. Proc., vol. A-12, p. 50 (1940).
13. A. C. DEB. Penetration of thin ionospheric layers. Ind. J. Phys., vol. 14, p. 451 (1940).
14. C. LAL. Measurement of the angle of incidence at the ground of downcoming short waves from ionosphere. Ind. J. Phys., vol. 15, p. 289 (1941).

15. S. N. GHOSH. Measurement of the intensity of the night sky light at Calcutta. Ind. J. Phys., vol. 20, p. 205 (1946).
16. S. N. GHOSH. A comparison of the variation of the night sky luminescence and of region F electrical density at night. Sci. and Cult., vol. 9, p. 170 (1943).
17. S. K. MITRA. Geomagnetic control of region F_2 of the ionosphere. Nature, vol. 158, p. 668 (1946).
18. S. K. MITRA. Night sky emission and region F ionization. Nature, vol. 155, p. 786 (1945).
19. S. K. MITRA and A. K. BANERJI. Fringe of atmosphere and ultraviolet light theory of aurora and magnetic disturbances. Ind. J. Phys., vol. 13, p. 107 (1939).
20. S. M. MUKHERJEE and A. R. PILLAI. The electrical characterization of days at Colaba (Bombay, India) during 1930-1938. Terr. Mag., vol. 45, p. 135 (1940).
21. S. M. MUKHERJEE. Effect of meteorological conditions on the electrical conductivity at Colaba (Bombay). J. Univ. Bombay, vol. 11, p. 45 (1942).
22. S. M. MUKHERJEE. Atmospheric electric potential gradient conductivity and air-earth current on electrically quiet days at Colaba. Poona, India Met. Dept. Scientific Notes, vol. VII, No. 19 (1938), pp. 131-148.
23. R. NARAYANSWAMI. Daily variation of irregular disturbances of earth's magnetic field at Bombay. Terr. Mag., vol. 46, p. 147 (1941).
24. M. N. SAHA and B. K. BANERJI. Wave treatment of propagation of electromagnetic waves in the ionosphere. Ind. J. Phys., vol. 19, p. 159 (1945).
25. M. M. SEN GUPTA and S. K. DUTTA. On the experimental investigation of night time E ion densities and their determination by the application of Chapman's formula. Ind. J. Phys., vol. 18, p. 88 (1944).
26. J. M. SIL. Some atmospheric electric observations at Poona. Terr. Mag., vol. 43 (1938), pp. 139-142.
27. J. M. SIL and K. S. AGARWALA. The atmospheric potential gradient at Poona. Terr. Mag., vol. 45, p. 139 (1940).
28. R. RAO. Measurement of the angle of arrival of downcoming waves from Indian regional short-wave stations. Ind. J. Phys., vol. 16, p. 347 (1942).
29. K. VENKATARAMAN. Radio reception during the magnetic storm and ionospheric disturbances from 17th September to 20th September 1941. Curr. Sci., vol. 10, p. 517 (1941).
30. K. VENKATARAMAN. Radio fade-outs in February and March 1942. Curr. Sci., vol. 11, p. 185 (1942).

ITALY

RAPPORTO SULL'ATTIVITA' DELL'OSSERVATORIO MAGNETICO DI GENOVA NEL PERIODO 1939-1947

By Cap. di Vascello Alfredo Viglieri

L'Osservatorio Magnetico di Genova (Castellaccio) ha proseguito le sue registrazioni, iniziate nel 1932, anche durante gli anni 1939-47, assolvendo il suo compito principale, pel quale era stato costituito, e cioe' a servire di base per la taratura e per la riduzione delle Osservazioni di campagna che hanno servito alla compilazione delle nuove carte magnetiche del territorio nazionale e per la continuazione in un certo numero di Stazioni di ripetizione per lo studio della variazione secolare.

L'Osservatorio e' una dipendenza diretta dell'Istituto Idrografico della Marina in Genova; le operazioni di campagna invece, sono state eseguite, salvo un lieve rallentamento causato dallo stato di guerra, e vengono continuate dalle squadre operative dell'Istituto Geografico Militare di Firenze, anche in numerose stazioni di ripetizione atte a determinare la distribuzione geografica della variazione secolare in Italia.

I risultati conseguiti in tale collaborazione sono statitrias-sunti dal Dott. C. Morelli nella sua Nota intitolata: Stato attuale della rete geofisica e geodetica in Italia, 1946 (pubblicazione dell'Istituto Geofisico di Trieste, n. 222, 1946).

Durante tutto il periodo 1939-47, come precedentemente, l'attivita' dell'Osservatorio e' risultata normale, nei riguardi della registrazione della Declinazione e della Componente orizzontale; la registrazione della componente verticale, invece, non ha potuto essere effettuata con continuita', sia per lo stato del variometro, gia' noto all'inizio delle registrazioni come risulta dalla descrizione dell'Osservatorio [1], sia per la successiva crescente importanza delle perturbazioni prodotte dalla rete elettrica della citta'. Relativamente brevi le interruzioni causate dagli eventi bellici.

I dati rilevati dalle registrazioni e regolarmente spogliati, non essendo considerati definitivi, non hanno potuto essere ancora pubblicati, ma sono disponibili in forma manoscritta, insieme con i risultati delle normali misure assolute di verifica nei registri dell'Osservatorio; di essi puo' essere fornita copia agli interessati.

Oltre a servire di base alle osservazioni di campagna, tali dati sono stati oggetto di un'analisi, condotta con metodo grafico descritto dal Prof. Tenani [2] in una nota pubblicata negli atti dell'Accademia d'Italia anno 1941, in vista di ottenerne i grafici mensili della variazione diurna in coordinate X Y della proiezione orizzontale del vettore rappresentativo del campo magnetico della variazione diurna.

Questa analisi, compiuta insieme, e per confronto, con quella dei dati magnetici raccolti a Mogadiscio durante l'anno Polare 1932-33, e' stata estesa al periodo 1932-42, ma i risultati di questo primo ciclo decennale, per quanto molto regolari e conformi a quelli caratteristici della latitudine magnetica dell'Osservatorio, sono stati ritenuti suscettibili di uno studio piu' approfondito in base a un ciclo piu' completo di registrazioni prima della loro pubblicazione insieme con quelli di Mogadiscio. -Sullo svolgimento di tale lavoro hanno notevolmente influito le vicende belliche, che hanno sostretto il Prof. Tenani a trasferirsi insieme al resto dell'Istituto Idrografico fuori della sede dell'Osservatorio, a causa dei bombardamenti aerei della citta'. -A cio' si sono aggiunte poi altre vicende conseguenti, che, se non hanno interrotto seriamente la continuita' della raccolta delle registrazioni e delle misure assolute di controllo, ne hanno pero' limitata enormemente l' attivita'.

Solo alla fine della guerra, nel 1945, l'Osservatorio ha potuto riprendere la sua normale attivita'.

Pur nelle difficili condizioni accennate, il personale dell'Osservatorio ha potuto compiere qualche studio e qualche ricerca; fra questi da mettere in evidenza lo studio di un apparato a induzione per la misura della declinazione e della inclinazione, descritto in Ricerca Scientifica 1941 [3]. Inoltre sono state realizzate alcune importanti applicazioni alle bussole magnetiche pubblicate dall'Istituto Idrografico.

Recentissimamente, con l'opera di ricostruzione della rete ferroviaria dello Stato susseguita alla distruzione degli impianti prebellici, le sorti dell'Osservatorio sono state irrimediabilmente pregiudicate. -La trasformazione, infatti, della trazione ferroviaria da corrente alternata trifase a corrente continua, e' venuta ad aggiungere alle preesistenti perturbazioni gia' accennate e dovute alle successive modificazioni della rete cittadina, altre e piu' cospicue perturbazioni, che rendono inevitabile un trasferimento dell'impianto.

I problemi connessi a tale trasferimento sono molteplici. Innanzi tutto deve essere fatta la scelta della localita', che in una regione come l'Italia, sia per la natura del suolo sia per la forma della penisola e per l'estensione assunta dalla trazione elettrica, presenta gravi difficolta' e richiede una attenta ricognizione preliminare: la ricognizione e' ora in corso.

In occasione del trasferimento verra' presa in considerazione la opportunita' di migliorare ed aumentare l'attrezzatura dell'Osservatorio allo scopo di renderlo piu' conforme alle esigenze scientifiche attuali.

References

[1] M. TENANI. L'Osservatorio Magnetico dell'Istituto Idrografico in Genova, Ricerca Scientifica, Roma, 1933.

[2] M. TENANI. Sulla utilizzazione delle registrazioni di variazione del campo magnetico terrestre. Rend. Acc. d'Italia, Roma, 1941.

[3] M. TENANI. Nuovo metodo della Declinazione e Inclinazione del campo magnetico terrestre. Ricerca Scientifica, Roma, 1941.

Istituto Idrografico della Marina Italiana
Genova, Italy

JAPAN

JAPANESE NATIONAL REPORT ON GEOPHYSICS

Prepared by the National Research Council of Japan

Terrestrial Magnetism and Atmospheric Electricity

Compiled by

Mankiti Hasegawa
Geophysical Institute
Kyoto University
Kyoto, Japan

and

Takesi Nagata
Geophysical Institute
Tokyo University
Tokyo, Japan

Research Activities in Terrestrial Magnetism and Electricity

By M. Hasegawa and T. Nagata

During the nine years from 1939 to 1948, scientific researches in Japan in the field of terrestrial magnetism and electricity have been considerably augmented, chiefly as the result of an increase in the number of those having interest in this field. This tendency has been particularly noteworthy after the end of the war, more precisely from the end of 1945.

On the occasions of solar total eclipse on September 21, 1941, and February 5, 1943, ionospheric as well as geomagnetic observations were carried out with close cooperation among members of the expedition parties which were sent. The results of observations, however, remain largely unpublished.

A list at the end of this report shows the publications concerning terrestrial magnetism and electricity and related phenomena that have been printed between October 1939 and February 1948. Because of economic difficulties prevailing under present circumstances the publications after 1944 have been necessarily limited in number, in spite of the striking increase in the number of papers read before the related scientific meetings in Japan.

Terrestrial Magnetism

Magnetic Observatories. The standing magnetic observatories, Kakioka, Aso, and Simoda, have continued their regular observations. The Toyohara Observatory in Saghalien continued its regular work until the end of the war. A new observatory at Onagawa, belonging to Tohoku University, and another one at Wakkanai in Hokkaido, belonging to the Physical Institute for Radio Waves, are now under construction and will be working by the end of this year.

Magnetic Surveys. The regular magnetic survey of Japan and its neighboring regions was carried out in 1942-1944 by the Hydrographic Department; a summary of the results is given in its own report. A detailed magnetic survey of Hokkaido was made in 1943 through the cooperation of Tokyo, Kyoto, and Tohoku Universities. All these surveys were carried out by means of the three-component magnetometer of the "Suirobu" pattern.

Theoretical Work. The theoretical studies made during 1939-1948 may be classified into four main groups.

(1) Statistical investigations of the solar-diurnal variation in the geomagnetic field during the Second Polar Year were conducted chiefly by M. Hasegawa and his collaborators. In their series of studies, various patterns of day-to-day change, the longitudinal inequality of S-field and their relation to magnetic activity were dealt with. S-field and its change with universal time in the polar region were especially studied in detail. On the other hand, the S_D-field, geomagnetic bays and the longitudinal inequality in the S-field were theoretically examined from the dynamo-theoretical point of view by T. Nagata and T. Rikitake, with good agreement with the observed facts. Almost all of these papers, however, remain as yet unpublished.

(2) Geomagnetic changes accompanying solar flares were statistically studied in a series of papers by S. Imamiti, and theoretically examined by M. Hirayama and others. The relation between the solar-flare-type change and occurrence of magnetic storms was examined by various investigators, being referred to radio fade-out as well as to the simultaneous ionospheric change. It was pointed out by Y. Kato and Y. Sekido that the effect of a magnetic storm upon the intensity of cosmic rays depends on the time elapsing from the "commencement" to the beginning of the main phase in storms. They are re-examining the theories of magnetic storms in the light of the above-mentioned fact.

(3) The electric state of the interior of the earth was theoretically examined by K. Terada with an approximation of higher order. The same problem was attacked by T. Rikitake, using as basic data for calculation the recent results of analysis of S-field, storm-time variation, bays, and other short-period changes.

(4) Magnetic surveys in various localities, including volcanic and seismic zones, were carried out by Y. Kato, T. Minakami, S. T. Nakamura, T. Nagata, R. Takahashi, T. Yumura, and others. Temporary magnetic observatories at Mt. Asama and Miyake-sima Island recorded anomalous changes in the geomagnetic field accompanying their eruptions. For the purpose of interpreting local geomagnetic anomalies and their changes, the magnetic properties of rocks were experimentally examined by both Y. Kato and T. Nagata. In the course of his work, Nagata clarified the mode of development of particular residual magnetization in volcanic rocks, and discussed its relation to geomagnetic anomalies. Studies for deducing the secular variation in the geomagnetic field from the residual magnetization of sedimentary strata have been continued by Nagata and his collaborators.

Ionosphere

Ionosphere Observatories. As the standing ionosphere observatories, five stations are now continuing their regular work, namely, hourly observation of h'-f curves. These stations, which belong to the Physical Institute for Radio Waves, are situated at Wakkanai, Fukaura, Shibata, Kokubunji (Tokyo), and Yamagawa. Various experimental observations are being carried out at Hiraiso by members of the Electro-Technical Laboratory and at Kokubunji by members of the Physical Institute for Radio Waves.

Statistical and Theoretical Work. Ionospheric researches in Japan before 1942 were chiefly made by electrical engineers alone, such as Y. Ito, K. Maeda, K. Ohno, H. Shinkawa, and H. Uyeda. The topics of research were: Daily and seasonal variations in the ionosphere, application of ionospheric knowledge for preparing prediction-of-ionization charts, and observations of fade-outs. Since then, several theoretical discussions on the mechanism of formation of the ionosphere have been made by T. Araki, S. Miyamoto, and his collaborators from astrophysical points of view and by H. Nagaoka from physical standpoints. Upon the establishment of the Ionosphere Research Special Committee in 1946, there were instituted joint observations of the ionosphere, terrestrial magnetism, solar phenomena, field intensity of radio waves, cosmic rays, and night-sky light, with close cooperation among its members, and the results obtained have been investigated from the several viewpoints. The efforts of members of the committee have been directed in general along the following two main lines: (1) Fundamental research on the formation of, and variations in, the ionosphere, and their relation to solar activity, terrestrial magnetism and cosmic rays, and (2) related practical problems in radio-wave communication and the prediction of ionospheric conditions. In fundamental research, the following are worthy of note: The distribution of average electron density and its daily and seasonal variations over the earth were studied by H. Uyeda, particularly a systematic distribution of these quantities with respect to geomagnetic coordinates, and the presence of some anomalous zones was pointed out; the mode of ionospheric disturbance was investigated by Y. Aono, F. Minozuma, T. Nagata, Y. Nakata, and M. Ota, respectively; the relation of solar eruptions to ionospheric and magnetic disturbance was examined by K. Osawa, T. Hatanaka, S. Imamiti, and Z. Suemoto; the coefficients of recombination and attachment were investigated by T. Yonezawa from total-eclipse data as well as short-period fluctuations in f_{F2}; the relation between ionospheric and magnetic daily variation was statistically studied by M. Ota, Y. Nakata, and Y. Sekido; the phenomenon of ionospheric bays was discovered by T. Nagata and N. Fukushima; the relation of variation in electron density of the F_2 layer to that in the intensity of night-sky light was examined by M. Furuhata and T. Yonezawa; the ionospheric change due to meteors was experimentally and theoretically studied by T. Kohno and Y. Furuhata.

As to the practical work, the method of predicting ionospheric conditions by means of a world-wide ionization map, proposed by H. Uyeda, and the studies with the aid of a new model for formation of F_2 layer, proposed by Y. Nakata, may be mentioned first. The determination of absorption of radio waves in the ionosphere was advanced by K. Maeda and Y. Aono, while the changes in field intensity of radio waves due to magnetic storms and Dellinger effect were studied by K. Ohno, S. Matsuo, and K. Miya, those studies being established on the fundamental and geophysical basis. The characteristics of the sporadic E layer and its utilization for wireless communication were promoted by T. Kohno.

Atmospheric Electricity

Observatories. The routine observation of atmospheric-electric potential gradient has been continued at Kakioka, while intermittent observations of atmospheric electricity have been carried out at the Kakioka Observatory, Tokyo, Kyoto, and Tohoku Universities, the Electro-Technical Laboratory and others. The variations in potential gradient, point-discharge current, electric conductivity, space charge, air-earth current and other effects are observed there.

Experimental Work. Small, intermediate, and large ions in the atmosphere were continuously observed by T. Aoki and his collaborators at several localities in Japan. A number of investigations on ions have been made from the medical point of view also.

A new alti-electrograph was constructed by G. Yamamoto for the purpose of examining the distribution of electricity in thunder-clouds, while mechanical collectors were designed and constructed by M. Hasegawa, M. Misaki, and K. Hirao, who used them for the observation of thunder storms. As to the thunder-storm electricity, Y. Tamura investigated the distribution of electricity in thunder clouds by means of mechanical collector, concluding that the type of charge distribution in clouds varies according to the stage of their development. H. Hatakeyama observed the horizontal distribution of sudden changes in the electric field due to lightning and determined the discharge electricity. Z. Yoshida constructed a rotating photographic instrument composed of ten Leica cameras, by means of which he could analyze the cause of electrification of ice particles.

The distribution of the electric field intensity in relation to weather conditions was investigated at several localities by H. Arakawa, S. Kikuchi, and others.

The disturbances of atmospheric potential gradient caused by the smoke-clouds of Asama volcano, dust storms, smoke from locomotive engines, smoke-clouds of fires, and snow storms, were examined by H. Hatakeyama. The potential gradient and space charge in the lower stratum of the atmosphere were also studied by him with the aid of a captive balloon. T. Nagata and his collaborators observed the point-discharge current at various places and discussed its variation due to rainfall, snowfall, and volcanic smoke.

In the realm of high frequency work, the wave form of atmospherics from thunder clouds was investigated by J. Kinpara and his collaborators with applications of locating the position of their origin, while studies of tropospheric reflection were conducted by T. Kohno, K. Maeda, and K. Utsumi.

Earth-Currents

Observatories. At Kakioka, routine observations have been continued. The Toyohara Observatory continued its regular work until the end of the war. New observatories have recently been built at Morioka, Haranomachi, Owashi, and Miyakonojo, and are now in operation. Similar observations were also carried out intermittently at Aso, Onagawa, and Tsukuba.

Experimental and Theoretical Work. Systematic investigations of earth-current variations and their relation to magnetic and ionospheric variations and also to earthquake occurrences have been continued by T. Yoshimatsu, who discussed not only the data at Kakioka but those at other permanent stations as well.

The effect of anisotropic electrical conductivity of the earth's crust on the variation in earth-current has been one of the subjects of many studies. With regard to this problem, a number of experimental and theoretical studies were made by H. Hatakeyama, K. Hirao, M. Hirayama, T. Nagata, and T. Yoshimatsu, respectively. Pulsations in earth-currents, changes accompanying magnetic bays, earth-current storms, vertical earth-currents, and anomalous variations at earth-quake-faults were examined from this viewpoint. Temporary observations of earth-current were carried out on volcanic and seismic zones during their active periods. Those studies were made by T. Hagiwara, K. Hirao, M. Nanba, and T. Rikitake, and some of them reported anomalous changes.

Supplementary Remarks on the National Report

By M. Hasegawa

The whole interval 1939-1948 can be divided into two periods with regard to the research work on terrestrial magnetism and electricity in Japan. In the first period, most research personnel were engaged in military service, and in the second period, owing to the good understanding of the occupation forces on the one hand and the intensive efforts of many talented students in this field of science on the other hand, the revival of research made good progress. With the surmounting of various difficulties we are now engaged in constructing in this country a new research system which is far more active than before.

In the earlier period, although pure research work was seriously hampered by the war, three important activities which were continued throughout the period are worthy of note.

(1) Regular observations were continued at Kakioka Observatory, and the periodic magnetic survey was carried out in 1943 by the Hydrographic Department.

(2) A statistical investigation of the diurnal variation of geomagnetism during the Second Polar Year was worked out by M. Hasegawa in Kyoto University, assisted by M. Ota and others. The hourly values of terrestrial magnetism during the 13 months were collected from 69 observatories over the world.

The distribution of observatories suffices to take account of the variation according to longitude. These are represented as the universal-time variations and others independent of local time.

The magnetic field of S in the Polar region was investigated in detail. A preliminary report on this subject was sent to the Washington Meeting of the Union, and a brief article on the electrical conductivity of the upper atmosphere is being communicated to this Meeting. The existence of a zone of abnormal diurnal variation of conductivity would be worthy of notice in reference to radio communication across the polar region.

The positions of the centers of the corresponding electric current vortices of the S field on both hemispheres were followed through 13 months. It was indicated that the displacement of the centers could be taken as a good measure of the activity of the S field. Some relations to ionospheric data were also suggested.

The non-potential field, calculated from the difference of potentials of S field derived from X and Y components, shows a regular form rotating with the sun. Its intensity was computed to correspond to an air-earth electric current of the order of 10^{-14} ampere per cm^2. But the physical interpretation is not yet successful.

In so far as the contribution of these studies to our knowledge about the varying magnetic field of the earth is of value, it stresses the urgent need for a new plan of international cooperation in magnetic observation, like the Polar Year, in a year of the sunspot maximum.

(3) With reference to geomagnetic phenomena such as regional and local anomalies and secular variation, the magnetic properties of rocks composing the earth's crust were experimentally investigated by T. Nagata of Tokyo University.

In this work, a large number of rock samples, the chemical and petrological characters of which were also determined, were systematically examined from various viewpoints. The scope of this work included complete hysteresis curves, intensity of saturation magnetization, coercive force, susceptibility and its change with temperature, natural remanent magnetization and the physical cause of its development, and others, also the mutual relations among the respective quantities mentioned above and petrological characters. The magnetic properties of igneous rocks thus expressed in a fairly general way were actually related to local and regional anomalies in the geomagnetic field and their secular variations with a satisfactory agreement.

On the other hand, magnetic orientation of Pleistocene deposits in horizontal strata was determined for the purpose of finding the secular variation in ancient eras, and the physical mechanism of the cause of that orientation was also experimentally examined.

List of Publications

Abbreviations

AIKU	Scientific Reports of the Astronomical Institute, Kyoto University.
BERI	Bulletin of the Earthquake Research Institute, Tokyo University.
Chikyu-butsuri	Chikyubutsuri, published by the Geophysical Institute, Kyoto University.
CPIRC	Collected paper of the Ionospheric Research Committee, National Research Council.
GM	Geophysical Magazine, published by the Central Meteorological Observatory, Tokyo.
GN	Geophysical Notes, published by the Geophysical Institute, Tokyo University.
JECE	Journal of the Institute of Electrical Communication Engineers of Japan.
JETL	Journal of Electro-Technical Laboratory.
JIEE	Journal of the Institute of Electrical Engineers of Japan.
Jishin	Jishin, published by the Seismological Society of Japan.
JJAG	Japanese Journal of Astronomy and Geophysics.
JMS	Journal of the Meteorological Society of Japan.
JSHU	Journal of Faculty of Science, Hokkaido University.
MKO	Memoirs of the Kakioka Magnetic Observatory, Central Meteorological Observatory of Japan.
NPIRW	Note of the Physical Institute for Radio Waves.
PIAT	Proceedings of the Imperial Academy, Tokyo.
RHGF	Report of the Hattori Gratitude Foundation.
RPIRW	Report of the Physical Institute for Radio Waves.
SRIRC	Special Report of the Ionospheric Research Committee, National Research Council.
SRTU	The Science Report of the Tohoku University

(A) Terrestrial Magnetism

1. Hirayama, M. Some problems on the earth-magnetic and electric fields. JMS 17 (1939) 435.
2. ________. On the earth-magnetic changes and Dellinger's effect of radio waves. GM 13 (1940) 117-136.
3. Imamiti, S. Dellinger effect and variation of the earth's magnetic field. MKO 3 (1940) 21-22.

4. Imamiti, S. Characteristics of the earth's magnetic field in the last maximum period of sunspot. MKO 3 (1940) 23-28.
5. ________. Great magnetic storm of March 24, 1940. MKO 3 (1940) 48-52.
6. Kato, Y. Investigation of the changes in the earth's magnetic field accompanying earthquakes or volcanic eruptions. 2nd report: On the strong earthquake of May 29th, 1938, which occurred near Kuttyaro Lake, Hokkaido. SRTU Ser. I, 29 (1940) 315-328.
7. ________. Loc. cit. 3rd report: On the strong earthquake of November 5th, 1938, which occurred in the sea bottom near Iwaki, Fukushima Prefecture. SRTU Ser. I, 29 (1940) 329-342.
8. ________. Investigation of the magnetic properties of the rocks constituting the earth's crust. 2nd report: On the susceptibility of rock. (Part I) SRTU Ser. I, 29 (1940) 602-628.
9. ________. Loc. cit. 3rd report: On the susceptibility of rock. (Part II) SRTU Ser. I, 29 (1940) 629-648.
10. ________. Changes in the earth's magnetic field accompanying the volcanic eruption of Miyake-sima. PIAT 16 (1940) 467-472.
11. ________. Investigation of the magnetic properties of rocks. 2nd and 3rd report. RHGF 9 (1941) 267-286.
12. ________. Loc. cit. 4th report. RHGF 9 (1941) 287-312.
13. ________. On the mechanism of magnetic storms. CPIRC 1 (1947) 14-32.
14. ________. Report on the synthetic results of cooperative observation. (Relates to magnetic storms.) SRIRC 1 (1947) 43.
15. Koiwai, M. Correlations of magnetic disturbances and solar activities. MKO 3 (1940) 1-20.
16. Minakami, T. Magnetic survey of volcano Asama II. BERI 18 (1940) 178-251.
17. ________. A magnetic dip survey of Miyake-sima, in the eruption in 1940. BERI 19 (1941) 356-362.
18. ________. Time variations in magnetic dip and their topographical distribution in Miyake-sima, in the eruption in 1940. BERI 19 (1941) 363-366.
19. ________. Magnetization of the new lava-flows of Miyake-sima Island. BERI 19 (1941) 612-618.
20. ________. Variation of magnetic declination of Asama Volcano. BERI 22 (1944) 110-129.
21. Nagaoka, H. Six month period of terrestrial magnetic activity and its relation to F2-layer of the ionosphere. PIAT 16 (1940) 26-32.
22. ________. Magnetic disturbance during sudden fadeouts of radio transmission. PIAT 16 (1940) 201-207.
23. ________. Magnetic storms and lunar phase during sunspot maximum from standpoint of ionospheric disturbance. PIAT 16 (1940) 290-293.
24. ________. Sudden commencement of magnetic storms and its probable cause. PIAT 17 (1941) 250-255.
25. Nagata, T. On the natural remanent magnetization of the lava composing the central cones of Mihara Volcano. BERI 18 (1940) 281-288.
26. ________. The mode of causation of thermo-remanent magnetism in igneous rocks. Preliminary note. BERI 19 (1941) 49-81.
27. ________. The magnetic properties of the new ejecta, in the eruption of Miyake-sima in 1940. BERI 19 (1941) 3-4-324.
28. ________. Anomalous change in geomagnetism accompanying volcanic activity, in the eruption of Miyake-sima in 1940. BERI 19 (1941) 335-355.
29. ________. A geomagnetic study of the minor activities of Mihara Volcano, Oosima Island, August 1940. BERI 19 (1941) 402-410.
30. ________. Measurement of changes in magnetic susceptibility of igneous rocks with temperature in a weak magnetic field. BERI 19 (1941) 579-596.

31. Nagata, T. A note on regional anomaly and secular variation in geomagnetism. BERI 20 (1942) 107-121.
32. ________. The mode of development of thermo-remanent magnetism in igneous rocks, II. BERI 20 (1942) 192-214.
33. ________. On a relation between the local geomagnetic constant and regional anomaly in the geomagnetic field. Jishin 14 (1942) 109-120.
34. ________. The natural remanent magnetism of volcanic rocks and its relation to geomagnetic phenomena. BERI 21 (1943) 1-196.
35. ________, Akasi, K., and Rikitake, T. The natural remanent magnetism of sedimentary rocks. (Preliminary note) BERI 21 (1943) 276-297.
36. ________. The magnetic hysteresis curve of volcanic rocks. BERI 21 (1943) 354-365.
37. ________. Regional anomaly and secular variation in geomagnetism, II. BERI 21 (1943) 366-375.
38. ________. On the isodynamic lines of regional and local anomalies in the geomagnetic field. Jishin 15 (1943) 75-79.
39. ________, Harada, Y., and Hirao, K. The natural remanent magnetism of sedimentary rocks, II. BERI 23 (1945) 79-96.
40. ________, ________, and Okada, A. Measurement of natural residual magnetization of sediment by means of a new type magnetometer. GN No. 13 (1947).
41. ________, and Fukushima, N. The movement of electric charge due to the current system of "Sq". GN No. 14 (1947).
42. ________, and Sugiura, M. Longitudinal inequality in solar diurnal variation in the geomagnetic field. GN No. 36 (1948).
43. Nakamura, S. T. Magnetic observation at Sendai in the Second Polar Year from August 1932 to August 1933. SRTU 29 (1940) 562-601.
44. ________. Observation of geomagnetic anomalies in Sendai Plain and Yonezawa Basin. Jubilee Pub. Com. Yabe 2 (1941) 1117-1123.
45. Takahashi, R., and Hirano, K. Changes in the vertical intensity of geomagnetism that accompanied the eruption of Miyake-sima in 1940. BERI 19 (1941) 373-380.
46. Terada, K. Electric currents as a probable cause of daily magnetic variation. JMS 20 (1942) 353.
47. ________. Loc. cit. (Supplementary note). JMS 21 (1943) 171-177.
48. Tsuboi, C., Miyamura, S., and Kuwabara, T. Geomagnetic disturbances and moon age. BERI 20 (1942) 297-315.
49. Yoshimatsu, T. The earth's magnetism and earthquakes, I. MKO 4 (1943) 23-40.
50. Yumura, T. Distribution of the earth's magnetic field in Aomori Prefecture. MKO 2 (1940) 101-131.
51. ________. Some problems of relation between disturbed magnetic force and a magnetized body. MKO 4 (1942) 7-19.
52. ________. Distribution of the earth's magnetic field in Akita Prefecture, Part I. MKO 4 (1942) 20-45.

(B) Ionosphere

1. Aono, Y. Method of calculating skip distance and attenuation in the ionosphere. RPIRW.
2. Araki, T. On Chapman's theory of the ionosphere. AIKU No. 1 (1944).
3. ________. On the radiative equilibrium in the upper atmosphere, I, II. AIKU No. 2 and 4 (1944).
4. ________, and Shibahara, R. On radiative equilibrium in the upper atmosphere, III. AIKU No. 5 (1944).
5. Hatanaka, T. Some notes on the results of the cooperative observation for ionospheric variation. SRIRC 1 (1947) 15-16.

6. Inaba, K. Study on round-the-world echoes. Report of Radio Department of Japanese Naval Technical Laboratory. Brief Report No. 32 (1939).
7. Ito, Y. Variations of the F2-region in a year. Report of Japanese Naval Technical Research Laboratory. Technical Report No. 2179 (1939).
8. Kohno, T. Ionosphere observations during the solar eclipse of February 5, 1943. Rep. Hiraiso Branch Electr. Lab. (1943).
9. Koshikawa, Y. On the result of the 6th cooperative observation for ionospheric observation. SRIRC (1947) 29-36.
10. Maeda, K., and Uyeda, H. Ionospheric conditions in East Asia (No. 2): Predictions of ionization chart of F2-layers. RPIRW No. 3 (1942).
11. ________, ________, and Utsumi, K. Ionospheric conditions in East Asia (No. 3): Predictions of ionization charts of the E- and F1-layers. RPIRW No. 5 (1942).
12. ________, ________, ________. Propagation charts of short waves in the equatorial zone. RPIRW No. 6 (1942).
13. ________, ________, ________. Propagation charts of short waves in the equatorial zone. (Supplement.) RPIRW No. 7 (1942).
14. ________, Senda, K., Aono, Y., Nakano, T., and Azuma, C. Ionospheric observations during the total eclipse of September 21, 1941. RPIRW No. 7 (1943).
15. ________, Uyeda, H., and Shinkawa, H. Differences of ionospheric conditions in the F2-layer between two points lying on the same latitude but having different longitudes. RPIRW No. 2 (1942).
16. Miya, K., and Suzuki, Y. Oblique transmission between Chureki (Taihoku) and Hankao during the solar eclipse of September 21, 1941. CPIRC 1 (1947) 58-79.
17. Miyamoto, S. On the recombination coefficient. AIKU No. 3 (1944).
18. ________. On the formation of the ionosphere. AIKU No. 8, 9, 11, 12, 13 (1944), 14, 16 (1945).
19. Nagaoka, H. Diurnal variation in the production of ions in the ionosphere. PIAT 18 (1942) 144-149.
20. ________. The formation of the F1- and F2-layers of the ionosphere. PIAT 18 (1942) 382-389.
21. ________. Sudden fade-out of high frequency electric waves caused by alpha-particles formed in the uppermost atmosphere. PIAT 18 (1942) 635-642.
22. Nagata, T., and Fukushima, N. Report on the synthetic results of the cooperative observation for ionospheric variation. SRIRC 1 (1947) 51-66.
23. ________, ________. Geomagnetic studies on the results of the 8th and 9th cooperative observations for ionospheric variation. SRIRC 2 (1947) 17-32.
24. ________, ________. Ionospheric bay accompanying geomagnetic bay. GN No. 35 (1948).
25. Nakata, Y. Predicted ionization charts of f^{o}_{F2}, Zo, Zd, f^{o}_{E} and X from December 1944 to November 1945. RPIRW (1944).
26. ________. Prediction of monthly mean f^{o}_{F2} and formation of F layer. RPIRW.
27. ________. On the mechanism of formation of F12 and application to prediction of critical frequencies of F layer. CPIRC 1 (1947) 1-13.
28. Ohno, K. Abnormal phenomena in long distance propagation of the commercial short wave band. Radio 34 (1942) 99.
29. ________. Radio transmission disturbance during the 7th cooperative observation for ionospheric variation. SRIRC 1 (1947) 47-50.
30. Ota, M. Relation between the diurnal variation of terrestrial magnetism and the ionosphere on quiet days. SRIRC 2 (1947) 11-16.
31. Osawa, K. Report on the synthetic results of the cooperative observation for ionospheric variation. SRIRC 1 (1947) 23-28.
32. ________. Provisional report of the 9th cooperative observation for ionospheric variation. SRIRC 2 (1947) 33-42.

33. Sekido, Y. Synthetic study on the 9th cooperative observations for ionospheric observation. SRIRC 2 (1947) 57-66.
34. Shibahara, R. On the integral equation of radiative equilibrium. AIKU No. 15 (1945).
35. Shimizu, K. Ionospheric change at the time of solar eclipse. AIKU No. 10 (1944).
36. Suyemoto, Z. Radiation of the sun at the time of its eruption. SRIRC 1 (1947) 5-14.
37. Suzuki, Y. Continuous temperature radiation. AIKU No. 7 (1944).
38. Uyeda, H. Some results of the 5th cooperative observation for ionospheric observation. SRIRC 1 (1947) 5-14.
39. ________, and Ishikawa, S. The characteristics of the ionosphere for the calm time at the 8th cooperative observation for ionospheric observation in winter. SRIRC 2 (1947) 1-10.
40. Wakatsuki, T. On the critical condition of the atmosphere in radiative equilibrium. AIKU No. 6 (1944).
41. Yokoyama, H. A new type ionospheric measuring equipment and some ionospheric observation during the total eclipse of February 5, 1943. NPIRW No. 1 (1947).
42. Yonezawa, T. On the variation of electrons and ions in the F2-layer at the time of the solar eclipse on February 5, 1943. NPIRW No. 1 (1947).
43. ________. On the reflection of radio waves from meteors. NPIRW No. 1 (1947).
44. ________. Report of the investigation of the records of the 9th cooperative observation for ionospheric observation. SRIRC 2 (1947) 43-56.

(C) Atmospheric and Terrestrial Electricity

1. Aoki, T. Diffusion of ions from the ion generation and effects to it under some conditions. JETL 5 (1941) 436.
2. ________. On a new method to measure the instantaneous values of atmospheric ions. JETL 7 (1943) 278.
3. ________. Observation of atmospheric potential gradient at Tanashi annex of the electro-technical laboratory. JETL 7 (1943) 319.
4. ________. A new revolving type electrometer. JETL 8 (1944) 136, 145.
5. ________. Design of the new revolving type electrometer. JETL 8 (1944) 463.
6. ________, Okada, H., Sakimura, H., and Kano, K. Diurnal variation of the intermediate ions at Urakawa and Nitta. JETL 10 (1947) 639.
7. Arakawa, H. Atmospheric electric field and cyclones. GM 13 (1940) 211.
8. Hagiwara, T. Changes in earth potential after the eruption of Miyake-sima in 1940. BERI 19 (1941) 365-372.
9. Harada, Y. Point discharge current in snowy days. GN No. 28 (1947) 17.
10. Hasegawa, M. On the newly designed mechanical collector. Chikyubutsuri 4 (1940) 161-169.
11. Hatakeyama, H., and Kubo, T. On the variation of atmospheric potential gradient caused by the cloud of smoke of Asama Volcano. JMS 21 (1943) 49-51, 420-425 and 25 (1947) 39.
12. ________, and four others. Atmospherics and atmospheric potential gradient during snow storms. JMS 22 (1944) 203 and 25 (1947) 40.
13. ________, and Kubo, T. On the variation of atmospheric potential gradient caused by dust storms. JMS 22 (1944) 261 and 25 (1945) 35.
14. ________, ________. The variation of atmospheric potential gradient caused by the smoke of locomotives. JMS 25 (1947) 38.
15. ________. The potential gradient and space charge in the lower stratum of the atmosphere. JMS 25 (1947) 40.

16. Hatakeyama, H. The atmospheric potential gradient near the surface of a captive balloon. JMS 25 (1947) 41.
17. ________. Report on the observation of atmospheric electricity during the thunder storm near Maebashi in the summer of 1941. JMS 25 (1947) 41.
18. ________. Atmospheric potential gradient due to the model distribution of electric charge. JMS 25 (1947) 42.
19. ________. The electric charge neutralized by lightning discharge. JMS 25 (1947) 43.
20. Hirao, K. Changes in earth currents after the Nankai Earthquake. GN No. 29 (1947).
21. ________, Fukushima, M., and Takahashi, T. Point discharge current under volcanic smoke. GN No. 28 (1947) 25.
22. Hirayama, M. On the disturbance of atmospheric electricity by snow drift. Snow and Ice 6 (1944) 169.
23. Hosi, T. On the geo-electromagnetic variation. MKO 2 (1939) 69.
24. Kato, Y., and Oguti, T. Changes in electrical conductivity of the atmosphere accompanied by changes of weather conditions. JMS 25 (1947) 57.
25. Kawano, M. Notes on the mechanism of causation of point discharge current in the atmosphere. GN No. 28 (1947) 1.
26. Kikuti, S. On the electricity of rain. MKO 4 (1943) 1-10.
27. ________. On the atmospheric potential gradient at the top of the hill, "Kakioka Fujiyama". MKO 4 (1943) 17-22.
28. Kimpara, A., Yamasita, A., Fujita, T., and Izumigawa, K. On the wave forms of atmospherics. JIEE 63 (1943) 451.
29. Kitaoka, T., and Miyamoto, I. On the variation of the electric current flowing through the moorings of a captive balloon, and the Haze-layer. Memoirs of the Aerological Observatory of Tateno, 3 (1947) 257.
30. Kohno, T. Reflection of radio waves from the troposphere. JECE 25 (1941) 613.
31. Maeda, K., and Utsumi, K. Measurements of tropospheric reflections of radio waves at frequency of 4 Mc/sec. NPIRW No. 2 (1947).
32. Misaki, M. On a mechanical collector. MKO 4 (1943) 11-16.
33. Miyake, Y., and Yumura, Y. On a radioactive collector. JMS 20 (1942) 49.
34. Nagata, T. Variation in earth currents in the vicinity of the Sikano-fault. BERI 22 (1944) 72-82.
35. ________. Measurement of earth currents in the vicinity of Sikano-fault. PIAT 20 (1944) 81-85.
36. ________. A note on anisotropic conductivity of the earth's surface. GN No. 3 (1946).
37. ________, and Takahashi, T. Electric charge of volcanic ash caused by collision with rock mass. GN No. 28 (1947) 31.
38. Noto, H. Some studies on thunder storms. JJAG 17 (1939) 101, 18 (1940) 73.
39. Ota, M. On the electricity of snow. JMS 21 (1943) 259.
40. Rikitake, T., and Yamada, J. Observation of earth current after the Nankai Earthquake. Special BERI No. 5 (1947) 186.
41. Sao, K., and Iida, K. Nomogram for design of collecting electrode of the ion counter having some cut off mobility of the ion counter. JETL 11 (1947) 35.
42. Sone, K. Antenna-earth currents beneath thunder clouds. JMS 17 (1939) 56.
43. Tamura, Y. Observation of changes in electric potential gradient. Chikybutsuri 4 (1940) 170-180.
44. ________. On the distribution of electricity in a thunder cloud. Chikybutsuri 4 (1940) 181-226.
45. ________. On electricity in a thunder cloud. Chikybutsuri 7 (1943) 81-111.
46. Terada, K. Electromagnetic induction within the earth's crust of variable conductivity, I. GM 13 (1940) 63-104.

47. Yahagi, F., and Obayashi, T. Anomalous change in point discharge current during rainfall. GN No. 28 (1947) 10.
48. Yamamoto, G. New altielectrometer. JMS 19 (1941) 1.
49. Yokouti, Y. On the earth current potential at Memanbetu, Ishigaki, and Nemuro. MKO 5 (1943) 54.
50. ________, and Kikuti, S. Observation of disturbed field of atmospheric electricity and some notes on Bendorf's electrometer. MKO 3 (1940) 29.
51. Yoshida, Z. On the electrification of ice particles and the mechanism of generation of electric charge in thunder cloud. Low temperature science 1 (1944) 149.
52. ________, and Hanazima, Z. A new photographic instrument for analyzing lightning flashes. JSHU Ser. 2 3 (1942) 165.
53. Yosimatu, T. Variations of earth current potential related to the Tottori earthquake, September 10, 1943. MKO 5 (1943) 66.

(D) Solar Phenomena, Cosmic Rays, Night Sky Light and Miscellaneous

Solar Phenomena

1. Notsuki, M., Suemoto, Z., and Senba, I. Monthly bulletin of solar phenomena, (Jan. 1941-Mar. 1945). Tokyo Astronomical Bulletin, Nos. 515, 524, 535, 541, 557, 578, 580, 582, 595, 607, 609, 611, 616, 617, 623, 625, 627, 640, 645, 648, 664, 668, 669, 671, 674, 675, 678, 680, 696, 699, 701, 702, 704, 707, 709, 711, 713, 715, 717, 719, 722, 723, 726, 727, 729, 731, 733, 734, 736, 738.
2. ________, and Senba, I. Solar eruptions, (Jan. 1944-Mar. 1945). ibid. Nos. 717, 722, 723, 726, 727, 729, 731, 733, 734, 736, 738.

Cosmic Rays

3. Arakawa, H. On the vertical shift of meson-formation layer. Phys. Rev., 58 (1940) 1118.
4. ________. Seasonal and diurnal variations of cosmic ray intensities. GM 13 (1940) 215.
5. Ishii, C. Several characters of Nishina model I cosmic-ray meter. Bulletin of the Institute of Physical and Chemical Research, 23 (1944) 191.
6. ________, Asano, Y., Sekido, Y., and Shimamura, F. Intensity variations of cosmic rays. ibid. 18 (1939) 1066.
7. ________, ________, ________, ________. Intensity variations of cosmic rays. JMS 18 (1940) 160, 256.
8. Nishina, Y., Sekido, Y., Shimamura, F., and Arakawa, H. Cosmic-ray intensities and air masses. Phys. Rev., 57 (1940) 663.
9. ________, ________, ________, ________. Air mass effect of cosmic-ray intensity. Phys. Rev., 57 (1940) 1050.
10. ________, ________, ________, ________. Cosmic-ray intensities and cyclones. Nature, 145 (1940) 703.
11. ________, ________, ________, ________. Cosmic-ray intensities in relation to cyclones and anticyclones. Nature, 146 (1940) 95.
12. ________, ________, ________, ________. Cosmic-ray intensities and typhoons. Phys. Rev., 59 (1941) 679.
13. Sekido, Y. Latitude variation of the barometer effect of cosmic rays. Journal of the Physico-Mathematical Society of Japan, 16 (1942) 77.
14. ________. Cosmic rays and the upper atmosphere in the tropics. ibid. 16 (1942) 78.

15. Sekido, Y. Effects of cosmic rays. Scientific Papers of the Institute of Physical and Chemical Research, Tokyo, 40 (1943) 456.
16. ________, Asano, Y., and Masuda, T. Cosmic rays on the Pacific Ocean. Part I - Latitude Effect. ibid. 40 (1943) 439.
17. ________, ________, ________. Cosmic rays on the Pacific Ocean. Part II - On the barometer effect of cosmic rays. ibid. 40 (1943) 456.

Night Sky Light

18. Furuhata, M. A photoelectric study of the light of the night sky. CPIRC 1 (1947) 33-57.
19. Utsumi, M. Some investigations of the light of the night sky. MKO 5 (1943) 1-44.

Miscellaneous

20. Kato, Y. The report of the total solar eclipse of 21st September, 1941. Proc. Geophys. Section, National Research Council of Japan (1943).
21. Koiwai, M. On the spectrum of lightning. MKO 4 (1942) 1-6, MKO 5 (1943) 69.
22. Sato, T. On the corpuscular eclipse of 21st September, 1941. PIAT 16 (1940) 461-462.
23. ________. On the ultra-violet light eclipse at the upper ionized layer, in a solar eclipse (with an example of the coming eclipse of September 21st, 1941). SRTU Ser. 1, 29 (1941) 649-672.

APPENDIX I TO THE JAPANESE NATIONAL REPORT

Report of Ionosphere Research Special Committee of the National Research Council

By Yusuke Hagihara, Chairman

The Ionosphere Research Special Committee, which was formally established in May of 1946, is an extension and an amplification both in its scale and in its plan of the work of the 25th Committee (Solar Radiation and its Action) of the First Division of the National Research Council, and has included a part of the work of the 32nd Committee (Earth Magnetism and Electricity) of the First Division of the National Research Council.

The aim of the research work of this Committee is the study of the ionosphere and its associated heliophysical and geophysical phenomena and the investigation of the nature of the mechanisms in the ionosphere as well as of geomagnetism and geoelectricity, together with their relationships to the radiation and the corpuscular streams from the sun, and has for its application the search for remedies against radio communication anomalies by predicting them a sufficiently long interval of time before their occurrence.

The activity of the Committee may be summarized as follows:

(1) Simultaneous cooperative observations for fixed terms:
- (a) For spring: March 10 - April 10
- (b) For summer: June 10 - July 10
- (c) For autumn: September 10 - October 10
- (d) For winter: December 10 - January 10

(2) Simultaneous cooperative observations for disturbed intervals:
- (a) Period of observation: 10 days
- (b) Time of start of observation: Judged by a careful watch on the solar phenomena.

(3) Regular general monthly meeting
- (a) Report the observed data during the last period.
- (b) Report the synthetic study of the data in various fields.
- (c) Compile and publish the reports.

(4) Monthly colloquium
- (a) Report the results of research of members and distribute a summary of the reports.
- (b) Report foreign research work.

(5) Subcommittee meeting (not regularly held)
- (a) Try to find out the best way to achieve efficiently the aim of the Committee.
- (b) Consider improvement and development of observation methods, instruments, method of representing data, and so forth.

(6) Intercommunication and exchange of data among observing stations by radio.
The two frequencies, 3,550 kc and 9,175 kc, are allotted for this purpose.

The radio facilities can be used for sending an alarm signal, when anomaly is observed or expected to occur.

(7) Publications

(a) Collected Paper of the Ionospheric Research Committee, National Research Council, 2 Vols.

(b) Special Report of the Ionospheric Research Committee, National Research Council, 3 Vols.

The organization of the Committee will be briefly described in the following.

Chairman: Yusuke Hagihara, Doctor of Science, Professor of Tokyo University.

Members: About 50 (assistants not included)

Address: Tokyo-to, Daito-ku, Ueno-park National Research Council.

Participating organizations and their research fields

(a) Solar phenomena

Tokyo Astronomical Observatory, Tokyo University (sunspots, calcium flocculi, chromospheric eruptions in Ca radiation)

Mt. Ikoma Observatory, Kyoto University (sunspots)

(b) Geomagnetism

Kakioka Geomagnetic Observatory, Central Meteorological Observatory (continuous records of horizontal and vertical components and declination)

Mitsui Geophysical Institute, private (the same)

Mt. Aso Observatory, Kyoto University (the same)

Geophysics Department, Tohoku University (variation of horizontal component)

Geophysics Department, Tokyo University (the same, also continuous observations of dip)

(c) Ionosphere

Physical Institute for Radio Waves and its Four Branches, Ministry of Education (semi-hourly observations of h′-f curve)

Hiraiso Branch of the Electro-Technical Laboratory, Ministry of Communications (the same, also observations of radio-wave scatter)

(d) Telecommunication

Ohira Laboratory of the Radio Wave Bureau, Ministry of Communications (observation of field intensity of radio waves from America and Europe)

Osaka Branch and Ono Receiving Station of International Telecommunications Section, Ministry of Communications (the same, from Europe)

Komuro Receiving Station of International Telecommunications Section, Ministry of Communications (the same, from America)

Tokyo and Osaka Office of the Bureau of Electrical Communication Technique, Ministry of Communications (the same, and that of domestic communications)

(e) Night sky light

Astronomy Department, Tokyo University (observation by photo-cells)

Geophysics Department, Tohoku University (the same)

Electrical Engineering Department, Nagoya University (observation by monochromatic photography)

Research Laboratory of Central Meteorological Observatory (the same)

(f) Cosmic rays

Department of cosmic rays of the Institute for Physical and Chemical Research, private (time variation of cosmic-ray intensity)

Research Laboratory of Central Meteorological Observatory (the same)

(g) Earth currents

Kakioka Geomagnetic Observatory, Central Meteorological Observatory

Besides the above projects and observations the Committee is planning to extend its activity to the research of meteoric reflection of radio waves, extraterrestrial radio noise and quantum-mechanical study of ionosphere.

APPENDIX II TO THE JAPANESE NATIONAL REPORT

Magnetic Observations by Hydrographic Department, Ministry of Transportation

The activity of the Japanese Hydrographic Department in the field of terrestrial magnetism continues as before, because it is entrusted with the duty of publishing the magnetic charts necessary for navigation. From the year 1939 up to the present the Department has maintained magnetic observatories and also executed a complete magnetic survey. It is now contemplated to execute the fifth decennial survey in the year 1952.

1. Magnetic survey during the period 1942 to 1944. A complete magnetic survey as part of the series of decennial magnetic surveys of Japan was executed by the Hydrographic Department in the interval between May 1942 and March 1944 in spite of difficulties during the war. This fourth survey covered the entire extent of Japan and the southern part of Manchuria. The three magnetic elements were observed at 213 stations distributed uniformly over the whole area surveyed, of which 136 are so-called repeat stations, common at least to the former magnetic survey for the epoch 1933.0.

The instruments used throughout this survey of Japan were of the same type as in the survey of 1933.0, namely, the Nippon Suirobu Type Magnetometer, which is suitable for the measurement by an electromagnetic method of three elements of the earth's magnetic field: Declination, dip, and horizontal intensity. The complete results of the magnetic observations have not yet been published, but chart No. 6024 showing the contours of equal magnetic declination for the epoch 1945.0 was issued by the Department on April 18, 1947.

2. Magnetic observations at the observatories. The Department has now only one observatory, in the town of Katuura, Wakayama Pref., where magnetic observations have been made every five days by means of the Nippon Suirobu Type Magnetometer since October 21, 1946. The resulting data will be reported in the Suiro-Yoho monthly. Details of the observatories are shown by Tables 1 and 2. At all observatories only absolute observations have been made. The file of geomagnetic data up to 1945 was destroyed by the air-raid fire of March 10, 1945, except the data of Katuura and those reported in Terr. Mag., vol. 52, No. 3, pp. 410-411.

3. Secular variation. According to the results of the fourth decennial survey and of observations made at the observatories, the secular variation of the declination is stationary in the Ryukyu Islands, easterly in the Formosa but still remains

westerly in Japan, Korea, Manchuria, Saghalien and Kurile Islands. The annual change is about 1.5 minutes in the middle of both Honsyu (Japan proper) and Korea, and about three minutes in the southern part of Saghalien and Kurile Islands.

Table 1

Observatory	Locality	Situation	North Latitude	East Longitude	Height above sea-level
			° ′ ″	° ′ ″	Meters
Zinsen[1]	Korea	The northern part of the city of Zinsen	37 29 54	126 37 36	50
Taihoku[2]	Formosa	The northeastern part of the city of Taihoku	25 03 58	121 32 57	7
Otomari	Saghalien	The northwestern part of the town of Otomari	46 38 46	142 46 17	37
Palau	Caroline Islands	Kororu Island in Caroline Islands	7 20 00	134 28 48	30
Jaluit	Marshall Islands	Jabol, Jaluit Island in Marshall Islands	5 54 49	169 38 59	1
Minami-Torishima	Marcus Island	The central part of the island	24 17 25	153 58 42	1
Matsuwashima	Kurile Island	The southeastern part of the island	48 03 37	153 15 46	40
Katsuura	Honshu (Japan proper)	The northern part of the town of Katsuura, Wakayama Prefecture	33 37 46	135 56 56	35

Table 2

Observatory	Year of commencement	Elements measured	Remarks
Zinsen[1]	1918	Declination, dip and horizontal intensity	Stopped since August 1945
Taihoku[2]	1919	Declination	Stopped on May 1, 1945
Otomari	1920	Declination	Stopped since August 1945
Palau	1926	Declination	Stopped since 1942
Jaluit	1938	Declination	Stopped since 1943
Minami-Torishima	1941	Declination	Stopped on September 1, 1943
Matsuwashima	1943	Declination	Stopped on September 26,1944
Katsuura	1945	Declination, dip and horizontal intensity	Stopped on August 23, 1945. Commenced again on October 21, 1946

1) Interrupted for several years, because of damage to the building from a severe typhoon in the summer of 1920.

2) Site of observatory was changed twice, first on July 28, 1938, and then to the recent tabular situation on January 1, 1941.

APPENDIX III TO THE JAPANESE NATIONAL REPORT

Present Status of the Magnetic Observatory and the Laboratory of Geophysical Electricity and Magnetism under the Central Meteorological Observatory, Tokyo

By K. Wadati

(A) Magnetic Observatory. There are two magnetic observatories under the Central Meteorological Observatory. One of them is the Kakioka Magnetic Observatory (ϕ = 36° 13′ 51″, λ = 140° 11′ 21″) and the other is that temporarily situated at Ikutora (ϕ = 43° 10′, λ = 142° 35′) in Hokkaido, the most northern district of Japan. The latter was established in lieu of the Toyohara Magnetic Observatory (ϕ = 46° 56′.8, λ = 142° 44′.7) which was opened in August 1932 and is now under the Russian Government.

At Ikutora we observe earth currents only, but before the end of this year, magnetic and electric observations will be started.

In addition to these observatories, it is planned to establish in the near future a new magnetic observatory in the southern part of Japan.

As above stated, at present the Kakioka Magnetic Observatory is the only practically active one under the Central Meteorological Observatory, so we briefly describe the work of this Observatory.

The Kakioka Magnetic Observatory began its work on January 1, 1913, and has conducted observations continuously ever since. During the war it did not undergo any damage. The work is carried on normally by 50 persons as personnel.

Observational Subject

(1) Geomagnetism
- (a) Absolute observations
  Principal observations of three magnetic elements are made once a week, and auxiliary observations every three days. Instruments used in absolute observations are Ad. Schmidt's normal magnetic theodolite, Edelman's magnetic theodolite, and Nippon Suirobu type magnetometer (electromagnetic method).
- (b) Recording of variations
  - (i) Variations are continuously recorded on photographic paper --the horizontal intensity and declination by Eschenhagen's magnetic variometer, and the vertical intensity by Lloyd's balance type variometer.
  - (ii) Continuous recording of horizontal intensity is maintained by Imamiti's visually recording magnetometer.
  - (iii) Continuous recording of variability of vertical intensity by horizontal rectangular wire loop.

(2) Earth current
Earth current observations are widely distributed all over Japan. Beside its central station Kakioka, we have five other stations, Morioka (ϕ = 39° 42′, λ = 141° 01′), Haranomachi (ϕ = 37° 37′, λ = 140° 56′),

Owase (ϕ = 34° 04′, λ = 136° 12′), Miyakonojo (ϕ = 31° 42′, λ = 131° 01′) and Ikutora. At these stations earth potential is recorded continuously by a photographic method, and the separation of the two electrodes for each component is given below.

	Long-base system		Short-base system	
	N-S	E-W	N-S	E-W
Kakioka	1.0 km	1.5 km	100 m	100 m
Morioka	0.93	1.44	--	100
Haranomachi	0.85	1.33	--	100
Owase	--	--	123	161
Miyakonojo	--	--	328	307

At Kakioka recording of the earth's resistivity will be commenced in the near future.

In addition to earth current observation, we carry out continuous recording of the variability of the earth's magnetic total intensity by Nagaoka's induction magnetometer at Miyakonojo.

(3) Atmospheric electric observation
  (a) Potential gradient near the earth's surface is continuously recorded by Bendorf's self-recording electrometer, and a mechanical collector combined with a string electrometer is used to record fine potential variations.
  (b) Antenna earth current is recorded by a galvanometer when atmospheric electric field is disturbed. Two antennas, each 10 meters long and 3 meters above the ground are stretched east to west and north to south.
  (c) Recording of point-discharge current by galvanometer.
  (d) Recording of charge of rain.
  (e) Observation of ion-number and conductivity of air.

(4) Observation of the surface of the sun
  (a) Photographic observation of sunspot by Zeiss' 200 mm equatorial.
  (b) Sketch of prominences by Zeiss' direct-vision spectroscope.

(5) Seismographic observations are carried out by the following instruments.
  (a) Wiechert's 200 kg horizontal seismograph.
  (b) Wiechert's 80 kg vertical seismograph.
  (c) Strong-motion seismograph.
  (d) Simple seismograph.

(6) Meteorological observations
  Three times a day, at 6^h, 14^h, and 22^h, by ordinary methods.

Work Shop

Design, manufacture and repair of magnetic and electric instruments are carried on.

Publication

(a) Annual Report of the Kakioka Magnetic Observatory. Reports already issued are for the years 1913, 1914 and from 1924 to 1934. Owing to the great earthquake in the year 1923, magnetic records from 1913 to 1923 were lost by fire, and it became impossible to report our magnetic data during these years. Issue of the report of 1935 and thenceforth is making rapid progress.

(b) The Report of Solar Phenomena for 1932-1938.

(c) Memoir of the Kakioka Magnetic Observatory. Contents of this memoir are investigations in geophysics, solar physics and ionospheric phenomena. Volumes already issued are as follows:

Vol. 1, Nos. 1, 2, 3, and 4 (1938)
Vol. 2, Nos. 1, 2, and 3 (1939), No. 4 (1940)
Vol. 3, Nos. 1 and 2 (1940)
Vol. 4, No. 1 (1942), No. 2 (1943)
Vol. 5, No. 1 (1943)
Vol. 6, No. 1--this will be issued in coming May.

(B) Laboratory of Geophysical Electricity and Magnetism. This Laboratory is attached to the Meteorological Institute of the Central Meteorological Observatory and is conducted by Dr. S. Minakawa, the Chief of this Laboratory. The present status of investigations carried out there is briefly given below.

(a) Cosmic ray section (number of investigators, 7). After the end of the war we endeavored to construct a counter telescope to measure the cosmic ray intensity, separating its hard and soft components. Outline of our apparatus is as follows: 3 trays of G.M. counters, each having 20 G.M. counters (diameter 45 mm, length 280 mm, total effective area of counter tray is 0.25 m^2). Lead absorber 10 cm thick is placed between the middle and the lower trays. The upper and the middle counter trays serve to measure total component, and the middle and the lower ones serve to measure hard component. The pulses of G.M. counter trays are fed to suitable coincidence apparatus (resolving time is 2×10^{-6} sec) and scale of 64 recorders. The final records are taken automatically on recording paper. From the middle of 1947 the preliminary run was carried out and some data were obtained. We are now studying the relation of variation of cosmic ray intensity with geomagnetism, upper air temperature and other geophysical phenomena.

(b) Electric waves section (number of investigators, 4).

(i) Atmospherics. After the end of the war we reconstructed the Ratkin type of direction finder for atmospherics, and at Owada (Saitama Prefecture) we began routine work to record the direction and the frequency of occurrence of atmospherics. We intend to establish at least two observing stations (Nagoya and Fukuoka) in the near future. On the other hand, we are now making efforts to construct the instantaneous type of direction finder using Braun tube and the measuring apparatus of the wave form of atmospherics.

(ii) Reflection of electric waves from the "C-layer". We are now constructing the apparatus to measure reflection of electric waves due to "C-layer". The apparatus consists of four Mc pulse generator, receiver and indicator. The aim of this project is to study the relation between the reflection of electric waves and the meteorologically discontinuous layer. The apparatus is expected to be completed before the coming summer.

APPENDIX IV TO THE JAPANESE NATIONAL REPORT

Report of Physical Institute for Radio Waves, Ministry of Education

By Ken-ichi Maeda, Director

The Japanese ionosphere work had been originated and promoted solely from the practical aspects of radio communication. The need of amplification, and at the same time the consolidation, of ionosphere work of the separate organizations was first acknowledged by technical components of Army, Navy and the Ministry of Communications in 1939-1940, and shortly after that a new organization to co-ordinate the work was established on the 3rd of March, 1941. This organization was called the Physical Institute for Radio Waves (Denpa-Butsuri Kenkyujo) and placed under the direct supervision of the Minister of Education.

The establishment of many overseas ionosphere stations and the utilization of observed data for practical communication purposes were the main work of the Japanese ionosphere group (The Physical Institute for Radio Waves being its center) during the war, and improvement of prediction of ionospheric conditions and calculation of received field-intensity characteristic charts were the major part of the research activity of the Physical Institute for Radio Waves until the end of the war.

The end of the war brought termination of all the overseas ionosphere stations, of which Toyohara (46°.9 N, 142°.8 E) in Karafuto, Hankow (30°.7 N, 114°.3 E) in China, Naha (nearly completed) in Okinawa and Tainan (nearly completed) in Formosa belonged to the Institute. Rearrangement of the Institute, re-establishment of four branch observatories in Japan, and standardization of ionosphere work were completed towards the end of 1946 by encouragement and help of the occupation forces. Basic research on the ionosphere and radio propagation, and cooperation with the field of research in general physics, geophysics and solar physics have been stressed. The main activity of the Institute concerning the ionosphere is included in the work of the Ionosphere Research Special Committee of the National Research Council.

The present organization of the Physical Institute for Radio Waves, Ministry of Education, is as follows:

Location: (35°.7 N, 139°.5 E) Tokyo-to, Kitatama-gun, Koganei-machi (near Kokubunji)
Personnel: 299 (non-technical personnel included)
Director: Ken-ichi Maeda, Doctor of Engineering

Ionosphere observation group:
- Kokubunji central observatory (35°.7 N, 139°.5 E)
- Wakkanai branch observatory (45°.4 N, 141°.7 E)
- Fukaura branch observatory (40°.6 N, 139°.9 E)
- Shibata branch observatory (37°.95 N, 139°.3 E)
- Yamakawa branch observatory (31°.2 N, 130°.6 E)

Research group:
- 1st group: Ionosphere and ionospheric radio propagation.
- 2nd group: Troposphere and tropospheric radio propagation.
- 3rd group: Development of equipments.

Besides, the Institute has five small branches for radio propagation measurements.

Publications:

Report of the Physical Institute for Radio Waves: 7 volumes.
Notes of the Physical Institute for Radio Waves: 3 volumes.

APPENDIX V TO THE JAPANESE NATIONAL REPORT

Report of the Society of Terrestrial Magnetism and Electricity of Japan

By M. Hasegawa, Chairman

The Society of Terrestrial Magnetism and Electricity of Japan was established in 1946 with support of about 200 active members for the purpose of promoting theoretical studies in terrestrial magnetism and electricity and mutual understanding among related fields of science. The Society is supported by all organizations and individuals having interests in terrestrial magnetism and electricity in Japan, covering ten related branches, namely, terrestrial magnetism, magnetic surveys, earth-currents, atmospheric electricity, ionosphere, communication technique; cosmic rays, solar physics, atomic physics, and instruments. The Chairman of the Society is Prof. M. Hasegawa of Kyoto University.

General meetings were held in May and in October 1947 at Tokyo and Kyoto, respectively. There were read 59 original papers, 20 concerned with terrestrial magnetism and its relation to ionosphere, 12 with the ionosphere, 11 with atmospheric electricity, 5 with cosmic rays, 4 with earth-currents, and 7 with electric and magnetic properties of rocks, including magnetic prospecting. Since these papers include a number of important works worthy of circulation, we are now endeavoring to publish them in the Proceedings of the Society notwithstanding various difficulties in the present circumstances. The third general meeting is to be held at Kakioka in June 1948.

Report from Director of the Central Meteorological Observatory of Japan

By K. Wadati

The Kakioka Magnetic Observatory has taken the following steps to adhere to Resolutions 4 and 10 of the Washington Assembly.

Resolution (4), Control of Variometers and Absolute Instruments:

(a) Declination variometer was adjusted June 1932, and now the direction of the magnetic axis of it deviates from magnetic meridian about 30 minutes of angle. A new declination variometer is under setting.

(b) Corrections to be given to the instruments used for determination of declination and inclination do not exceed the standard error of a single observation.

Resolution (10), Recommendations regarding Publication of Observatory Data:

(a) Accuracy of observation.

	Single observation
Edelman type	$\pm 8\gamma$
Schmidt type	$\pm 2\gamma$
Indian Survey Pattern	$\pm 5\gamma$
Nippon Suirobu type	$\pm 0.9\gamma$

(b) Temperature coefficient of variometer.

Horizontal intensity	$27\gamma/1°C$
Vertical intensity	$10\gamma \sim 15\gamma/1°C$
Declination variometer	$2.2''/1°C$

Temperature coefficient of our horizontal variometer is too large as above mentioned. At present, an experiment to compensate temperature effect on magnetic moment of a magnetic variometer by special alloy is under progress. In April 1948, it will be completed and regularly installed.

(c) Scale value of variometer.

Horizontal intensity	$3.6\gamma \pm 0.03\gamma/mm$
Temperature coefficient	$0.00024\gamma/mm/1°C$
Ordinate coefficient	$0.00075\gamma/mm/mm$
Declination	$0'.757 \pm 0'.005/mm$
Vertical intensity	$5\gamma \sim 6\gamma \pm 0.1\gamma/mm$

(d) Reliability of data.

Horizontal intensity	$\pm 2\gamma$
Declination	$\pm 0'.05$
Vertical intensity	$\pm 2\gamma$

(e) Comparison.

Schmidt-Edelman	$= -7\gamma$
Nippon Suirobu Type - Edelman	= 0 (1946-1947)
Indian Survey Pattern - Edelman	$= -33\gamma$
Schmidt - Potsdam	$= -7.8\gamma$ (1927)
Edelman - Carnegie	$= -24\gamma$

(1929 - Ault and Parkinson)

Differences of declination and inclination are very small.

MOROCCO

RAPPORT NATIONAL MAROC

Par G. Bidault

La campagne de mesures des éléments du champ magnétique terrestre commencée au Maroc en 1938 a été poursuivie en 1939 par dés determinations complètes aux stations de répétition de Casablanca et de Mazagan. En Juillet 1939, les instruments de l'Institut scientifique chérifien: le théodolite Chasselon, moyen modèle, No. 178, et la boussole d'inclinaison Chasselon, moyen modèle No. 171, ont été étalonnés par comparaison aux instruments de l'observatoire de Chambon-la-Forêt. L'ouverture des hostilités a ensuite interrompu toute activité magnétique; ce n'est qu'en 1941 que quatre stations de répétition: Rabat, Mazagan, Safi, Mogador ont pu être réoccupées et que douze stations nouvelles ont été établies le long d'une ligne traversant le Maroc du NW au SE. En 1942 les mesures se sont poursuivies, cinq stations complètes ont été occupées dans le Haut-Atlas central, une à l'observatoire d'Averroeës et une à Rabat où les instruments de l'Institut scientifique chérifien ont été comparés aux instruments de campagne de M. Dubief de l'Institut de Physique du Globe de l'Algérie. La reprise des hostilités en Afrique du Nord a de nouveau interrompu l'activité magnétique de l'Institut scientifique chérifien.

En 1945, un levé détaillé dans la région restreinte du Djebel Hadid, entre Mogador et Safi, a été réalisé par l'Enseigne de Vaisseau Tingry pour détecter des perturbations magnétiques qui auraient pu être a l'origine du déréglement des compas de petits bâtiments naviguant dans les parages du Cap Hadid. Les mesures de la déclinaison effectuées en 24 points convenablement situés à la périphérie du Djebel ont confirmé, aux erreurs expérimentales près, la valeur de la déclinaison déduite d'un tracé normal des isogones dans cette région. Les recherches sont maintenant orientées vers la nature des fonds marins au large du Cap Hadid.

Malgré d'importantes difficultés de transport quelques mesures ont pu être faites en 1947. C'est ainsi que deux nouvelles comparaisons aux instruments de M. Dubief, l'une à Rabat, l'autre à Alger, ont confirmé les écarts constatés dans la mesure de H; aussi a-t-il été décidé d'envoyer le theodolite No. 178 et la boussole No. 171 à l'observatoire de Chambon-la-Forêt pour un nouvel étalonnage qui devra précéder la reprise des mesures régulières au Maroc.

Tous les résultats de mesure ont été publiés ou sont en cours de publication. Une carte de la déclinaison magnétique au Maroc au 1er Janvier 1947 a été dressée par M. Bidault. Des cartes des lignes isoclines et des lignes isodynamiques dressées par M. Bidault et Debrach sont actuellement sous presse.

Bibliographie

G. Bidault. Mesures magnétiques. Ann. du Service de Physique du Globe et de Météorologie de l'I.S.C., Maroc, 1938.

G. Bidault. Variations séculaires du champ magnétique terrestre au Maroc. Bull. de la Soc. des Sc. Nat. du Maroc., t. XXII, Rabat, 1942.

G. Bidault. Mesures magnétiques. Ann. du Service de Physique du Globe et de Météorologie de l'I.S.C., Maroc, 1941 (sous presse).

G. Bidault. Carte de la déclinaison magnétique au Maroc au 1er Janvier 1947. Institut national de Géographie (Annexe du Maroc) 1947.

G. Bidault et J. Debrach. Physique du Globe et Météorologie-Etat de nos connaissances en 1947. Bull. Jubilaire de la Soc. des Sc. Nat. du Maroc (sous presse).

NORWAY

REPORT OF RESEARCH ON AURORAE AND EARTH MAGNETIC STORMS MADE AT NORDLYSOBSERVATORIET, TROMSÖ, DURING THE YEARS 1939-1946

By Leiv Harang

This period was mainly the years of occupation, and the research was restricted to working up material and observations previously obtained. Papers giving the results on research on aurorae, ionosphere, and earth magnetic storms have been published. The following results have been obtained:

1. Aurorae. A statistical study of the heights of 355 arcs and 293 draperies has been made. It was shown that there is a gradual decrease of the heights of the lower border when going from weak, medium to strong aurorae [see (1) of "Literature" below]. A curve giving the diurnal variation of the directions of arcs is given.

The results of a study of the luminosity curve of the aurorae have been given. Assuming that the aurorae luminosity is produced by a bundle of cathode-rays penetrating the atmosphere and being exponentially absorbed, the theoretical absorption and luminosity curve is compared with the actual luminosity curve observed. From this the scale-height of the atmosphere $H = kT/mg$ in different heights of the atmosphere in the region 100-200 km height has been determined [2].

2. Ionosphere. Noon-values of the critical frequencies of the ordinary layers have been recorded. In addition to this observations on scattered reflections have been made on various frequencies. The diurnal variation of distant scatter (600-2500 km equivalent reflection distances) on the frequencies 8-12 Mc/s has been studied [3] using a pulse-transmitter of considerable power. With the same arrangement scatter from the E-region of meteoric origin was recorded on 6-8 Mc/s. Using a special transmitter on 7.3 m scattered reflections from a very intense aurorae arc were obtained [4]. During the eclipse July 9, 1945, the critical frequencies of the layers were observed at Tromsö [5].

3. Earth Magnetic Storms. A discussion of the nature and appearance of pulsation in the earth magnetic records at Tromsö has been given. Two classes of pulsations were studied, one with a period lying between 70 to 150 sec (giant pulsations) and another class with periods less than one second (vibrations). The diurnal and annual variation has been discussed and for the giant pulsations a definite relation between period and diurnal time of appearance was established [6].

The mean field of disturbance, the D-field, during polar storms has been studied by means of records from a series of stations between Spitzbergen and Niemegk, using the material from the Polar Year 1932-33. The mean diurnal variation of the field across a geomagnetic meridian at about $\Lambda = 120°$ has been demonstrated on maps in all three components and for four different degrees of storminess. The D-field is explained as due to current systems flowing along the auroral zone. From the maps of the D-field it is further evident that the currents along the auroral zone are discontinuous, they are broken up into two segments. The gradual displacement of the auroral zone towards south with increasing earth magnetic activity is demonstrated on the maps [7].

Literature

[1] A study of auroral arcs and draperies. Geofys. Publ., vol. 13, No. 14 (1944). Terr. Mag., vol. 50, 297 (1945).

[2] The luminosity curve of the aurorae. Geofys. Publ., vol. 16, No. 6 (1945). Terr. Mag., vol. 51, 381 (1946).

[3] Experimental studies on the reflection of radio waves from the ionized regions. Geofys. Publ., vol. 13, No. 4 (1942). Terr. Mag., vol. 50, 287 (1945).

[4] Echoversuche auf Ultrakurzwellen. IS für Hochfrequenztechnik u. Elektroakustik, vol. 55, 105 (1940).

[5] Radio echoes observations at Tromsö during the solar eclipse on July 9, 1945. Geofys. Publ., vol. 16, No. 11 (1946). Terr. Mag., vol. 50, 307 (1945).

[6] Pulsations in the terrestrial magnetic records at high latitude stations. Geofys. Publ., vol. 13, No. 3 (1942). Terr. Mag., vol. 44, 17 (1939).

[7] The mean field of disturbance of the polar earth-magnetic storm. Geofys. Publ., vol. 16, No. 12 (1946). Terr. Mag., vol. 51, 353 (1946).

REPORT ON AURORAL WORK SINCE 1939

By Carl Störmer

[See Report of the Auroral Committee, pp. 286-288.]

REPORT FROM THE WORK OF THE TWO NORWEGIAN OBSERVATORIES, TROMSÖ AND DOMBÅS DURING THE EPOCH 1939-1947

By B. Trumpy

Since the Seventh General Assembly of the International Union, 1939, the registering of the three magnetic elements D, H, and V has been carried on continuously both for Tromsö and Dombås. Owing, however, to difficulties in getting register paper, there has occasionally been missing curves during periods up to two to three months at Dombås.

Year books are published for Tromsö up to 1945 and for Dombås up to 1941. The year books for 1942-1945 are, however, almost ready for publishing and we hope to have this paper ready at the time of the Assembly at Oslo this year.

Besides the year books Dr. Harang has published two magnetic papers in "Geofysiske Publikasjoner", vol. XIII, nr. 3 and vol. XVI, nr. 12, and two papers in the journal "Terrestrial Magnetism", vol. 44, March 1939, and vol. 51, September 1946.

In a special series "Magnetisk Byrå og Norges Sjökartver" Dr. B. Trumpy has published "A Magnetic Survey of Norway". A special report of this work and a detailed magnetic survey, which is now going on were previously sent to the Committee in Washington.

K. F. Wasserfall has published two papers in "Geofysiske Publikasjoner", vol. XIII, nr. 2, and vol. XVI, nr. 4, one paper in "Publikasjoner for Det Norske Institutt for Kosmisk Fysikk", nr. 16, and eleven papers in the journal "Terrestrial Magnetism".

Data for the three-hour-range, expressed by Index K, have been sent regularly since 1939 (also during the war time) and this is also the case with data for the Character Numbers.

A paper, treating the daily observations for inclination for the epoch 1870-1908, is under preparation. (These observations are left by Hansteen.)

In the summer 1948 there will be started permanent registering of the three magnetic elements D, H, and V at the new founded station at Björnöya.

REPORT ON INVESTIGATIONS ON THE PHYSICS OF THE IONOSPHERE AND ITS RELATION TO SOLAR PHENOMENA

By L. Vegard

Since 1939 investigations, which have a bearing on the physics of the ionosphere and solar-terrestrial relationships, have been undertaken by the writer partly in collaboration with E. Tönsberg, G. Kvifte, and B. Rypdal. The results are to be found in a number of papers, the most important of which are contained in the list of publications.

This report intends to give a short summary of the problems and effects dealt with and the results obtained.

1. Detection, Measurement, and Interpretation of Auroral Lines

It is known from previous investigations that the auroral spectrum first of all is dominated by the strong green OI-line, the red OI-doublet and the nitrogen bands belonging to the negative and the 1st and 2nd positive group. The wavelength of the green line and the strongest component of the red doublet were very accurately measured by an interferometer.

The wavelength of the second red component and its intensity relative to the strongest one have been measured by means of spectrograms taken with large dispersion (9, 10). The wavelength was found to be λ = 6363.9 A and the relative intensity 0.35 in good agreement with the theoretical value 0.33.

In addition to these strong lines and bands a number of weaker ones appear. Some were referred to the so-called Vegard-Kaplan bands, and some were interpreted as atomic lines from O- and N in various states of ionization. During the years 1940-43, eight very successful and strongly exposed spectrograms were obtained at the Auroral Observatory, Tromsö. From these spectrograms about 65 new weak lines were detected and measured making the total number of auroral bands and lines as yet measured equal to about 170.

Among the new lines we may mention the nebular lines originating from the metastable ground states of the doubly ionized O-atoms, namely, the doublet OIII ($^1D_2$ - $P_{2,1}$) (5006.7, 4961) corresponding to the red OI-doublet and the lines OIII ($^1S_0$ - $^1D_2$) (4363) corresponding to the green OI-line.

Some permitted lines from neutral O-atoms, a large number from singly ionized and perhaps some from doubly ionized O-atoms appear. The spectral analysis of the auroral luminescence thus shows, that atomic oxygen partly neutral and partly singly and doubly ionized is present in the auroral region. Up to the present no trace of oxygen bands has been found.

While the bands from nitrogen appear with great intensity atomic N-lines, if they appear at all, are much weaker than the atomic lines from oxygen. A moderately strong line λ = 3467.5 may possibly be identical with the forbidden NI-line (^4S - ^2P), but the doublet (^4S - ^2D) (5200.1, 5197.8) has not yet been found. A line 5202.9 very distinctly observed and accurately measured from spectrograms of fairly large dispersion (9, 10) has a difference in wavelength which is much greater than the possible error. Some weak auroral lines, however, coincide within the limit of error with lines from N-atoms in the neutral or ionized state, but the interpretation cannot yet be regarded as settled.

2. The Occasional Occurrence of Hydrogen Lines and the D-line of Sodium

Ordinarily hydrogen lines do not appear in the auroral spectrum. Spectrograms obtained at Oslo during the autumn 1939 showed fairly strong lines coinciding with H_α and H_β indicating that showers of hydrogen from the sun occasionally penetrated into the atmosphere (1, 2, 3).

Spectrograms obtained at Tromsö 1940-41 with a spectrograph of greater dispersion showed a sharp line exactly coinciding with the H_β-line of the comparison spectrum (9).

On spectrograms taken with the same spectrograph on the same kind of plates and quite as strongly exposed, the sharp H_β line had vanished, but in its place appeared near to it towards shorter waves a broad line or band with a wavelength 4856.5 A (10).

The line coincides with an OII line 4856.5, but as it is not sharp it can hardly be a single atomic line. The fact that it had not been previously observed and the probable occurrence of hydrogen showers would suggest that such showers had been in operation during the exposure, and that we were observing the H_β-line displaced through doppler effect. If so, the average displacement of about 5 A corresponds to a mean velocity towards the observer of about 300 km/sec.

The yellow sodium line which appears with great intensity in twilight is also observed in the auroral luminescence and even in the middle of the night (8, 9, 10, 12). Its intensity is found to fluctuate enormously both in the auroral and in twilight. Some times it is too weak to be observed. This indicates that also showers of sodium from the sun occasionally enter into the atmosphere.

3. Variability within the Auroral Spectrum

The red OI-doublet which occasionally is very weak is sometimes largely enhanced and produces red aurorae of the A-type. The probability of red aurora of this type increases with solar activity.

A comparison between spectrograms from Tromsö and Oslo showed that the red doublet and the green line are enhanced toward lower latitudes. The enhancement of the red doublet is much greater than that of the green line which means that the occurrence of red auroral of type A increases when the latitude diminishes (1, 2).

Altitude effects--Since the enhancement with altitude of the negative bands relative to the green line was discovered in 1923 a number of very pronounced altitude effects have been detected of which we shall call attention to the following:

When we pass towards greater altitudes, the red OI-doublet (1) and certain OII-lines (12) are enhanced, while the intensity of the bands of the first positive group diminishes (1). The last of these effects is explained from the fact that the velocity of the exciting rays diminishes and the pressure increases downwards. Determination of the excitation function (6) shows that the light intensity along the electron ray has a pronounced maximum just above the excitation potential. These effects explain the red aurorae of type B, where the red color is restricted to a narrow band near the bottom edge.

Spectrograms of the red lower border of aurorae of type B have been obtained which show the red bands of the first positive group greatly enhanced, while at the same time the red OI-doublet is extremely weak or hardly observable (9). This shows that in the case of type B the red color is not caused by the enhancement of the red OI-doublet.

In the case of red aurora of type A, exposed to sunlight, we obtained spectrograms where the red OI-line 6300 was more than six times as strong as the green line 5577 (9).

A number of other variability effects have been treated in previous papers, e.g. in G.P. XI, No. 16, 1937.

4. Determination of the Ionospheric Temperature from Aurorae at Different Altitudes or in a Sunlit Atmosphere

In order to explain the coronal structure of the auroral region, e.g. marked by the slowness with which the density decreases upwards, it is of fundamental importance to determine the temperature within the terrestrial corona. This can be done by determining the development and extension of the rotational bands of the negative nitrogen group.

Since the first estimates of the temperature by this method were applied in 1923, a considerable number of quantitative measurements have been carried out. Spectrograms suitable for this purpose must have a fairly large dispersion and with the spectrographs at our disposal the time of exposure was very long.

The spectrograms previously obtained for this purpose were taken in the way that the collimator was directed on the part of the aurora showing maximum intensity.

The measurements undertaken in this way correspond to an altitude interval of 110-140 km and all of them gave temperatures far below 0°C with an average of -47°C.

In 1941 and 1942 we were able to measure the temperature from three spectrograms corresponding to aurorae exposed to sunlight. The following temperatures were found -26°, -40°, and -57°C. Mean value -41°C.

In 1938 we obtained with the big quartz spectrograph a pair of spectrograms, one corresponding to the lower, the other to the upper limit of the auroral streamers. The temperature found from the 3914 band was exactly the same (-63°C) in both cases.

The determination of temperatures from sunlit aurorae and for large altitudes will be continued, but the measurements undertaken up to the present give no indication of any essential increase of temperature with altitude or when the aurorae are exposed to sunlight.

5. The Physics of the Ionosphere and its Relation to the Solar Phenomena

Already in 1923 the study of the auroral spectrum at different altitudes had shown that the auroral region ordinarily did not contain noticeable quantities of the light gases hydrogen and helium, but was mainly composed of molecular nitrogen and atomic oxygen to the very top of auroral rays, which sometimes reach altitudes of 600-1000 km. The slow rate at which the gas-density diminishes upwards in this "coronal structure" on the top of our atmosphere cannot be explained by a high temperature, which is in fact below 0°C.

The only other possible alternative is that matter is driven up to higher altitudes through electric forces. This requires a process which produces ionization and an electric field through separation of positive ions and electrons. The theory of the ionosphere which was based on these observational facts, was first given in papers published in 1923. This theory is based on the assumption that the sun in addition to the ordinary thermal radiation emits an abundance of radiation of short wavelength of the type of soft X-rays. Such a radiation would ionize the gas and produce an electric double layer with its negative side directed upwards, and the matter with a surplus of positive electricity would be driven upwards.

The soft X-radiation should produce two layers of maximum ionization, one where the absorption of the rays per unit length of path is a maximum at a height of about 100 km or perhaps somewhat less, and one produced by the electrons driven upwards through the photoelectric action of the solar X-rays. The height of this maximum should be of the same order of magnitude as that of the auroral ray streamers--the altitude of which may vary from, say, 250-1000 km.

In between these two maxima should be one produced by the solar radiation in extreme ultraviolet region. These consequences of the theory were confirmed in a striking way by the radio-echo measurements inaugurated in 1926 by Breit and Tuve and by Appleton and collaborators.

A discussion of the correspondence between the ionospheric properties derived from auroral investigations and those derived from radio-echo measurements were given in a paper published in 1938 in Geofys. Publ., Oslo (1) and in "Ergebnisse d. exakt. Naturwiss.", V. XVII. The two layers produced by the solar X-rays correspond to the E- and F_2-layers and the one due to ultraviolet light is identified with the F_1-layer. The theory accounts in a simple way for the properties found for these layers.

The distribution of matter which followed from the theory when the influence of the sun and the earth's magnetic field is taken into account, showed the existence of a kind of twilight phenomenon produced by the ionosphere, which was identified with the zodiacal light. Thus the explanation of the zodiacal light came as a by-product or part of the theory of the ionosphere.

The ionospheric theory was directly applicable to the solar corona. This consequence of the theory was discussed in greater details in a paper published in 1928 in connection with results from observations of the total solar eclipse in Norway in 1927.

The production of the soft X-rays which form the basis of the theory of the ionosphere and the solar corona was explained by assuming that matter of high energy and highly ionized ions, was brought from the inter to the surface of the sun, where it produced soft X-rays by recombination. When the coronal lines were interpreted by Edlén in 1941, I published a paper (11), where it was shown that Edlén's important results were in perfect accordance with my coronal theory and that they gave a direct proof of the existence of the solar X-rays which form the basis of the coronal theory.

The coronal theory also gives an explanation for the production of the ray bundles which produce the aurorae and certain types of magnetic disturbances. The coronal streamers are usually composed of a mixture of electrons, positive ions, and neutral particles.

The showers of hydrogen and sodium, the existence of which were indicated by the spectral studies, may only mean that sometimes coronal streamers reach the earth.

The narrow bundles of electron rays which usually produce the auroral phenomena may be prevented from losing their velocity by having their track neutralized by positive ions, so as a rule very little ordinary matter is transported to the earth during aurorae and magnetic storms.

In the paper referred to (11) the excitation process connected with the emission of the coronal lines, is discussed and the coronal theory explains why only forbidden lines connected to metastable states appear in the coronal luminescence.

6. Origin and Excitation of the Sodium Line in Twilight

With a large spectrograph we obtained at the Auroral Observatory at Tromsö two spectrograms from twilight giving separation of the two components of the yellow sodium line (8).

At Oslo series of twilight spectrograms were taken first in the zenith direction and soon afterwards in a nearly horizontal direction. Assuming with Bernard that the emission of the sodium line is determined by the shadow formed of visible light by the solid earth, the zenith observations gave a smaller height of the upper limit of the emission layer than those taken near the horizon.

Assuming, however, that the action of ultraviolet light is essential for the emission of the D-line and that the atmosphere below a certain height (H_S) acts as a screen for the effective solar rays the screening height (H_S) was found from the condition that the zenith and horizon observations give the same upper limit (H_u) for the twilight emission of the D-line (7). The Oslo observations gave $H_S = 58$ km, $H_u = 119$ km. Similar observations from Tromsö gave $H_S = 50$ and $H_u = 109$ km (8).

It was found that the effective radiation should have a wavelength between 2000 and 3000 A or probably near 2500, and that the atmospheric ozone was responsible for the absorption and the screening effect.

The work was continued at Oslo in collaboration with G. Kvifte. The observational method was improved and formulae were given for a direct calculation of (H_S) and (H_u) (12). The observed quantities are: The times of disappearance of the D-line τ_z and τ_h at the zenith and near the horizon respectively, azimuth (a) and height (α) of the collimator axis for the exposures near the horizon. In order to fix these quantities accurately we always used a lens in front of the collimator with the slit in the focus plane. These measurements gave the values $H_S = 44$ km, $H_u = 105$ km.

Also in this case the screening height is situated at an altitude where the ozone concentration is extremely small, the maximum ozone concentration being situated at a height of about 25 km. The way in which the intensity of the D-line varies with time indicates that the D-emission from twilight mainly originates from a fairly thin layer with its upper limit at 105-110 km, or the sodium layer is found at the lower part of the auroral region or just at the bottom of the ionosphere.

The auroral spectra show that sodium exists in small concentration also at greater altitudes within the auroral region. The localization of the effective sodium layer and the large fluctuations of the intensity of the D-line both in twilight and in the aurorae suggests that the sodium comes into the atmosphere from space --probably from the sun.

7. Laboratory Experiments of Importance for the Interpretation of the Auroral Spectrum and its Variability

In order to explain the variability effects, especially the variation with altitude of the relative intensity of auroral lines and bands, it is of importance to know the way in which the intensity varies with the velocity of the exciting electron rays, and how the emission of the lines and especially the forbidden ones are affected by the collisions made by the excited particles.

The ignition potentials and the excitation functions for nitrogen bands have been determined in collaboration with B. Rypdal (6).

Experimental investigations on the physical conditions for the emission of the green auroral line and the red OI-doublet have been undertaken in collaboration with G. Kvifte (13).

The intensity variations of these lines have been studied from discharges in pure oxygen and in oxygen-neon mixtures. A theory, which agrees well with experiments, led to the determination of the probability (α), that an O-atom in the metastable $^1S_0$-state is disturbed by collisions with O_2-molecules, and the probability (β) that the same state is disturbed by collisions with neon atoms. We found $\alpha = 3.6\ 10^{-6}$ and $\beta = 2.9\ 10^{-7}$. The experiments have thus given the unexpected result that the metastable $^1S_0$-state is very stable against collisions. Only about one collision of a million will disturb the $^1S_0$-state.

It was found that under the conditions of our experiments the number of O-atoms (N) which are excited to the $^1S_0$-state is about 70 times greater than the number (n) of O-atoms which is transferred to the upper state of the permitted line 5555. This indicates that in the source (positive column) the number of electrons, having energies sufficiently great to excite the low $^1S_0$-state, is very large compared with the number which are able to excite the higher ordinary non-metastable states.

This result might suggest that the great intensity, with which the green line and sometimes the red doublet appear in the auroral spectrum, might be explained if the O-atoms were mainly excited by secondary electrons of small velocity, and the changes of relative intensity might correspond to changes of the energy distribution of the secondary electrons.

List of Papers

1. L. Vegard, Vörgange und Zustände in der Nordlichregionen, Geof. Publ. (G.P.) Oslo V. XII, No. 5, 1938.
2. L. Vegard, On some recently detected important variations within the auroral spectrum, Terr. Mag., 1939.
3. L. Vegard, Hydrogen showers in the auroral region, Nature, V. 144, 1089, 1939.
4. L. Vegard, Weak bands and atomic lines in the auroral spectrum, G.P., Vol. XII, No. 8, 1938.
5. L. Vegard, Continued investigations on the auroral luminescence and the upper atmosphere, G.P., Vol. XII, No. 14, 1940.
6. B. Rypdal and L. Vegard, The excitation functions of nitrogen bands and their bearing on auroral problems, G.P., Vol. XII, No. 12, 1940.
7. L. Vegard, The atmospheric layer from which the yellow line in twilight originates, Nature, V. 145, p. 623, 1940.
8. L. Vegard and E. Tönsberg, Investigations on the auroral and twilight luminescence including temperature measurements in the ionosphere, G.P., Vol. XIII, No. 1, 1940.
9. L. Vegard and E. Tönsberg, New important results relating to the auroral spectrum and the state of the upper atmosphere, G.P., Vol. XIII, No. 5, 1941.
10. L. Vegard and E. Tönsberg, Results of auroral spectrograms obtained at Tromsö Observatory during the winters 1941-42 and 1942-43, G.P., XVI, No. 2, 1944.

11. L. Vegard, Coronal phenomena and their relation to solar and terrestrial processes, G.P., Vol. XVI, No. 1, 1944.
12. L. Vegard and G. Kvifte, Spectral investigations of aurorae and twilight, G.P., Vol. XVI, No. 7.
13. G. Kvifte and L. Vegard, On the emission of the forbidden lines from the metastable groundstates $^1S_0$ and $^1D_2$ of the neutral oxygen atom, G.P., XVII, No. 1, 1947.

PERU

GEOPHYSICAL WORK IN PERU

The Huancayo Magnetic Observatory, which had been operated since 1922 by the Carnegie Institution of Washington, was transferred on July 1, 1947, with equipment and personnel, to the Ministerio de Fomento, of the Peruvian Government. Its name has been changed to Instituto Geofísico de Huancayo. The regular program in geomagnetism is being continued. Some improvements in instrumental equipment, especially that for measuring vertical intensity, will be made, and arrangements for the restandardization of the absolute instruments are nearly complete. A magnetic-survey program is also contemplated for obtaining data for use in the construction of isomagnetic charts of Peru. This work has previously been done with the aid of cooperative surveys made by the U. S. Coast and Geodetic Survey. It is planned to undertake measurements of the earth's magnetic field in the ionosphere, using polarized radio waves, in cooperation with the Carnegie Institution of Washington.

At the present time a geophysical program of broad character is under way. Other equipment in operation includes vertical and horizontal seismographs, a cosmic-ray meter, multifrequency ionospheric and various field-intensity recorders, potential gradient and conductivity apparatus, spectrohelioscope, and various meteorological instruments. New buildings have been constructed for convenience in operation and for the use of visiting investigators.

Because of the location of the Institute at a high elevation near the magnetic equator, it is expected that new and important experiments will be conducted from time to time as in the past. Studies of seismic micropulsations, and interpretations of deep-seated geological features of the Andes based on seismic results will be undertaken.

Active cooperation with other Peruvian agencies, notably those concerned with geodesy, meteorology, and geology is planned.

POLAND

GEOPHYSICAL OBSERVATORY IN SWIDER

By Z. Kalinowska

In spite of the tragic German invasion in Poland in 1939 and the occupation, which lasted almost six years, creating terrible conditions of life and destroying all cultural acquisitions of our nation, the Geophysical Observatory in Swider has suffered relatively small losses. Its buildings were not destroyed; it succeeded in keeping almost all of the scientific equipment and the collected observation material; moreover it kept up continuity of work, not interrupting it even in the hardest moments, when the front line ran in the close vicinity of Swider during the years 1939 and 1944.

The losses of the Observatory could be shortly stated as follows: On account of the German invasion of Poland in September 1939, one of our scientific workers did not get back to Warsaw from the Wilno province, where he had been conducting surveys. He was forced to spend the whole period of war abroad, partially in a camp. As a result, the Observatory lost a magnetic Chasselon theodolite with all accessories necessary for field surveys, including a chronograph and a motor car. During the siege of Warsaw the house on Górnośląska Street 26, where the Observatory had its office, was partially destroyed. In connection with this the Observatory suffered some losses in the observation material being kept there for preparation. Concerning researches in earth magnetism, only some of the computations have been destroyed. Protocols and magnetograms were kept in Swider and so all of them have been saved. We are enabled thus to work them out again and it has been already partially done. Completely destroyed, however, were notes on atmospheric electrical potential for the period of almost nine years and data concerning their reduction.

In the final period of the war in Poland, when Warsaw was being purposefully destroyed by Germans in 1944. field variometers of A. Schmidt type and a chronometer, temporarily kept in Warsaw, were burned. Also a library of the Observatory, which remained during the entire occupation in a secured part of a partially destroyed office of the Observatory in Górnośląska Street 26, inasmuch as it was not possible to transfer it to Swider, fell a victim to fire.

I am able to state, however, that, as regards the losses in instruments, they are already almost compensated, thanks to the financial help, granted to us by the Commission on Matters of the Reconstruction of Polish Science at the Central Planning Board. It is, of course, a much harder problem to reconstruct the library. In any case, we have already begun to supplement it. I wish to take advantage of this opportunity to thank once more, and to express our gratitude to all kindred institutions abroad, who, in reply to our circular, attached to Volume X of the "Travaux de l'Observatoire à Swider," have supplied us with their publications.

The greatest loss, suffered by the Observatory in the beginning of the regained independence, was the death, in March 1946, of its founder and Director, Professor Stanislaw Kalinowski. Hard war conditions were undoubtedly an indirect cause of his death.

As I have already pointed out, the activities of the Observatory were kept up during the entire period of the war (1939-1945); nevertheless, because of the difficult conditions in which we were living during the occupation, the scope of the work had to undergo some restrictions. Concerning the magnetic work during the war, it has been restricted to researches conducted at the Observatory itself. There have been conducted regular registrations of elements D, H, and Z by means of a slow run recorder (the time of the cylinder's rotation, 24 hours). Absolute measurements were made at intervals of two weeks by means of basic instruments (a Cambridge Scientific Instrument Company magnetometer N. 169 type Kew, and an earth inductor N. 107 of Schulze), and additionally by means of a Sarterius magnetometer. The material received from observations has been worked out, the priority being given to the computation of data on the changes in declination. On account of the personnel being greatly reduced (to three persons), the registration of variometers H and Z is computed with some delay. This was aggravated by the necessity for calculating for the second time data relating to the years 1937 and 1938, which, as I have already mentioned, were destroyed in 1939.

In 1946 field surveys have been resumed. In view of the changed boundaries of our state, and in view of the fact that from the time of publishing the previous magnetic map of Poland (1935) 11 years elapsed, we considered it advisable to work out a new map for 1947. The map appeared in the spring of 1947. It has been elaborated on the basis of pre-war materials of our Observatory, of materials supplied by the Observatory in Potsdam for our recovered territories, and by controlling surveys, executed by us in the summer of 1946 in various places, distributed more or less equally upon the territory of the entire state.

In the summer of 1947 we were continuing field work. Sixty absolute measurements were made; in the majority of cases of the three elements D, H, I, partly of the two D, I. Our purpose in making those surveys was to establish our own net of points in the recovered territories, and also to furnish material for working out the course of secular variations (measurements in old surveying points).

There has also been worked out the Warsaw anomaly on the basis of a detailed survey made in the years 1937-38 by means of Schmidt's balances. Those instruments, as I have mentioned above, unfortunately got lost. Thus it has been impossible to complete the material now in our possession, which constituted a starting point for proposed further studies of this anomaly.

During the war we were of course unable to keep contact with foreign countries and to transmit our data to the international organizations. From June 1943 to July 1944 we have marked the K-indices from our magnetograms, and those data were taken from us by the Geophysical Institute in Potsdam. In 1947 we transmitted to the Carnegie Institution of Washington both the daily magnetic character C and the three-hour-range indices K. We also transmitted the data for the first and second quarter of 1948.

As mentioned in Volume X of the "Travaux de l'Observatoire", in the summer of 1939 our Observatory started work on a new additional registering station at a distance of 3 km from Swider to control the effects of electrification of railways on the recordings at Swider.

Unfortunately, the war forced us to liquidate that station before the observations could be brought to end. At present we are in the course of erecting a new recording station at a distance of 15 km from Swider and far from all railways, for similar control observations.

Concerning observations in other fields of geophysics, we were obliged during the war for technical reasons to interrupt observations of atmospheric electricity; also we conducted neither meteorological nor actinometrical observations. Now we have started by observing atmospheric potential and in the near future we shall take up meteorological observations.

Concerning our publications, in the year 1946 was issued Volume X of the "Travaux de l'Observatoire", containing a short history of the Observatory during the war, tables, results on the mean diurnal variations of the magnetic elements in the period 1921-1935, and a detailed table of magnetic observations done in Swider in the year 1936.

In 1947 Volume XI of the "Travaux de l'Observatoire" was issued, including a map of isogons in Poland for the year 1947. Both those publications were sent to all institutions and observatories in Poland and abroad.

The successive 12th volume of the "Travaux de l'Observatoire" will contain a report on observations concerning the Warsaw anomaly. Unfortunately, financial difficulties did not permit us to print that work until now.

SWEDEN

REPORT ON WORK IN TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY SINCE THE WASHINGTON ASSEMBLY

By Harald Norinder

Progress of work in terrestrial magnetism and atmospheric electricity in 1939-1948

Continuous magnetic observations have been made at the observatory at Lovö, Stockholm, during the period 1939 to 1948. At Abisko, magnetic observations were interrupted in 1942 and did not resume until 1945.

Survey work has been carried out by the Hydrographic Office of Sweden for general and navigational purposes and by the Geological Survey of Sweden for geological purposes.

With regard to the geographical situation of Sweden, where extended regions exist, above the polar circle which can easily be reached by train from Stockholm in 24 hours, it was highly desirable to establish a geophysical observatory for continuous work in these far northern parts of Sweden. In 1945, Swedish geophysicists discussed the future of the Abisko station and a committee of Swedish geophysical specialists was formed under the auspices of the Royal Swedish Academy of Science, to which the Abisko station belonged. In January 1947 the committee delivered an extended plan for a new geophysical research institute. The new institute was planned to be adapted for continuous geophysical observations and would contain a first-class meteorological station, arrangements for registration of magnetic, of seismic elements, of atmospheric electricity, and of the ionosphere. The institute was planned to be furnished with good instrument shops and with special laboratory rooms to be at the disposal of scientific specialists, who wanted to stay at the institute in order to carry out special investigations in the arctic regions. As a suitable locality for the new institute a place not too far away from the town of Kiruna was chosen. The proximity to Kiruna should allow part of the staff of the institute to settle in the town. At this locality conditions were very favorable for both meteorological and more general geophysical work. The restricted economic situation in Sweden has not yet allowed the Swedish government to present the proposal of the new institute before the Swedish parliament, but it is hoped that the Swedish government will show a benevolent attitude towards this project.

The starting of ionospheric investigations at the Electronic Laboratory of the Royal Chalmers University of Technology is of greatest value. Earlier ionospheric researches were entirely lacking in Sweden. It is also hoped that the construction of ionospheric recording instruments at the Institute of High Tension Research of the Uppsala University and the starting of some ionospheric investigations there will stimulate continuous recording of ionospheric elements in Sweden, a research subject, which is from many points of view necessary and important.

As is to be seen from the subjoined Special Reports, the Swedish geophysical research work is mainly characterized by investigations on special geophysical problems.

Special Reports

Investigations carried out at the Department of Electronics at the Royal Institute of Technology (Kungl. Takniska Högskolan), Stockholm

By Hannes Alfvén

Theoretical investigations. Problems concerning magnetic storms, aurorae, the solar corona, solar prominences and the sunspots have been treated in a series of publications (1-9).

Model experiment on the aurora, by K. G. Malmfors. In connection with a theory of the aurora, proposed by H. Alfvén, some model experiments have been carried out (10). A gaseous discharge was studied in the vicinity of a magnetized sphere placed in an electric field. As in Birkeland's experiments there arose an illuminated ring around each pole and it could be shown that these rings are a consequence of the shape of the gaseous discharge. If the earth during a magnetic storm enters an electric field the auroral phenomena may possibly be explained in a similar way.

Registrations of cosmic radiation, by K. G. Malmfors. During the years 1939-1941 cosmic radiation was recorded in different directions by means of coincidence counters (11). The total number of counts amounted to 1.2×10^8. The registrations show that the diurnal variation is not the same in different azimuths.

This year a new apparatus has been constructed which is capable of registering 120,000 counts per hour.

Model experiment determination of cosmic ray orbits in the earth's magnetic field (12), by K. G. Malmfors. An electron ray was emitted from the surface of a magnetized sphere and the asymptotic direction in which the ray leaves the magnetic field was determined. Results were obtained for particle energies corresponding to $2 \times 10^9 - 10^{10}$ e.v. in the cosmic radiation. In one series of measurements the electron gun at the surface of the sphere was directed towards the zenith and the latitude was varied between 40° and 90°. In a second series of measurements the latitude was kept constant at 58° (the magnetic latitude of Stockholm), the elevation and azimuth angles being varied. The results which are presented graphically, are correct within some degrees and show good agreement with paths calculated by Störmer.

From the results it can be concluded that the difference in diurnal variation, mentioned above, cannot be explained as due to the influence of the sun's magnetic field.

Publications

H. Alfvén:

(1-2) A theory of magnetic storms and of the aurorae. K. Sv. Vetenskapsakademiens handlingar IIIBd 18, no. 3, 1939; no. 9, Stockholm, 1940.

(3) Tentative theory of solar prominences. Ark. f. mat., astr. o. fysik, Bd 27 A, no. 20, Stockholm, 1940.

(4) On the motion of a charged particle in a magnetic field. Ark. f. mat., astr. o. fysik, Bd 27 A, no. 22, Stockholm, 1940.

(5) On the solar corona. Ark. f. mat., astr. o. fysik, Bd 27 A, no. 25, Stockholm, 1941.

(6) Remarks on the rotation of a magnetized sphere with application to the solar rotation. Ark. f. mat., astr. o. fysik, Bd 28 A, no. 6, Stockholm, 1942.

(7) On the effect of a vertical magnetic field in a conducting atmosphere. Ark. f. mat., astr. o. fysik, Bd 29 A, no. 11, Stockholm, 1943.

(8) Magneto-hydrodynamic waves and sunspots. Monthly Notices of R.A.S., vol. 105, no. 1, no. 6, 1945.

(9) Solar magnetic field and diurnal variation of cosmic radiation. Phys. Rev., vol. 72, no. 1, July 1, 1947.

K. G. Malmfors:

(10) Experiments on the aurorae. Ark. f. mat., astr. o. fysik, Bd 34 B, no. 1, Stockholm, 1946.

H. Alfvén and K. G. Malmfors:

(11) Directional measurements of cosmic radiation. Ark. f. mat., astr. o. fysik, Bd 29 A, no. 24, Stockholm, 1943.

K. G. Malmfors:

(12) Determination of orbits in the field of a magnetic dipole with applications to the theory of the diurnal variation of cosmic radiation. Ark. f. mat., astr. o. fysik, Bd 32 A, no. 8, Stockholm, 1945.

Report from the Earth Magnetic Section of the Hydrograpnic Office of Sweden (Kungl. Sjökarteverket), Stockholm

By Nils Ambolt

The two magnetic observatories in Sweden, Lovö and Abisko, belonging to the Hydrographic Office and the Royal Swedish Academy of Science, respectively, have both encountered some difficulties during the period since the last meeting.

At Lovö the magnets belonging to the magnetic theodolite type CIW were stolen and damaged in 1940. The base-line values for H and Z instruments have, after that accident, been determined by the aid of QHM and BMZ from the corresponding values in Rude Skov, Denmark. The base value determinations for D were carried out with the CIW theodolite after the D-magnet was repaired. However, the intention is to take absolute determinations of H and I with the CIW theodolite, although it is only designed as a field instrument and will not be able to give too high a degree of accuracy. Plans are also made to reconstruct a modern geodetic theodolite to form a magnetic theodolite giving better angle determinations. The Lovö Observatory has been provided with tube-scale instruments for direct reading of D, H, and Z. Some of the variometers have shown irregularities, which were certainly due to biological causes. In order to avoid such disturbances in the future, the instruments have recently been cleaned and overhauled and a drying agent has been installed in the registration chamber. The three tube-scale instruments are read three times daily and thus also give a good control of the registrations, especially when read at disturbed conditions. Lovö now has the following registering systems: one continual registration, one minute-point registration, one quick-run registration, one continual, low sensitivity registration.

The base values at Abisko have not been very accurate due to imperfect instruments and also due to inferior conditions in the registering chamber. From

1942 it has not been possible to get an observer at that place and the registrations have been interrupted. From 1945 the Hydrographic Office has taken over the task of carrying out determinations of base-line and scale values there, after a thorough revision and repair of the registration chamber and the instruments, and Abisko may now be considered a station with reliable hourly values for the magnetic elements. However, its registrations show rapid disturbances which are due to the neighboring electric railway.

Both at Lovö and at Abisko the correct position of the variometer magnets is controlled at least once every year.

The Hydrographic Office has made an investigation of places where testing of naval compasses usually is carried out in order to ascertain that the area in question is magnetically homogeneous. Along the Swedish coasts, lines have been marked whose magnetic azimuth is determined and published. These permit ship masters to check the deviation of their compasses by comparing observed with published values. This is of special value when the vessel has been recently demagnetized, because the compass deviation is then changed.

Similar tests of the magnetic homogeneity have been made at the airports in Sweden. In order to give an idea of the importance of such magnetic investigations of testing grounds for airplanes, it may be mentioned that 40 investigations resulted in the discovery of eight places where the anomalies were too large. Of these eight anomalies five were caused by human activity and three were due to geological features of the ground.

Publications

Gustaf S. Ljungdahl: The resurvey of the magnetic main repeat-stations in Sweden, for the epoch July 1, 1936. Kungl. Sjökarteverket, Jordmagnetiska publikationer no. 12, Stockholm, 1939. The Swedish magnetic-survey boat "Kompass". Terr. Mag., vol. 44, 171-173 (1939). Magnetic measurements on the "Kompass" in the Baltic Sea 1938. Kungl. Sjökarteverket, Jordmagnetiska publikationer, no. 13, Stockholm, 1940.

Nils Ambolt: The magnetic homogeneity of testing grounds for investigation and compensation of airplane compasses. Kungl. Sjökarteverket, Jordmagnetiska publikationer, no. 14, Stockholm, 1946.

Sven Aslund: Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Lovö (Stockholm) im Jahre 1930-1945. Kungl. Sjökarteverket, Stockholm, 1933-1947. Comparisons between the horizontal-intensity values at the observatories Copenhagen (Rude Skov) and Lovö (Stockholm). Terr. Mag., vol. 4 42, 281-282 (1937). Gustaf S. Ljungdahl (1882-1940). Terr. Mag., vol. 46, 121-126 (1940).

Report on magnetic investigations carried out at the Geophysical Laboratory (Geofysiska Laboratoriet), Djursholm

By Gustaf Ising

The papers (1) and (2) below give an account of the author's researches on the magnetic properties of varved clay, extending through several years and primarily undertaken in the hope of obtaining some information on the earth's magnetic field at the time when the clay was deposited. The idea was that the clay containing ferromagnetic grains with a preferential axis of magnetization (oblong shape or crystal anisotropy), during its sedimentation might have acquired an anisotropic susceptibility which would remain an invariable property of material, unaffected by any subsequent change of its remanent magnetization. By determining the anisotropy-ellipsoid one would be able, on the basis of De Geer's varve chronology, to follow the secular variation of the earth's field very far back in time.

The investigation was begun in the physical laboratory of the Stockholm University, where preliminary experiments were carried out in 1926, followed by the construction of more accurate instruments and a rather extended series of measurements in 1930-31, with some supplements in 1933. These older measurements, though somewhat influenced by disturbances, established the presence in varved clays of a remanent magnetization, having much less inclination than the present earth's field, as well as of a considerable anisotropy, the susceptibility parallel with the (horizontal) strata being about ten per cent higher than in the perpendicular (vertical) direction. The azimuth of maximum susceptibility in the strata plane could, however, not be determined with any accuracy, as the difference between the two principal values in this plane was very small (only a few per cent of the average horizontal susceptibility-excess). This magnetic preponderance of the strata plane must be ascribed to purely mechanic actions on the grains during and after their sedimentation, a good deal of them probably having the shape of flat slabs or lenses.

The investigation was then put aside until 1940, when it was taken up again at the Geophysical Laboratory, Djursholm, where outside disturbances are absent, and a long varved series from Viby (near Kristianstad in southern Sweden) was carefully examined. The measurements confirmed and extended the previous results; the declination of remanent magnetization in this clay was found to coincide, within a few per cent, with that of the present earth field. Even now it was not possible to ascertain the azimuth of maximum susceptibility in the strata, as this maximum is experimentally very apt to be overshadowed by the much greater general strata excess.

Apart from the directional determination, some other interesting facts were brought to light. Curves were obtained for the average decrease of the clay's magnetism with increasing distance from the ice border and, further, a very pronounced annual periodicity of the susceptibility established, the susceptibility in the spring part of each varve generally being several times greater than that of the winter part. This result opens up interesting views for researches bearing upon the hydrographic conditions at the sedimentation of the clay. A quite similar periodicity of susceptibility was also found in Australian varved (glacial) shales from the Carboniferous.

Subsequently the author (results so far unpublished) has examined clay samples from some localities in middle Sweden and found that the declination of their remanent magnetization was different from that of the present earth field. At one locality the annual periodicity of the susceptibility was remarkable, in so far that the spring part of the distal varves had a lower susceptibility than the winter part. A silurian shale from Styggforsen, Dalarna, with distinct varves showed a periodic susceptibility-variation similar to that previously found in the Australian shale and in the quarternary varved clay.

Paper (3) gives a preliminary account of the author's investigation (still in progress) of new methods and apparatus for earth magnetic measurements.

Publications

Gustaf Ising: (1) Den varvigalerans magnetiska egenskaper. Geolog. Fören. förhandl. s 126-142, Stockholm, 1942.
(2) On the magnetic properties of varved clay. Arkiv. f. mat., astr. o. fysik, Bd 29 A, no. 5, s 37, Stockholm, 1942.
(3) Nya metoder för magnetometri. Teknisk Tidskr., s 1299-1306, Stockholm, 1946.

Report on the magnetic survey work of the mainland of Sweden carried out by the Geological Survey of Sweden (Sveriges Geologiska Undersökning), Stockholm

By Kurt Molin

The field work started in the year 1928 and was concluded in 1934. The elements D, H, and I are measured at 2359 observation places evenly distributed all over the country. The values are reduced to the epochs July 1, 1933, and July 1, 1929. All charts refer to our main epoch 1933.5. The different elements have been published separately, Part 1 (declination) in 1936, and Part 2 (inclination) in 1939. Since the Washington Assembly the observations of H have been published in 1941. Part 4 contains Z, X, Y, T, for the epoch 1933.5 and a chart of the horizontal disturbing force to the scale 1:2 million. Further, the lines of equal magnetic potential of the disturbing field are graphically constructed as a system of curves orthographically cutting the field lines or the directions of the disturbing vector. Part 4 was published in 1942.

With each publication are subjoined four charts, of which there are three large charts to the scale 1:2 million and a smaller one to the scale 1:400,000, the latter covering Skåne, where the density of the field stations is greater than for the country in general.

Publications

Kurt Molin: A general earth magnetic investigation of Sweden carried out during the period 1928-1934 by the Geological Survey of Sweden. Part 1, Declination. Ser. Ca, no. 25, 1936. Part 2, Inclination. Ser. Ca, no. 29, 1939. Part 3, Horizontal intensity. Ser. Ca, no. 33, 1941. Part 4, Vertical intensity and horizontal disturbing force. Ser. Ca, no. 34, 1942. Sveriges Geologiska undersökning, Stockholm. 1928-1934 års jordmagnetiska uppmätning av Sveriges fastland. Del 2 - Inklinationen. In Kosmos. Physical papers edited by the Swedish Physical Society, Vol. 17, Stockholm, 1939. Bidrag till kännedomen om den jordmagnetiska inklinationens minimum i Sverige. J. Arvid Hedvalls festskrift, Göteborg, 1948.

Investigations of atmospheric electric discharges and related phenomena carried out at the Institute of High Tension Research (Institutet för Högspänningsforskning) at the University of Uppsala

By Harald Norinder

The variations of the electromagnetic field caused by lightning discharges have been investigated by using cathode ray oscillographic equipments of the special design of the Institute. The researches have been executed partly within adjacent regions of the lightning channels up to a distance of 10 km and partly at considerable distances. In the later cases simultaneous records of lightning discharges with cathode ray oscillographs have been carried out by operation of two or three stations at mutual distances varying from 20 km to 300 km. In order to localize the centers of the thunderstorms situated at considerable distances, cathode ray oscillographic direction finders of special design were used.

Extended investigations of the variation of the magnetic field, as caused by lightning discharges, were carried out in the vicinity of the lightning channels. Frame aerials shielded from the influence of the rapid variations of the electric field and combined with aperiodic amplifiers and cathode ray oscillographs were applied. A close theoretical analysis was undertaken in order to examine the possible methods of calculating current values from the magnetic field variations. Under special assumptions it was possible to calculate the corresponding current variations both with regard to main and partial lightning discharges. Statistical distribution curves of current variation values, duration of lightning strokes, sequences of multiple strokes and transported charges were calculated.

Three simultaneously recording stations, situated along a straight line at distances up to 60 km were used, in order to record the variation with the distance from sources of the electric field component, as caused by lightning discharges of known origin.

The investigations of the variations of the electromagnetic field at considerable distances from the lightning storm centers, e.g., the atmospherics, were carried out by using two simultaneously recording cathode ray oscillographic stations. For one sequence of measurements the distance was 200 km and at another 300 km.

The disturbances, characterized as rapid impulse currents in electric and telephone overhead line systems, and caused by lightning discharges, were investigated.

Links, consisting of a very small permanent magnetic steel alloy wire, were fastened in a bakelite holder. A great number of such holders were placed along the lines and allowed an investigation of the distribution of the impulse disturbance currents, as caused by lightning discharges in the vicinity of the lines.

Lightning surges on high voltage transmission lines, caused by adjacent lightning discharges, have been investigated by operating movable field stations equipped with sets of cathode ray oscillographs. The stations have been operated and connected to high tension lines at selected localities in the southern part of Sweden.

Three ionospheric recording equipments of special design have been constructed at the Institute. The instruments have been operated during the passage of two solar eclipses in Sweden. An investigation of relations between thunderstorm situations and certain variations in ionospheric conditions has been undertaken.

An analysis has been executed of the internal resistances in artificial lightning discharge channels carrying heavy impulse currents of values varying from 5 to 100 kiloamperes (in print).

A special method has been developed in order to study the resistance conditions, when the ground is exposed to heavy artificial lightning currents.

Publications

Harald Norinder et Robert Nordell: Influence de la nature de la terre et de la disposition des électrodes sur la résistance des prises de terre aux courants d'impulsion. Conference Internationale des Grands Resaux Electriques à Haute Tension, No. 302, Paris, 1939.

Harald Norinder och C. E. Olsson: Blixtströmmar i lågspanningsanläggningar. Teknisk Tidskrift H. 18, s 553, Stockholm, 1944.

W. Stoffregen: Ionospheric measurements in connection with thunderstorm research. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 30 A, No. 19, Stockholm, 1944.

Harald Norinder: A new method to measure crest values of impulse currents. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 31 A, No. 13, Stockholm, 1944.

Harald Norinder and Orvar Dahle: Measurements by frame aerials of current variations in lightning discharges. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 32 A, No. 5, Stockholm, 1945.

W. Stoffregen: Ionosphere observations during the solar eclipse on September 10, 1942. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 32 B, No. 9, Stockholm, 1945.

Harald Norinder and Willy Stoffregen: The nature and variation of atmospherics caused by lightning discharges. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 33 A, No. 16, Stockholm, 1946.

Harald Norinder: Undersökningar av överspänningar på några svenska högspänningsledningar. Kgl. Svenska Ingenjörsvetenskapsakademien, I.V.A.H.6, Stockholm, 1945.

W. Stoffregen: Records of the ionosphere during the total eclipse in the north of Sweden on July 9, 1945. Terr. Mag., 1946.

W. Stoffregen: Distant localization of individual atmospherics with a cathode ray direction finder of unidirectional type. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 34 A, No. 26, Stockholm, 1948.

H. Norinder: Some aspects and recent results of electromagnetic effects of thunderstorms. Journal of the Franklin Institute, vol. 244, Nos. 2 and 3, Philadelphia, 1947.

H. Norinder: Gewitterforschung in Schweden, Entwicklung und neuere Resultate. Bulletin Schweizerischer Elektrotechnischer Verein, Jg. 38, No. 25, Zürich, 1947.

H. Norinder och G. Petropoulos: Impulse characteristics of the ground under direct discharges and with pointed electrodes. Ark. f. mat., astr. o. fysik, Kgl. Svenska Vetenskapsakademien, Bd. 35 A, No. 26, Stockholm, 1948.

Report from the Section of Geophysics of the Research Laboratory of Electronics at the Royal Chalmers University of Technology (Kungl. Chalmers Tekniska Högskola), Göteborg, 1940-1947

By Olof Rydbeck

(a) The Ionospheric Observatory--Fixed frequency ionospheric recordings were started in the fall of 1940. Manual sweep frequency recordings were started in 1941 and automatic recordings in 1942.

A grant from the Wallenberg Foundation, Stockholm, made it possible to build a special field station at Askim, 10 kilometers south of Gothenburg. Most of the recording equipment was moved to the new locality in 1942. The fixed frequency recorders were equipped with polarization pre-selectors in 1943 which made separate recording of the ordinary and the extra-ordinary components of the down-coming wave possible.

The field station has also been equipped with field strength recorders and trans-Atlantic short-wave stations have been recorded continuously over periods of several years. The recording receiver is crystal controlled to avoid temperature effects.

Continuous long-wave recording was started in the fall of 1947 on about 18,000 meters. At present (January 1948) Rugby (GBR) is recorded.

The observatory was equipped with a big trailer in 1944. This trailer, which is constructed both for summer and winter work, can house two ionospheric recorders, has dark-room facilities for photographic work and sleeping quarters for one person.

This trailer was used during the summer of 1945 by the Ionospheric Solar Eclipse Expedition to northern Sweden of the Research Laboratory of Electronics. Two sweep frequency recorders and one field-strength recorder were in operation during the eclipse.

A new geophysical observatory was built by the Chalmers Institute of Technology on the new campus in 1946. This observatory, which has four steel towers 115 feet tall, is operated jointly by the ionospheric laboratory and the department of radio-meteorology.

A new panoramic recorder was constructed for the ionospheric observatory in 1946. In sweeps from 1 to 20 Mc/s in 30 seconds. This recorder will be moved to the new observatory erected at Abisko by the Research Laboratory of Electronics. A second panoramic recorder will be built for the mother observatory at Askim.

The schooner Albatross, cruising the world with the deep-sea oceanographic expedition of Professor Hans Pettersson, has been equipped with an ionospheric recorder by the Research Laboratory of Electronics. This station is in charge of one of the assistants of the Research Laboratory. The main object of this observing station is to study the problem of the geomagnetic control of the F2-layer.

(b) The Department of Radio-Meteorology--This department was developed in 1946. A field station was erected at Hisings-Kärra about 13 kilometers north of Gothenburg. The propagation of 10.3 and 1 cm waves is recorded at this station. Powerful pulse and CW transmitters for this purpose have been installed at the geophysical observatory.

Frequency stabilized recorders with galvanometers are used throughout but synchroscope type recorders will later be used as complementing devices.

The effect of rain, fog, and snowfall has been recorded and studied in detail on many occasions. The extension of these measurements down to 5 mm wavelength has been discussed.

The Department of Radio-Meteorology also has several powerful radar sets at its disposal. One of these sets is used at present for cloud and rain detection.

Two noise recording stations are being erected at present for the study of solar and galactic noise. These stations will be equipped with paraboloids of 4 m diameter.

(c) Theoretical and Publications Department--This department is common for all sections of the Research Laboratory. On the geophysical side, work is concentrated on the physics of the upper atmosphere and on the propagation of waves. At present quantum-mechanical studies of the reactions of the upper atmosphere are in progress.

Publications

The following papers have been published by the Section of Geophysics, 1940-1947, viz.

1. The propagation of electromagnetic waves in an ionized medium at the calculation of the true heights of the atmosphere. Phil. Mag., vol. 30, 1940; Harvard Graduate School of Engineering Publ. 302, 1940; detailed review by J. Zenneck in Hochfrequenz u. Elektroakust., vol. 59, 1942.

2. A theoretical survey of the possibilities of determining the distribution of the free electrons in the upper atmosphere. Transactions of Chalmers University of Technology, 3, 1942 (TCU 3, 1942).

3. The reflection of electromagnetic waves from a parabolic friction-free ionized layer. Journ. Appl. Phys., 13, 1942.

4. Chalmers' Ionospheric Observatory, Göteborg, Sweden. Terr. Mag. and Atmos. Electr., 1942.

5. Further notes on the electron density distribution of the upper ionosphere. Terr. Mag. and Atmos. Electr., 1942. Phil. Mag., 34, 1943.

6. Chalmers Ionosphärenobservatorium, Gotenburg, Schweden. Hochfrequenstechnik u. Elektroakust., 60, 1942.

7. Radio fade-out in Sweden. Nature, 151, 1943.

8. The reflection of electromagnetic waves from a parabolic ionized layer. Phil. Mag., 34, 1943.

9. On the propagation of radio waves. 160 pp., TCU 34, 1944.

10. A simple Kerr-modulator for ionospheric recording. TCU 44, 1945.

11. Chalmers' solar eclipse ionospheric expedition 1945 (a detailed experimental and theoretical investigation). TCU 53, 1946.

12. On the propagation of waves in inhomogeneous media I. (In the press.)

To this comes four papers in Swedish on the general nature of the physics of the ionosphere. A list of publications of the other sections of the Research Laboratory will be submitted upon request.

A new series of publications has been started by the Research Laboratory, viz., Reports from the Research Laboratory of Electronics. Of the 15 reports scheduled for 1948 the first three will appear shortly. These reports will constitute a special section of the Transactions of the Royal Chalmers Institute of Technology. Research laboratories and organizations interested in these publications should communicate with the Research Laboratory of Electronics.

(d) Staff--The Research Laboratory of Electronics is directed by Professor O. E. H. Rydbeck. The Askim Observatory is in charge of Dr. Dietrich Stranz; the geophysical observatory and the Abisko Observatory are in charge of Mr. Rune Lindqvist. The Department of Radio-Meteorology is in charge of Mr. Bo Stjernberg.

Report on the ore-prospecting work in northern Sweden carried out by the Geological Survey of Sweden (Sveriges Geologiska Undersökning), Stockholm

By Sten Werner

The ore-prospecting work of the Geological Survey of Sweden includes inter alia earth-magnetic and electrical field measurements on a fairly large scale. Hitherto these investigations have been localized to the northern part of the country, north of latitude 64.5°. The object of the geophysical measurements has been to support the geological mapping and to determine the location of possible ore deposits. Ordinarily a network of observations of 1250 stations per km^2 has been used.

In the electric field measurements the occurrences of anomalous electrical conductors in the earth's crust are mapped. At present an electromagnetic method and instrumentation developed at the Geological Survey is used for these investigations. With this method a total area of about 50 km^2 a year is measured. In the areas hitherto investigated the electrical anomalies obtained have usually been caused by ore bodies, disseminations of ore minerals and above all, of shists containing graphite.

The earth-magnetic measurements have almost without exception included only determinations of the vertical intensity. Within areas of feeble disturbances these have been carried out by means of Schmidt's vertical balance; within areas of strong disturbances the Tiberg magnetometer has been used. In the first case usually an accuracy of about 10-20 γ is desired and in the second case the accuracy of the determination is around 300-500 γ. Since 1939 the detailed magnetic measurements have totaled an area of about 150 km^2, about 90 km^2 being surveyed with the Schmidt balance. In connection with prospecting for oil and salt in southwestern Skåne, investigations were carried out in 1939 within this region by means of a Schmidt balance. During the following winter measurements were performed on the ice in some parts of Öresund. In these cases the network of observations contained about one station per km^2.

In connection with the interpretation of the magnetic anomaly maps, determinations in several cases are made of the magnetic properties of rocks and ores. A fairly extensive investigation of this kind comprising the Swedish iron ore districts has been performed in collaboration with the Mining Research Board of Jernkontoret.

Publications

S. Werner: Determinations of the magnetic susceptibility of ores and rocks from Swedish ore deposits. Sveriges Geologiska Undersökning, Ser. C, no. 472, Stockholm, 1945.

S. Werner: Geophysical investigations in connection with prospecting for manganese ores in the parish of Jokkmokk. Sveriges Geologiska Undersökning, Ser. C, no. 487, pp. 71-83, Stockholm, 1947.

SWITZERLAND

RAPPORT SUR LES TRAVAUX EFFECTUES EN SUISSE DANS LES DOMAINES DU MAGNETISME ET DE L'ELECTRICITE TERRESTRES

Magnétisme Terrestre

Le premier levé magnétique du territoire suisse a été exécuté par M. Brückmann entre les années 1927 à 1930. Les résultats de ces mesures ont été publiés dans les Annales de la Station centrale suisse de Météorologie (MZA) pour les années 1930 et 1931.

Les observations ont été réduites à l'aide des enregistrements des variographes installés à Regensberg.

Durant l'année 1936 les vieux variomètres Toepfer ont été remplacés par les variomètres de Copenhague. Pour contrôler ces variomètres, la Station centrale a acquis les quarz-magnétomètres horizontaux à fil de quarz, QHM No. 8, 55, 77 et la balance magnétique BMZ 23 de Copenhague.

En 1940, une série de stations ont été de nouveau visitées; on y a mesuré D et H. Comme valeurs de la variation séculaire de D pour la période 1931.5 - 1940.5, on a obtenu les moyennes suivantes: $\Delta D = 9'.5$; $\Delta H \sim 6\gamma$.

Pendant les années 1941 - 1946, P. L. Mercanton et E. Wanner ont fait en Suisse-Romande un nouveau levé, à réseau de stations plus serré, pour étudier la zone perturbée des environs de Lausanne. En outre l'Institut de Géophysique de l'Ecole Polytechnique Fédérale a examiné, sous la direction de F. Gassmann les couches de minerai de fer du Mont-Chemin (Valais) et de Fianell (Val Ferrera, Grisons).

En collaboration avec la Station centrale suisse de Météorologie, l'Institut de Géophysique de l'Ecole Polytechnique fédérale a également examiné la grande perturbation du canton du Tessin qui embrasse les zones de racines des nappes pennines dans les environs de Locarno.

Les plus importantes publications parues en Suisse sont:

F. Gassmann: Magnetische Messungen auf dem "Mont-Chemin" bei Martigny, Verhandlungen der Schweiz. Naturforschenden Gesellschaft 1938.

E. Wanner: Die erdmagnetische Station Regensberg, Annalen MZA 1939.

F. Gassmann: Magnetische Messungen an alpinen Erdlagerstätten, Verhandlungen der Schweiz. Naturforschenden Gesellschaft 1941.

P. L. Mercanton et E. Wanner: Die magnetische Anomalie im Jorat, I Teil: Vertikalintensität, Annalen MZA 1943. II Teil: Horizontal Intensität. Deklination. Versuch einer Deutung, Ann. MZA 1946.

P. L. Mercanton et E. Wanner: L'anomalie magnétique du Jorat: I Composante verticale. Bulletin de la Société Vaudoise des Sciences Naturelles. Vol. 63. II Composante horizontale. Déclinaision. Essai d'interprétation. Ibidem. Vol. 270.

E. Niggli: Magnetische Messungen an der Mangan-Eisenerzlagerstätte Fianell (Val Ferrera) Schweiz. Mineralogische und Petrographische Mitteilungen, Band XXVI 1946.

G. Staub: Die magnetische Deklination als vermessungstechnisches Orientierungsmittel, Vermessung und Kulturtechnik. Jahrgang XLV, Winterthur 1947.

Electricité

I. Champ électrique et ionisation atmosphérique

Grâce à l'appui financier de la Commission helvétique (SHSN) d'Electricité atmosphérique et de SA. Ebauches, Neuchâtel (Dir. M.S de Coulon), M. le Dr. Jean Lugeon, directeur de la Station centrale suisse de météorologie à Zurich, piloté par M. G. de Chambrier, a pu exécuter à bord d'un planeur biplace, en septembre 1944 et juillet 1945, une série de vols dans le massif de la Bernina (Haute-Engadine) jusque vers 4000 m d'altitude. Il a pu déterminer la répartition horizontale et verticale des petits ions sur un certain nombre de parcours au dessus des talwegs de la Bernina et de la Haute Engadine. Elle est très irrégulière et dépend à la fois de la situation météorologique et du relief du sol; elle va de 600 à 8000 ions positifs par cm^3. Sur les dits talwegs la densité était maximum en général vers 2600 m; sur les hautes arêtes du Piz Languard elle était maximum à 3600 plutôt mais parfois à 4000 dans des courants ascendants secs; en revanche la ionisation était très faible dans l'alto-stratus précédant un front orageux.

Le champ en vol ne mesurait que quelques dizaines de volts/mètre au voisinage des talwegs, grandissant avec l'approche des versants pour atteindre 100 - 150 v/m sur les arêtes; il diminuait en devenant irrégulier au voisinage immédiat du glacier. Les lignes équipotentielles ainsi obtenues sont conformes à ce que l'on savait déjà et pouvait admettre à priori.

Il s'agissait ici de recueillir des données sur la conduction de l'atmosphère libre en vue du sondage thermoionique de la stratosphère par les échos radio-électriques, sujet qui préoccupe l'auteur [Jean Lugeon: Mesures du gradient du potentiel électrique et de l'ionisation en planeur dans le massif de la Bernina. Actes de la Société helvétique des Sciences naturelles (SHSN) Fribourg, pp. 132-133, 1945].

Eclairs rares

P-L Mercanton (Lausanne) a analysé un certain nombre d'éclairs rares (Bulletin de la Société vaudoise des Scineces naturelles, vol. 63, No. 265, 1945) dont il donne les photographies. Ce sont: (a) Un éclair qui a atteint le 10 septembre 1942 le pylône supportant l'antenne de Radio-Beromünster. Sa largeur a pu être determinée; elle était de quelque 4 mètres au point d'impact sur le pylône. (b) Un éclair complexe semblant constitué par une décharge centrale rectiligne horizontale s'étendant de la gauche vers la droite de l'observateur et enveloppé à quelque distance par un éclair en hélice qui s'est développé de la droite vers la gauche sous les yeux de l'observateur. (c) Un éclair jaunâtre à grand développement horizontal qui s'est déployé sous les yeux de l'auteur assez lentement pour que celui-ci en ait pu assurer la prise de vue. Il mesurait quelque 8 kilomètres de longueur au minimum. (d) Un très remarquable éclair, photographié à Asconale 20 juillet 1937 et qui s'est développé verticalement au large du quai, sur le Lac Majeur. La largeur du trait de feu était d'environ 4 mètres aussi. La photographie montre le trait de feu strié obliquement comme de bourrelets serrés. Le tout donne l'impression d'un tube, d'un boyau rempli d'une matière lourde qui descendrait par là vers le lac (matière fulminante de Mathias?).

Dans le même numéro du Bulletin P-L Mercanton décrit un singulier coup de foudre qui a atteint l'antenne du poste émetteur du Champ de l'Air, puis le toit de l'Observatoire du Champ de l'Air.

II. Mensurations de l'électricité atmosphérique à Locarno-Monti

Voir: "Luftelektrische Messungen in Locarno-Monti, Fl. Ambrosetti", Annales de la Centrale Suisse de Météorologie pour 1943 et 1944.

A l'Osservatorio Locarno-Monti de la Station Centrale Suisse de Météorologie on a exécuté, à l'aide de l'appareil Israël-Weger, depuis 1939 jusqu'au début de 1944, des déterminations du nombre des ions grands et moyens, positifs et négatifs (mobilité $< \frac{1}{2}$ cm^2/volt sec.), du nombre des petits ions positifs et négatifs (mobilité $\geqslant$ .1 cm^2/volt sec.) et des valeurs de la conductibilité électrique de l'air positive et négative (mobilité $\geqslant$ 2 cm^2/volt sec.). Le nombre des mensurations a été environ de 2800 pour les ions grands et moyens et à peu près de 2300 pour les autres grandeurs électriques considérées.

Le but de ces recherches était d'établir l'influence des facteurs météorologiques sur le nombre des ions et la valeur de la conductibilité, ainsi que d'étudier leur variation annuelle et diurne. En voici les résultats principaux: En général avec l'augmentation de l'humidité relative de l'air et de la brume, donc aussi avec la diminution de la visibilité, le nombre des ions grands et moyens augmente. Ceux-ci sont souvent plus nombreux par nébulosité forte que par nébulosite légère. Le nombre des ions grands et moyens diminue en général avec l'augmentation de l'intensité du vent et du gradient barométrique entre le nord et le sud des Alpes. Au contraire on trouve des résultats opposés pour les petits ions et la conductibilité.

L'influence du föhn du nord sur les grandeurs électriques étudiées est en général très marquée: on constate une forte baisse du nombre des ions grands et moyens et au contraire une forte hausse du nombre des petits ions et des valeurs de la conductibilité électrique de l'air.

Les rares déterminations effectuées par pluie d'une certaine intensité montrent une unipolarité négative.

En ligne générale: les causes qui provoquent une augmentation des ions grands et moyens, provoquent au contraire une diminution des petits ions et de la conductibilité électrique atmosphérique. Petits ions et conductibilité se comportent en général de la même façon.

La variation annuelle du nombre des ions grands et moyens montre un maximum bien évident en hiver et un minimum en été. Le contraire arrive pour les petits ions et la conductibilité. La variation diurne (sans la nuit) des ions grands et moyens présente un maximum, très prononcé en hiver, le matin et un minimum l'après-midi. La variation diurne des petits ions et de la conductibilité est moins caractéristique.

Pendant l'année, dans au moins 75 pour cent des cas, le nombre des ions grands et moyens est compris, positifs et négatifs considérés séparément, entre 800 et 4000 par cm^3. Très rarement leur nombre descend au-dessous de 300 ou dépasse légèrement 22000. Pour les petits ions, dans au moins 75 pour cent des cas (positifs et négatifs séparés), le nombre est compris entre 100 et 600. Pour les extrêmes on a trouvé 0 et 1300-1400. Dans 75 pour cent, et même plus, des cas, la conductibilité électrique (positive et négative séparées) a des valeurs comprises entre 20 et 120×10^{-6} u.e.s. Les valeurs extrêmes trouvées sont 0 et 300-350×10^{-6} u.e.s.

Les moyennes annuelles des années 1942 et 1943 pour le nombre par cm^3 des ions grands et moyens (toujours positifs et négatifs séparés) sont comprises entre 2500 et 3000; pour les petits ions entre 370 et 530; pour la conductibilité électrique les valeurs correspondantes sont comprises entre 75 et 100×10^{-6} u.e.s.

La comparaison des données de Locarno-Monti avec celles d'autres endroits suisses et aussi de Potsdam montre parfois des différences très remarquables; mais il ne faut pas oublier que, souvent, les mensurations ont été faites avec d'autres appareils et pour des périodes de longueurs différentes.

The Swiss Auroral Report is included in the report of the Committee on Aurora, pp. 288-289.

TURKEY

EXTRAIT DE LA BROCHURE CONCERNANT LA DESCRIPTION ET LES TRAVAUX DE LA SECTION DU MAGNETISME TERRESTRE DE L'OBSERVATOIRE D'ISTANBUL-KANDILLI

Dirigée par

Osman Sipahioğlu (Sous-Directeur de l'Observatoire)

Les bâtiments: Un grand pavillon en bois pour les mesures absolues; une cave en pierre presque sous-sol pour les variomètres et un bâtiment en pierre pour logement et travaux.

Position et Orientation: Les pavillons de la Section magnétique se trouvent à l'est de la partie principale de l'Observatoire situé au sommet Icadiye, sur la rive d'Anatolie du Bosphore. Les coordonnées du pilier des mesures absolues sont: Latitude: 41°04 00'' N; longitude: 29°03 55''5 E; altitude: 130 m.

Géologie du lieu: Les terrains primaires de la région se composent des schistes; des calcaires et des grès ordinairement fins tous appartenant d'une manière générale au Dévonien moyen, c'est-à-dire, pratiquement non-magnétique.

Les dérangements causés par les installations électriques et industrielles voisines ne font pas subir nos mesures magnetiques que des erreurs de: 0'1 pour D et 1.0 γ pour H et Z. Conclusion que l'on est arrivé, soit par les experiences directes, soit par l'examen des enrégistrements obtenus.

Appareils des mesures absolues: Le théodolite magnétique Chasselon, moyen modèle. Le grand inducteur terrestre d'Askania avec le petit galvanomètre Rosenthal.

Appareil de variation: Ils sont des variomètres de la Maison Askania dont on résume la description comme suit.

Variomètre pour H: Fil de suspension est en verre dur de 0.04 mm de diamètre. La sensibilitée est 4 fois augmentée par la double réflexion de la lumière sur les miroirs mobiles. Valeur d'échelle est de 3 γ. L'effet de température est compensé magnétiquement. Les oscillations sont amorties.

Variomètre pour D: Fil de suspension est en quartz de 0.025 mm de diamètre. La sensibilité est la même que celui de H. Valeur d'échelle est de 0'5. Amorties.

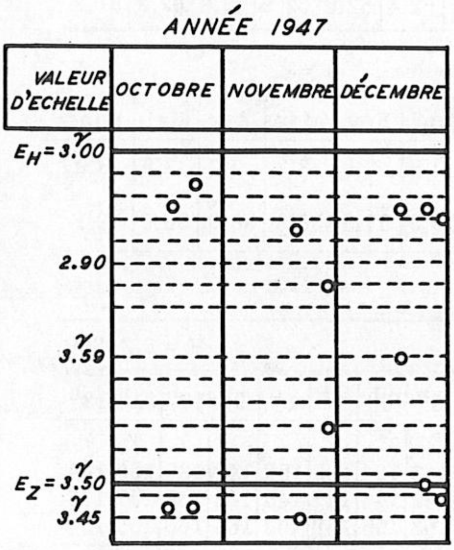
Variomètre pour Z: Le système mobile est posé sur des couteaux en quartz. La lumière ne subit pas la double réflexion; mais la distance d'enrégistrement est deux fois plus grande que celle de H. Valeur d'échelle est 3.5 γ. Compensé magnetiquement. Amorties.

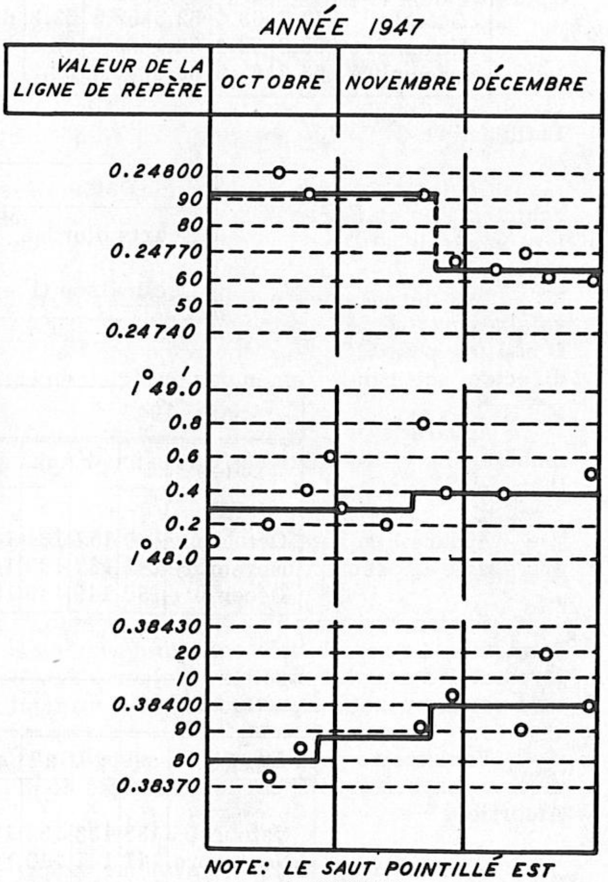
Appareil enrégistreur: Il est l'enrégistreur des variomètres de campagne d'Askania complété et modifié dans notre atelier selon le besoin. Le degré de précision atteint dans les mesures absolues est de 0'3 pour D, de 10 γ pour H et de 0'3 pour I.

Les valeurs d'échelle observées ne sont pas variées jusqu'à présent que de 0.3 γ pour H et Z, et celles de la ligne de repère de 10 γ pour H, de 20 γ pour Z.

Les figures suivantes montrent graphiquement la variation de la valeur d'échelle et celle de la ligne de repère. (Les valeurs observées sont marquées par de petits cercles et les valeurs adoptées par la ligne en forme d'escalier.)

Avis nécessaire: Dans les tableaux les heures sont heure de Turquie, à savoir, 2 heures en avance sur celle de T.M.G. (La valeur qui correspond à la 24 ème heure est, comme d'habitude, $M_{24} = M_0 + M_{24}/2$.)





NOTE: LE SAUT POINTILLÉ EST APPARENT

Moyennes mensuelles

Année: 1947											D_E(vers
Dates	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
Janvier	59'.3	59'.0	58'.8	58'.4	58'.2	57'.9	58'.1	58'.9	60'.0	59'.7	58'.5	57'.1
Février	58.8	58.4	58.5	58.4	58.1	58.2	58.2	59.5	61.1	61.5	59.9	57.2
Mars	60.0	59.9	59.3	59.2	58.9	58.8	59.6	61.1	62.7	61.8	59.1	56.6
Avril	59.7	59.6	59.7	59.8	59.7	60.1	61.2	62.1	62.6	61.0	58.9	56.5
Mai	58.7	59.0	59.1	59.4	60.1	61.4	62.3	62.6	61.8	60.8	57.2	55.7
Juin	59.3	59.8	59.7	59.9	60.6	61.7	62.7	62.4	62.0	60.5	58.4	57.0
Juillet	60.0	60.2	60.3	60.4	60.9	62.1	63.0	63.0	62.2	61.0	59.7	58.0
Août	59.7	59.9	59.8	60.1	60.3	61.1	61.5	62.2	61.7	60.8	58.0	56.9
Septembre	62.7	62.2	62.7	62.6	62.3	63.1	65.0	66.4	66.5	63.4	59.9	56.6
Octobre	62.7	63.4	62.5	62.5	62.3	62.6	63.4	65.6	66.4	64.7	61.8	58.8
Novembre	63.7	63.4	63.1	62.7	62.0	62.3	62.5	63.5	64.3	64.0	62.5	60.7
Décembre	63.7	63.6	63.0	62.7	62.2	62.2	62.4	62.6	62.9	63.2	62.2	61.2

Dates	Jan.	Fev.	Mar.	Avr.	Mai	Juin
Écarts diurnes	3'.8	6'.6	8'.2	7'.7	7'.8	6'.9
Déclinaison (1° +)	58.3	57.9	58.8	58.9	58.6	59.1

Année: 1947											H = 0.24700
Dates	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Octobre	160	157	161	163	162	164	162	150	140	137	139	144
Novembre	141	137	139	141	142	145	147	145	142	138	137	136
Décembre	150	149	149	151	153	155	158	163	164	160	156	154

Année: 1947											Z = 0.38300
Dates	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
Octobre	133	133	132	131	132	133	138	142	135	120	108	106
Novembre	141	141	140	140	140	140	141	143	140	137	129	127
Décembre	151	151	150	154	149	149	148	148	149	146	142	139

Dates	Octobre	Novembre	Décembre
Écarts diurnes	27γ	22γ	27γ
Composante horizontale (0.24700 +)	151	138	149

horaires

l'Est) = 1° + ... Istanbul-Kandilli

13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h	Moy
56'.5	56'.2	56'.7	57'.0	57'.2	57'.5	57'.6	58'.1	59'.0	59'.2	59'.3	59'.8	58'.3
55.5	54.9	55.4	55.6	56.4	56.5	57.3	57.5	57.9	58.3	58.6	58.6	57.9
54.7	54.5	55.3	56.8	57.7	58.2	58.6	59.2	59.7	60.1	60.2	60.0	58.8
55.2	54.9	55.4	56.7	57.7	59.0	58.7	58.6	58.9	59.4	59.6	59.4	58.9
54.8	54.9	55.4	56.2	58.1	58.7	58.8	58.4	58.6	58.6	58.6	58.8	58.6
56.1	55.8	56.0	56.6	57.7	58.4	58.7	58.6	58.9	58.9	58.9	59.1	59.1
57.1	56.6	56.7	57.3	58.2	59.2	59.5	59.3	59.5	59.5	59.7	59.9	59.7
56.2	56.2	56.4	57.1	58.3	59.0	58.9	59.1	59.0	59.2	59.4	59.8	59.3
55.4	55.4	56.1	57.5	58.9	60.4	61.0	61.3	61.8	61.7	62.8	62.4	61.2
57.2	57.1	57.9	59.5	60.2	60.9	61.1	62.5	62.8	63.3	63.7	63.6	62.0
59.7	59.6	59.9	60.6	60.8	61.3	61.9	61.7	62.7	64.8	63.9	64.0	62.2
61.0	60.8	61.1	61.6	61.8	61.9	62.8	62.9	63.3	63.5	63.7	63.5	62.5

Juil.	Août.	Sept.	Oct.	Nov.	Déc.	(Année)
6'.4	6'.0	10'.1	9'.3	5'.2	2'.9	6'.74
59.7	59.3	61.2	62.0	62.2	62.5	59.87

+ ... CGS Istanbul-Kandilli

13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h	Moy
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
148	150	145	138	140	146	146	148	151	154	156	159	151
136	134	129	126	125	128	131	135	138	137	139	141	138
152	151	144	138	137	137	137	140	142	146	150	152	149

+ ... CGS Istanbul-Kandilli

13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h	Moy.
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
109	117	125	131	131	127	134	135	130	136	135	134	129
128	133	135	139	139	140	142	142	143	143	143	142	138
144	146	149	152	152	152	153	154	154	153	153	152	150

Dates	Octobre	Novembre	Decembre
Écarts diurnes	36γ	16γ	15γ
Composante verticale (0.38300 +)	129	138	150

UNION OF SOUTH AFRICA

PROGRESS OF WORK IN GEOMAGNETISM, 1939-1948

The New Magnetic Observatory at Hermanus

At the time of the Washington Meeting in 1939 a site had already been chosen and plans drawn up for a new Magnetic Observatory at Hermanus (lat. 34°25.2′ S; long. 19°13.5′ E) to replace the Magnetic Observatory established at Cape Town (lat. 33°57′ S; long. 18°28′ E) during the Polar Year 1932-33 (1). The new buildings were occupied in 1940, and after the necessary overlap had been established, the final transfer was effected in January, 1941. The modern, well-equipped Magnetic Observatory at Hermanus is a fitting monument to the untiring efforts and many scientific achievements of its founder and first Director, Dr. Alexander Ogg.

In view of the present re-occupation of the secular variation stations in Southern Africa, the difference between the values of the geomagnetic elements at the two observatories has been re-calculated. Whereas the field stations established in 1938-39 were originally tied in with the Magnetic Observatory at Cape Town (2), the Hermanus Observatory is providing the necessary control for the magnetic survey of 1947-49. The method adopted for the reduction of the field readings requires a knowledge not only of the difference between the absolute values of the elements at the two observatories, but also of the difference between their secular variations during the period of either of the two magnetic surveys. The values adopted for the difference between the two observatories will ensure the continuity of the observations.

Difference (Hermanus - Cape Town), epoch 1941.0

D	H	Z	I
-21.6′	-106 γ	-187 γ	-18.9′

Owing to the delay in the publication of the 1941-44 Hermanus Results, numerous requests have been received for the latest available Hermanus data. It is felt that this report affords a favorable opportunity of summarizing for general information the results obtained at the new Magnetic Observatory during the first six years of its operation. The 1941-44 volume which contains details of the new buildings and instruments is now in the hands of the printers and will be distributed in the usual way before June 1948.

The values in the table are given with the usual notation and convention of sign.

Annual mean values of the geomagnetic elements at Hermanus

Year	D	I	H	X	Y	Z	F
1941	-23°51.6′	-64°01.4′	14252	13034	-5765	-29249	32537
1942	-23 48.1	-64 03.0	14187	12980	-5724	-29153	32422
1943	-23 47.1	-64 06.4	14109	12911	-5690	-29065	32309
1944	-23 46.8	-64 09.1	14040	12848	-5661	-28981	32202
1945	-23 45.9	-64 12.4	13966	12782	-5628	-28900	32097
1946	-23 46.4	-64 17.5	13875	12697	-5594	-28819	31985

Observatory Instruments and Standards

(a) Variometers. The Askania variometers installed at the new observatory in 1940 are used for the continuous recording of the geomagnetic elements at Hermanus, while the two sets of la Cour variometers, transferred from the Cape Town Observatory in 1941, serve as a stand-by. The latter are used not only when repairs or adjustments are to be made to the regular instruments, but also for the registration of severe magnetic storms during which the effective ranges of the sensitive Askania instruments are liable to be exceeded.

The adjustment of the horizontal intensity and declination variometers in 1942 was described in an earlier communication (3). An investigation made in 1947 to check the adjustment of these two instruments indicated that the needles are correctly orientated. This was to be expected since the total change in the mean declination at Hermanus during the intervening period was insignificant. An analysis by the method of least squares of observations taken with a quartz horizontal intensity magnetometer (QHM 30) during the period August-December 1947 gave the following results:

$$\Delta H \text{ in } \gamma = 2.38\ \Delta H_{mm} - 0.013\ \Delta D_{mm}$$

$$\Delta D \text{ in } ' = 0.537\ \Delta D_{mm} - 0.0005\ \Delta H_{mm}$$

The scale values of the H and D magnetograms, as determined with the Helmholtz coil during the same period, were 2.32 γ/mm and 0.533′/mm, respectively.

The orientation of the Z needle is less satisfactory. As the investigation is still in progress, final figures are not yet available, but it is quite evident from the preliminary results that the Askania Z needle deviates by several degrees from the prime vertical. It appears that the incorrect setting of the needle was due to mechanical difficulties encountered during the initial adjustment of the variometers. Since in this type of instrument the recording lamps, recording drum, and the three variometers all lie in the same meridional plane, it will be appreciated that the adjustment of the variometer mounted furthest from the recording drum (in our case the Z instrument), is hampered by the presence of apparatus (H and D variometers and Helmholtz coils) mounted permanently in the intervening space. The re-orientation of the Z magnet is to be attempted shortly. The results of this investigation, including the effect of variations in H and D on the earlier Z recordings, will be published later.

(b) Absolute instruments. During the period 1932-44 the Magnetic Observatory had the use of the C.I.W. 17 inductor-magnetometer of the Carnegie Institution of Washington. In 1944, at the request of the Director of the Magnetic Observatory, Elisabethville, and with the sanction of the Carnegie Institution, this instrument was transferred on loan to the Comité Speciale du Katanga (Belgian Congo) for an indefinite period.

A Schmidt standard theodolite magnetometer was obtained shortly before the outbreak of hostilities in 1939, but the deflecting magnets and standard bar which had been retained at the Reichsanstalt in Berlin for standardization were not received until 1945. The Meteorological Institution of Copenhagen was responsible for the safe keeping of these accessories during the war.

Other instruments in use at the Hermanus Magnetic Observatory are: A portable coil magnetometer (Cambridge Instrument Co. Ltd., No. L62993); an Askania field magnetometer (No. 578179); three la Cour quartz horizontal force magnetometers (Q.H.M. Nos. 29, 30, 58); a la Cour magnetic balance (B.M.10).

The delivery of the new magnetic balance (BMZ) ordered from Copenhagen in 1945 has been delayed owing to difficulties in procuring the necessary materials for its manufacture.

As the standard accessories of the Schmidt magnetometer were not available when the comparison of horizontal intensity instruments was made in 1942 (4), the deflecting magnets of the Askania field magnetometer were used instead. As yet it has not been possible to compare the complete Schmidt magnetometer with standard instruments at other observatories. A comprehensive investigation of magnetic standards at Hermanus Magnetic Observatory is, therefore, contemplated. The following program is suggested:

1. The re-calibration at the National Physical Laboratory, Pretoria, of the accessories of the portable coil magnetometer.
2. The checking of the temperature and induction coefficients of the various magnets.
3. The adjustment of the Askania standard declinometer and earth inductor at Hermanus.
4. Intercomparison of the various instruments at the Hermanus Magnetic Observatory.
5. Further comparisons with the C.I.W. 17 magnetometer, if available.
6. A comparison with the horizontal intensity I.M.S. in Washington, using a quartz horizontal force magnetometer.
7. A comparison of the constants, as determined at Copenhagen and at Hermanus, of the new BMZ instrument now on order.

The results of these investigations will be published elsewhere.

Secular Variation in South Africa

According to secular variation data published by the Carnegie Institution for the epoch 1942.5 (5), the line of zero change in declination, which runs roughly north-south, at that time intersected the coastline near Durban on the east coast of South Africa. An examination of the mean annual values of declination at Hermanus showed that during the period 1940-46 the line of zero change had apparently swept across the sub-continent from east to west. By 1946, therefore, the resumption of the field program interrupted by the war, had become a matter of some urgency. The plans for the repeat survey were considerably delayed by staff changes at the Magnetic Observatory, including the resignation of the field observer. The training of the new observer was completed by September, 1947.

The re-occupation of the 44 field stations established in Southern Africa in 1938-39 (1, 2) was commenced in October, 1947. The field work is progressing steadily, and it is hoped to complete the occupation of the existing network of stations by April, 1948.

The station at Boane in Mocambique has been abandoned owing to the erection of numerous structures, including a metal bridge, in the vicinity of the observing pillars.

An additional station has been established at Maun (lat. 19°58′ S, long. 23° 26′ E) in the Bechuanaland Protectorate. K. W. Simpson, who had conducted the 1938-39 survey under the direction of Dr. Ogg, was commissioned to determine the geographical coordinates of the Aeradio Station at Maun in 1940. An opportunity was thus afforded of establishing a magnetic station within the large central desert region. Air transport was provided for the occupation of this station in 1940 and again in 1948. Owing to its geographical position, Maun is regarded as one of the most important secular variation stations in South Africa.

The Government of Southern Rhodesia has expressed itself in favor of the extension into that territory of the network of secular variation stations already established in Southern Africa. The Survey Department of Southern Rhodesia has undertaken to erect suitable beacons at five or six points within an area extending from 17° S to 22° S latitude, and from 26° E to 33° E longitude. It is hoped to occupy these stations before July 1948. The magnetic observations will be undertaken by, and controlled from, the Hermanus Magnetic Observatory.

References

(1) Trans. Washington Meeting, pp. 124-129, 1939.
(2) Trans. Roy. Soc. of S. A., vol. 24, part 4, pp. 261-278.
(3) J. Terr. Mag., vol. 47, No. 2, pp. 171-172.
(4) Trans. Roy. Soc. of S. A., vol. 30, part 2, pp. 121-134.
(5) Final values of elements of the geomagnetic field at 5° intervals of latitude and longitude, epoch 1945, published by C.I.W., Washington, October 1, 1946.

BERNARD PRICE INSTITUTE OF GEOPHYSICS, UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Since the end of the war (during which all geophysical activities of the Institute ceased) work has been going on in the study of lightning by means of the photography of lightning flashes, and the study of oscillograms of the corresponding field changes. A new lightning camera has been brought into use and recently a method of following rapid changes in the static electric field, has been in use.

A short series of observations at 4800 feet underground and at the surface was undertaken by members of the staff in order to test the validity of Professor P. M. Blackett's theory of the variation of magnetic force with depth.

UNITED STATES

MAGNETIC WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY FROM JULY 1, 1939 TO APRIL 30, 1948

By E. B. Roberts

The United States Coast and Geodetic Survey, among other activities, makes geomagnetic observations, and compiles and publishes magnetic charts and related data. The Bureau also collects geomagnetic data from world-wide sources, and will in the future compile magnetic charts to be published by the Hydrographic Office of the United States Navy. Within the Bureau, these functions are performed by the Division of Geomagnetism and Seismology.

Observations are made at six observatories, two declination-recording stations, and selected repeat and distribution stations. In addition, occasional observations for declination are made during hydrographic, triangulation and airport surveys. Data are also received from other agencies of the Government and from universities and colleges. In recent years, additional observations have been made by observers of this Bureau in other parts of the hemisphere. All of these observations have been on land.

The initiation of programs of observations, the research on instruments and procedures, the processing of data, the compilation of processed reports, and the publication of isomagnetic charts are the functions of the Washington office.

Cooperation with other agencies and scientific institutions in the exchange of data and loan of instruments continues to enhance the mutual efforts and results in obtaining and utilizing geomagnetic data. Close cooperation has been maintained between our Bureau and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. International geomagnetic standards of the Carnegie Institution of Washington are maintained at the Cheltenham Magnetic Observatory. Cooperation has been extended to the Carnegie Institution of Washington, telephone and telegraph companies, radio laboratories, and other scientific investigators by operating cosmic-ray apparatus and instruments at some of our observatories for measuring earth currents and atmospheric electricity. Daily reports of magnetic storms are sent to agencies making studies of radio propagation. In addition, magnetic instruments of other agencies have been standardized and personnel trained to make observations; instruments have been loaned and special isomagnetic charts have been prepared. In cooperation with other American republics, magnetic observations have been made in Central and South America and in the Caribbean area.

Magnetic Observatories

Cheltenham maintains three magnetographs: The Eschenhagen type, consisting of D, H, and Z variometers of high sensitivity, with one recorder; the Adie, consisting of D and H variometers of high sensitivity and Z variometer of low sensitivity, with a separate recorder for each variometer; and the la Cour, consisting of D and H variometers of low sensitivity, with one recorder. International magnetic standards formerly established by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, are now maintained at this observatory with the sine galvanometer, standard Schulze earth inductor and standard magnetometer for declination. Instruments of other agencies and organizations are standardized here. The absolute instruments are maintained at a more constant temperature than formerly, due to additional insulation of the observatory buildings.

College is a new observatory which was constructed by the Coast and Geodetic Survey in 1947. The la Cour magnetograph which is operated here on a routine basis was formerly maintained by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, in a small observatory near the University of Alaska.

Honolulu was transferred to a new site in 1947; the transfer of instruments from the old observatory was completed in March of that year. The magnetograph at this observatory consists of Eschenhagen type D and H variometers and a la Cour Z variometer, and a standard recorder. The instruments are operated at high sensitivity, and provision has been made in the variation building for operation of insensitive instruments at some future time.

San Juan results have been improved by reconditioning and modernizing the magnetograph, which is now enclosed in a sealed housing for protection from excessive humidity. This magnetograph is similar to the one at Honolulu, with the Z-variometer modified for magnetic temperature compensation.

Sitka was transferred to a new site in 1942. Two magnetographs are maintained here: The Eschenhagen type, similar to the one at Cheltenham, and an insensitive magnetograph consisting of la Cour D, H, and Eschenhagen type Z variometers and a standard recorder. The insensitive H variometer is modified for magnetic temperature compensation. The two magnetographs are operated in separate rooms of the same building.

Tucson was transferred to a new site in 1941, close to the old observatory. The magnetograph is of the la Cour type modified for magnetic temperature compensation, and the D-variometer is operated at a scale value of 0'.5 per millimeter.

Declination-Recording Stations

Declination-recording stations were established at Logan, Utah, in October 1947 and at Gatlinburg, Tennessee, in June 1945. Another station in northern Florida is contemplated. These stations require inspection only every few months, and provide a continuous record of magnetic declination. The variometers are of the Eschenhagen type and the record is made on photographic tape which is driven at a speed of 2 mm per hour. The record capacity is about one year.

Magnetic Surveys

Magnetic surveys by observers of our Bureau have extended over a large part of the Western Hemisphere during the past nine years. A regular program of repeat observations in the United States and Alaska continues, for use in determining secular change. Additional observations at distribution stations improved the delineation of isomagnetic lines, particularly in regions of anomalies. One weakness in deriving a close representation of the earth's magnetic field is the lack of observations in the air and over adjacent seas. We are hopeful that adequate airborne-magnetometer surveys will be available in the near future, and will provide an abundance of needed geomagnetic data.

A program of observations in other American republics was begun in November 1941 in cooperation with the Interdepartmental Committee on Scientific and Cultural Cooperation, U. S. Department of State. These observations included several stations near Paricutin Volcano in Mexico, and stations in the Caribbean area.

A few observations in the Arctic and Antarctic were made possible during expeditions of the U. S. Navy in 1946 and 1947.

Magnetic Observations by U. S. Observers
From July 1, 1939 to April 30, 1948

Area	Repeat Stations				Other Stations	Total
	New		Old			
	Complete	D-only	Complete	D-only		
Antarctica			1		1	2
Bermuda			2	1	5	8
Caribbean Area	9		15	1	20	45
Central America	15	1	27		2	45
North America						
Alaska	13	1	50	4	285	353
Canada					12	12
Mexico	7		4		2	13
United States	76	16	191	116	854	1253
Pacific Islands					27	27
South America	47	2	70	2	5	126
Totals	167	20	360	124	1213	1884

Magnetic Instruments

New developments in the design and use of instruments in magnetic measurements include (a) the use of three-face, front surface mirrors for D and H variometers, which provide two reserve spots; (b) development of tape recorders for use at unattended recording-stations; (c) cooperation with manufacturers in the development and construction of magnetic variometers, magnetometers, earth inductors, and recorders; (d) cooperation in the development of induction variometers with visible recorders; (e) development of an induction magnetometer for field use; (f) considerable work in development of quartz-fiber technique, especially in methods of attachment of the fibers to the moving parts and to the torsion head; (g) some investigations leading up to the use of the photoelectric method for visible recorders; and (h) the development and construction of observatory earth inductors.

Charts, Publications, and Reports

The past nine years covered by this report include the war years, during which previously proposed schedules of published data were necessarily revised. The processing of biennial reports of magnetic observatory results including tabulation of hourly mean values was tentatively suspended; the latest reports are Cheltenham--1936, Honolulu--1938, San Juan--1930, Sitka--1936, and Tucson--1938.

Preliminary monthly and annual mean values have been issued in the form of Information Leaflets (MM46-50) listing the values at Cheltenham, San Juan, and Honolulu for the years 1938-1945, at Sitka for 1939-1945, and at Tucson for 1940-1945. A new program was started in January 1946 for issuing processed semi-annual reports of observatory results. These reports show quarter-size reproductions of the magnetograms and include base-line and scale values for convenience in making individual scalings.

Other routine publications include "Magnetic Declination in the United States --1945" and accompanying isogonic chart. "United States Magnetic Tables and Charts--1945", with accompanying isomagnetic charts of declination, horizontal and vertical intensities and dip, is in preparation and will succeed the previous publication for 1935. In addition to an isogonic chart for Alaska--1940 and 18 other isogonic charts of parts of the world on scale 1:5,000,000, isogonic lines on aeronautical charts of the entire world were prepared during the war years.

Special reports and publications include "Magnetic Observations in the American Republics, 1941-1944", accompanied by a small-scale isogonic chart for epoch 1945, and the College-Fairbanks Observatory results for the 2nd Polar Year, 1932-1934. In addition, weekly summaries of K-indices at Cheltenham are compiled and hectographed.

Future compilations of geomagnetic data will include isomagnetic lines for world-wide magnetic charts which will continue to be published by the Hydrographic Office. To meet this obligation, the Coast and Geodetic Survey has recently enlarged its world-wide program of collecting and exchanging geomagnetic data. This is in part a continuation of work formerly carried on by the Department of Terrestrial Magnetism, Carnegie Institution of Washington. The collection and dissemination of geomagnetic data in the form of isomagnetic charts or otherwise, will be useful to all nations.

UNITED STATES NAVAL ACTIVITIES IN TERRESTRIAL MAGNETISM IN RECENT YEARS

Introduction

During the intervening nine years since the Washington Assembly of the International Union of Geodesy and Geophysics, the U. S. Navy has devoted considerable time and effort to two main phases of terrestrial magnetism, the processing of magnetic data for charts and the improvement of magnetic navigation devices, both ship and airborne. In addition, a special study has been made of the distribution of the geomagnetic field and instruments have been developed which may eventually lead to an airborne magnetometer for surveying purposes.

Magnetic Field Studies

During the past decade a number of scientific institutions entered into contracts with the Navy to carry out certain special phases of work or assignments in terrestrial magnetism under Navy direction and technical supervision. Foremost among these was the Department of Terrestrial Magnetism of the Carnegie

Institution of Washington. This specific contract resulted in the immediate construction of the Kensington Nonmagnetic Laboratory where numerous problems concerned with the earth's field were studied and experimental equipment designed and constructed. Experience thus acquired was later utilized in constructing nonmagnetic facilities at the Navy's new ordnance laboratory at White Oak, Maryland.

Members of this Association are mindful of the activities of the Department of Terrestrial Magnetism which was founded in 1904, through private enterprise, for the express purpose of executing a world magnetic survey. Its activities extended throughout approximately a half century and rendered untold benefits to science and other activities dependent upon a definite knowledge of the earth's magnetic state and its secular change. Its voluminous and oftentimes hazardous land observations extended almost over the globe, especially in countries without appropriate facilities. Ocean observations were largely accomplished through the renowned cruises of the Department's vessels--the Galilee and nonmagnetic ship Carnegie. These vessels crossed and recrossed the navigable oceans many times in their ten combined cruises of more than 300,000 nautical miles and made continuous observations of magnetic and associated phenomena. The results of these voyages were widely distributed and contributed a major part to our knowledge of magnetism covering vast ocean areas, and formed the basis of our present magnetic charts. Unfortunately, this continued flow of material was cut off with the Carnegie's destruction in Samoan waters in 1929. Since that date the Department has concentrated on land observations. Because of the absence of ocean observations, our knowledge of the world field and especially its change, has perceptibly grown worse. The world survey was essentially completed in 1926, but the necessary sea observations to complete the secular change distribution necessary to keep it up-to-date have been lacking.

The Department's resources did not permit reduction of all the material thus acquired or the analysis and interpretation of the vast store of data eventually accumulated in the institution's voluminous files, covering their own and other U. S. data, and those of other nations. Recent requirements by our government for a better knowledge of the earth's field demanded that these observations together with all other available data be analyzed and appropriate deductions made therefrom. Thus, through funds provided by the U. S. Navy and the prolonged efforts of the Department of Terrestrial Magnetism, a consistent picture was obtained of practically all magnetic measurements made available throughout this century. While the data consisted largely of the Department's observations it was supplemented by information provided by land magnetic surveys undertaken by the principal civilized states in their own or dependent territories and by the work of many polar and other special expeditions. As a by-product of this sizeable project the Navy submits to the Association a consistent series of world isomagnetic charts. Their incompleteness and approximation in regions little visited by the magnetician, where interpolations and extrapolations were necessarily numerous, is fully recognized. Nevertheless, it is believed they present an interesting picture of the earth's complicated field and its changes.

Magnetic Field Changes

Considered of fundamental importance in charting the earth's magnetic field for a given epoch are the charts of secular change per year, called isoporic charts. In 1930 isoporic charts for all elements had been constructed for epoch 1922 showing distribution of the lines of equal rate of secular change. This appears to be the best present known method to show deep-seated and rapid physical changes within the earth's interior. This rather successful use of older as well as more current data extends observations for preparation of magnetic charts to numerous other areas and to other decades.

It was early decided that a series of such charts for four epochs would satisfactorily cover the approximate half century period since 1904, that period through which the accumulated observations of the Department of Terrestrial Magnetism extended. Epochs selected were 1912.5, 1922.5, 1932.5, and 1942.5. Through persistent effort these isoporic charts were finally constructed. The straightforward methods of attack and results obtained are interestingly set forth in the Department's two publications, "Description of the Earth's Main Magnetic Field, and Its Secular Change, 1905-45", Publication No. 578, and "The Geomagnetic Field, Its Description and Analysis", Publication No. 580. These volumes relate a progressive account of the difficulties encountered and of the various techniques employed in attempting to reduce data from past decades to recent epochs, and their ultimate inclusion in isomagnetic charts. The first volume is largely descriptive, the second is largely analytical. Together they comprise a comprehensive and detailed compendium of geomagnetic data especially adapted to the needs of students, engineers, and geophysicists concerned with the applications of geomagnetism.

The series of isoporic charts were prepared for all seven elements and for four epochs, thus totalling 84. These are portrayed on the same projections that are used for the present isomagnetic charts for 1945 that are to be described presently. It is intended that these isoporic charts will be printed by the Navy at a later date, and that these will be made available to those interested in such data. These, it is believed, will be valuable to agencies preparing charts or to individuals studying the many peculiar aspects of the world geomagnetic field, and especially its cycles of change.

Isomagnetic Charts--Epoch 1945

Utilizing the principle that the complete knowledge of any three of the magnetic elements uniquely defines the entire field, charts were first prepared for the elements of Declination (Variation), Horizontal Intensity, and Vertical Intensity. Other combinations of course are possible and sometimes highly desirable. Upon completion of these and their justification, the remaining charts for Total Intensity, North Component, East Component, and Inclination (DIP) were drawn up based on the field as established by D, H, and Z. Complete world coverage was accomplished by preparing three charts for each element. A world chart on the mercator projection extends through all longitudes from 69° South to 78° North (some elements extend even further) and is supplemented by North and South polar charts on the azimuthal equidistant projection. The equidistant charts of the polar areas overlap the mercator in extending from the poles to approximately 52° latitude. For the world charts, isomagnetic lines for D, H, and Z were first constructed on large sectional mercator charts which were eventually reduced in scale and incorporated into the present charts. This made possible inclusion of greater detail than is usually found in isomagnetic charts of equivalent scale.

In general appearance the series of 21 charts, except for number, resemble charts for other epochs previously prepared by the Naval Hydrographic Office. Isomagnetic curves or lines, continuous over both land and sea, are shown throughout in blue with appropriate differentiation in drafting to show variations in kind of data depicted. An overprint of isoporic curves for that element and the same epoch affords a convenient way of extending this period to other near periods. Both systems of curves are marked with appropriate legends designating the magnitude of the element or rate of change. Land tint and other appropriate detail supply adequate information for the maximum utility of the respective charts.

It is believed this group of isomagnetic charts is the first ever issued comprising all elements and of world coverage. This series of charts is submitted in the belief it will find many applications among other governments preparing geomagnetic data as well as serve advantageously many interests and needs of the scientist and mariner. Their construction has emphasized the dearth of material needed for such an undertaking. It is hoped their inadequacy appropriately suggests our profound need for international cooperation in the joint effort of mapping the earth's entire magnetic field in a more comprehensive manner.

Spherical harmonic analyses were made of the main field for 1945 and the earth's field computed and charted in table form for heights 100, 300, 500, 1000, and 5000 km above the earth, including indications of secular change.

In the extensive study of the basic magnetic field and related phenomena, much analytical and considerable experimental work was accomplished. Probably the most far reaching data to be organized were the large collections showing variations of the earth's magnetic field as a function of time at many stations in different latitudes. The analyses give such important statistical information as frequency of occurrence of variation of horizontal component as a function of magnitude, for each station. Many other important problems await analysis, such as studies of the periods and amplitudes of the fluctuations of the earth's magnetic field and the role played by magnetic storms in influencing these quantities.

Magnetic Test Facilities

The experimental work necessitated facilities for model scale work, and resulted in construction of the Kensington Laboratory, already mentioned, where the development of coil systems to simulate magnetic influences reached a high state of perfection. These coil systems of unusual size, design, and construction were called "Magnetic Generators" because of the functions they perform. The most useful of these from the Navy's point of view are noted as follows. A solenoid, 36′ × 3′ × 4′, gives a field uniform to better than one per cent over a cylindrical volume 24 feet long and 2 feet in diameter. A Helmholtz coil-pair, consisting of two coils 20 feet in diameter separated by 11 feet, is used to provide a constant field within a volume 10 feet in diameter, uniform to better than one per cent in a particular direction. An Ellipsoidal Magnetic Generator, suggested by Clark, provides a much more nearly uniform field in the direction of its major axis than does a Helmholtz pair. With the use of a cube-surface coil, right angles to each other and 24 feet on edge, it is possible to get uniform fields in any direction within a volume 10 feet in diameter and accurate to 0.1 per cent. A Gradhelm, 10′ × 10′ × 15′, yields a means for the production of given constant longitudinal and transverse gradients in a cylinder 10 feet long and 2 feet in diameter, accurate to about 0.1 per cent. These coil systems are adequately described in references to be given.

In addition to the Kensington Laboratory, a compass testing facility is now under construction at the New York Naval Shipyard. This will include such items of equipment as special power supplies, large Helmholtz coils, compass testing platforms, vibration machines, and a 75 foot nonmagnetic mast with suitable test platforms at 10 foot intervals along the structure. This mast will be motor driven to simulate roll, yaw, pitch and turns of a ship.

Another very valuable device was developed for the measurement of the magnetic field at a point. The device, known as the flux ball, obviates the principal difficulty of this measurement which usually represents the average over a fairly large volume, and should be suitable for measurements of terrestrial magnetism in regions of high gradient.

Airborne Magnetometer

Among the electronic developments conceived for naval use have come many devices of important scientific and engineering application. Outstanding among these is the Magnetic Airborne Detector, commonly known as MAD equipment. Originally developed as an anti-submarine device, MAD measures changes in the total intensity vector of the earth's field. Thus, it becomes a magnetic surveying instrument which, when adapted to measuring any three components of the earth's magnetic field, will provide for rapid aerial surveys over land and sea. The first experimental model of the equipment was produced by Gulf Research and Development Corporation and made use of a combination manual gyro stabilized saturable core magnetometer. Predecessors of present MAD equipments were developed by two separate groups. One group was the National Defense Research Council under the Office of Scientific Research and Development; the other the Naval Ordnance Laboratory working with Bell Telephone Laboratories. Though differing in the electronic method of handling the signals from the detector elements, both used saturable core magnetometers, and both utilized magnetic orientation of the detector coil. Fundamental features of this detector assembly included: (a) Three (or 3 sets) of mutually perpendicular saturable core magnetometers mounted in appropriate gimbal system; (b) electrically driven Servo motors to orient the coil system.

The signal produced by a saturated core magnetometer is directly proportional to the component of total magnetic force along its longitudinal axis. Hence, if such a coil is so placed that its longitudinal axis is parallel to the total intensity vector, maximum signal is generated. If placed perpendicular to the total intensity vector no signal occurs. If then, in a system of three mutually perpendicular coils, one known as the detector has its longitudinal axis parallel to the total intensity field, the longitudinal axis of the two remaining or orientor coils will be perpendicular to this vector and zero signal will be generated. Upon disturbance of the orientation system the two orientor coils will give rise to signals which amplified can be utilized to operate Servo motors which will re-establish the proper orientation.

The detector unit is mounted in an aircraft as far from magnetic materials as is possible. In some aircraft, the detecting unit is mounted in the wing tip or in the tail assembly while in others it is towed in a small nacelle as much as 200 feet below the aircraft. While in the latter installation a noise level less than one gamma can be obtained, yet operations become complicated in that the towed bird must be reeled out after aircraft takes off and retrieved before landing.

In 1944 MAD equipments were modified to provide stable operation over considerable periods of time. Measuring changes in the total magnetic vector, these equipments were flown over areas where magnetic anomalies, based on earlier surface surveys made with conventional field magnetometer, were known to exist. Excellent agreements between air and surface observations were obtained and the airborne gear was then flown over unknown areas for prospecting purposes. By minimizing instrument drift and utilizing photographic strip camera and shoran radio techniques for location control, total field intensity contour maps of large areas including many regions inaccessible to general crews were obtained through joint efforts of the Naval Ordnance Laboratory and the U. S. Geological Survey (Dept. of Interior). A discussion of the results of these flights, as well as more detailed information on the MAD, will be presented as separate papers by members of those organizations.

Surveying by airborne magnetometer offers the following advantages: (1) Rapid coverage; (2) elimination of local surface disturbances through altitude choice; (3) continuous profiles.

Notwithstanding the advantages, aerial surveys will still require absolute control observations made at carefully selected ground stations over land areas and with non-magnetic ships over ocean areas.

Degaussing

Appearing at the inception of the last world conflict, the magnetic mine continually harassed shipping. It is so constructed that it is detonated whenever the earth's field is materially upset due to the super-imposed magnetic field of a ship. As countermeasures, naval and merchant vessels were fitted with degaussing coils, electrical cables so placed on the vessel that the magnetic field set up by passage of a predetermined electric current through the cables would effectively nullify the magnetic field of the vessel. The passage of current through the degaussing coils produces a magnetic field at the magnetic compass causing deviations proportional to the current flowing and depending on the number of degaussing coils as well as the distance to them.

Compass compensating coils are employed to neutralize the degaussing field at the magnetic compass. A set of coils consists of sufficient windings and circuits to provide three component compensation for each installed degaussing coil. The three components are mutually perpendicular and are sometimes directed fore and aft, athwartships and vertically, as in the conventional correctors of the compass. In many cases the two horizontal components are directed intercardinally to lessen interaction with compass soft iron correctors. These coil sets are located at the compass - either beneath it or around it as conditions permit. The current in each winding is regulated by means of associated control boxes.

In addition to the protection of vessels from magnetic mines by degaussing, magnetic minesweeping provides an effective means for their removal. In magnetic minesweeping, a magnetic field is normally electrically produced in an area sufficiently divorced from the minesweeper and of such an intensity that any magnetic mines in that area are detonated and thereby destroyed without jeopardizing men or material.

Aircraft Compasses

Another field of unusual naval effort was in the development of magnetic and astro compasses for aircraft use. Prior to 1939 most compasses used in aircraft were of the direct reading liquid damped magnetic type. With the introduction of armor plate into the cockpits of military aircraft, location for unaffected direct reading compasses became increasingly difficult. This led to the development of remote indicating compasses. The first of these used in production aircraft was the unstabilized P-1 and G-1 or Magnesyn Type. These compasses were used as a means of setting the directional gyro indicator under unaccelerated conditions. The directional gyro was, in turn, used as a steering aid. Realizing the advantage of the gyro stabilized compass in eliminating setting the directional gyro, a development program was undertaken resulting in the stabilized compasses. These consist of two general types. In one, the sensitive flux measuring element (fluxgate) is maintained by gyro in a horizontal position. The signal from this flux element is amplified and used to control the indicator, which provides a stabilized magnetic indication. In the second type, an unstabilized magnetic transmitter is used to control the indication of a directional gyro indicator. Compasses of the first type are the P-2 and P-3 gyro fluxgate. Compasses of the latter type are the C-1 and C-2 gyrosyn and the G-2 compass.

Shipborne Compasses

The Navy is now embarked on a program of standardization and improvement of ships' magnetic compasses. At the end of 1945 there were approximately 17 different types of direct reading magnetic compasses and four types of remote indicating compasses in service for shipboard use. The present program has as its objective the reduction of direct reading compass types from 17 to 5, and the construction of two basic types of remote indicating compass systems for shipboard use.

The Astro Compass

The astro compass was designed to provide means of obtaining true heading of aircraft in flight, and is used for star identification and obtaining relative bearings on distant objects. Arguments for latitude, local hour angle and declination of a convenient celestial body are preset in the instrument. It is then rotated about its vertical axis until the sights or shadow bar are lined up on the body. When this is done, true heading or true north can be read directly from the azimuth scale. Since the astro compass is the only compass not subject to magnetic or accelerational interference, it has been widely used for checking magnetic compasses and directional gyros in aircraft. Used in conjunction with a magnetic compass or airborne magnetometer it will supply means for determining magnetic declination in flight.

The U. S. Navy's activities in these special fields of interest suggest many new problems in addition to those already engaging the attention of the scientist and geophysicist. Perhaps future years will find application of many of these principles in scientific developments of mutual benefit to all nations.

References

Description of the earth's main magnetic field and its secular change, 1905-45. Vestine, Laporte, Cooper, Lange, Hendrix, Carnegie Institution of Washington Publication 578 (under Contract NOrd-392), Washington, 1947.

The geomagnetic field, its description and analysis. Vestine, Lange, Laporte, Scott, Carnegie Institution of Washington Publication 580 (under Contract NOrd-392).

Facilities provided by the Kensington Magnetic Laboratory. B. P. Ramsay and F. L. Yost, Terr. Mag., vol. 52, pp. 357-367 (1947).

Research activities at the Naval Ordnance Laboratory. A photograph of this generator is shown by W. G. Schindler. J. App. Phys., vol. 15, p. 259 (1944).

A new method of obtaining a uniform magnetic field. J. W. Clark, Rev. Sci. Instr., vol. 9, pp. 320-322 (1938).

Cube-surface coil for producing a uniform magnetic field. S. M. Rubens, Rev. Sci. Instr., vol. 16, pp. 243-245 (1945).

Coil systems for producing transverse and longitudinal gradients. G. H. Shortley and A. May, J. App. Phys., vol. 16, pp. 841-843 (1945).

The fluxball. W. F. Brown and J. H. Sweer, Rev. Sci. Instr., vol. 16, pp. 276-279 (1945).

Airborne magnetometers. E. P. Felch, W. J. Means, T. Slonczewski, L. G. Parratt, L. H. Rumbaugh, and A. J. Tickner, Elec. Eng., vol. 66, pp. 680-685 (1947).

REPORT BY THE DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON, TO THE OSLO ASSEMBLY ON WORK DONE SINCE THE WASHINGTON ASSEMBLY

The contributions of the Department of Terrestrial Magnetism presented at the Oslo Meeting are included in a group of papers and reports in Part V, Communications. These reports cover work in terrestrial magnetism and electricity, aurora, the ionosphere, cosmic rays, and the earth's crust. There is given below a report on the publications program of the Department of Terrestrial Magnetism, 1940-48.

PUBLICATIONS PROGRAM OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM, 1940-48

By O. W. Torreson

Since the meeting of the International Union of Geodesy and Geophysics in Washington in 1939, the Department of Terrestrial Magnetism has conducted an extensive program of publication of scientific results obtained over a period of approximately 20 years. In 1941, Dr. Fleming, Director of the Department of Terrestrial Magnetism, made the initial plans for the publication of all scientific data collected during the seventh cruise of the Carnegie. Between 1942 and 1946, 13 volumes relating to the Carnegie data were published, three volumes of biological studies concerned with plankton being published in 1942. Additional volumes on plankton appeared in 1943 and 1944. In these five volumes there are 830 pages.

In 1943, two volumes on the meteorological results obtained on Cruise VII appeared. These included 260 pages.

In 1944, chemical results, in one volume, and two volumes dealing with oceanography were presented. In 1945 and 1946, the two final volumes in oceanography were published. The chemistry volume, a small one, contained 58 pages, and the four oceanography volumes totaled 778 pages. In 1946 also, a volume relating to the atmospheric-electric results, consisting of 178 pages, was completed. In all 13 volumes, there were 2105 pages.

In 1943, an extensive program of analysis of data from all parts of the world concerning the earth's main magnetic field and its secular change was begun by Dr. E. H. Vestine and his co-workers. This very great task was completed in 1946, and two volumes of the results were prepared and published in 1947. These two volumes contained 922 pages and included curves and diagrams showing secular change in the magnetic elements since 1905 at more than one hundred observatories scattered throughout the world. The method of analysis is described in detail in one of the volumes.

Upon retirement of Dr. Fleming as Director of the Department on June 30, 1946, Dr. M. A. Tuve, the new Director, continued the publications work already planned by Dr. Fleming and extended it to include a series of publications of data obtained at the observatories of the Department since the beginning of its observations. The observatory at Watheroo, Western Australia, had begun magnetic observations as early as 1919 and had initiated programs in atmospheric electricity, earth currents, and ionospherics in subsequent years. The observatory at Huancayo, Peru, had begun its magnetic work in 1922, and programs in atmospheric electricity, earth currents, and ionospherics similar to those at Watheroo had been undertaken here also. In addition, cosmic ray measurements were made for a number of years at Huancayo.

Magnetic data collected on numerous field expeditions by members of the Department after 1925 were awaiting publication.

Besides the work at the Department's observatories, cooperative work in atmospheric electricity was begun in 1929 and in earth currents in 1931 at the Tucson Magnetic Observatory of the United States Coast and Geodetic Survey. Cosmic ray observations were carried out with cooperation of observatories located in Greenland, New Zealand, and Cheltenham. One of the most recent cooperative projects was the ionospheric program begun at the College, Alaska, observatory under the auspices of this Department and the University of Alaska, supported by a contract with the United States Navy.

During the last two years, volumes pertaining to all the projects just enumerated have been prepared for publication. Fifteen volumes, containing 6753 pages, have been completed. Of the 15 volumes, four are concerned with magnetic results from Watheroo and Huancayo through the year 1944. Three volumes are concerned with earth current results at Watheroo, Huancayo, and Tucson observatories for the years 1932 through 1942. Three volumes present atmospheric electric results for Tucson, Huancayo, and Watheroo, the Tucson volume containing data for the years 1931 to 1934 and the other two for the period 1924 to 1934. Three volumes cover ionospheric research at Huancayo, Watheroo, and College, Alaska; the Huancayo and Watheroo results are for the period 1938 to 1946, while the College, Alaska, volume is for the years 1941 to 1946. The two remaining volumes present land and ocean magnetic observations taken in the years 1927 to 1944 and cosmic ray results from the several cooperative observatories for the period 1936 to 1946.

The 15 volumes are part of Publication 175 of the Carnegie Institution of Washington, the first being designated volume seven to follow the six volumes which appeared prior to 1927. The 15 volumes outlined here bring the volume numbers to 19 (magnetic results of each observatory are divided into parts A and B of a single volume).

To date (July 1, 1948), the Publications Division of the Carnegie Institution of Washington has published the 13 Carnegie volumes, the two analytical volumes of Dr. Vestine and his co-workers, and nine of the 15 observatory volumes. The publication date of the remaining six observatory volumes has not yet been fixed. All the observatory volumes either have been microfilmed or will be so processed before the end of 1948. It is the plan of the Department to supply positive copies of these films to approximately 60 basic depositories situated in all parts of the world. In most cases, the 60 basic depositories have already received copies of all the volumes published, and in addition, the Department of Terrestrial Magnetism and the Publications Division of the Carnegie Institution of Washington have forwarded copies to an additional list of approximately 500 organizations and individuals throughout the world. A few copies of these researches are still held for distribution by the Publications Division of the Institution.

Future plans include volumes to continue presentation of magnetic results from both Watheroo and Huancayo through the year 1947. It is anticipated that a single volume will be sufficient for the presentation of both Huancayo and Watheroo results. Another volume is in prospect which will be a type of summary volume giving a general view of the work of the Department since its founding in 1904, outlining some of the major achievements of the Department's researches and enumerating problems which still remain in the fields of geomagnetism, atmospheric electricity, ionospherics, cosmic rays, and earth currents.

Since the beginning of the publications program in 1941, the work of putting the technical material in form for final publication has been in the hands of two people. Mrs. R. M. Crow carried through the processing of the 13 Carnegie volumes and Miss M. H. Walburn has prepared the two analytical volumes and the 15 volumes of observatory results. The entire publications program, except for the two earliest volumes, has been handled by the planograph, or photo offset, method of printing as a matter of both economy and speed of preparation, and the volumes have given excellent presentation to both textual and illustrative material. The volumes have been well received by all workers in the fields with which these publications have been concerned.

REPORT OF THE SECTION OF TERRESTRIAL MAGNETISM AND ELECTRICITY OF THE AMERICAN GEOPHYSICAL UNION, 1939-1948

By David G. Knapp, Secretary

I. General

The gradual restoration of constructive scientific endeavor following the holocaust of World War II finds heartening sustenance in the remarkable recent growth of interest and activity accruing to the geophysical sciences. This resurgence has been particularly noteworthy in the realm of this Association. The corresponding section of the American Geophysical Union, according to the designated affiliations of members of the Union, is now composed of just under 1000 persons, as compared with 230 in the year 1939. The section has experienced a like increase in the attendance at the annual meetings held in Washington each spring, and a rise in both the number and significance of the papers presented at these meetings or submitted for publication in the Transactions of the Union. This organ has undergone a change in several respects. It is now a bimonthly periodical with each number suitably departmentalized, and is supervised by an editorial board comprising representatives of the several sections of the Union.

In view of the extended period covered by this report and the diversified activities represented, it will be convenient to discuss separately the several fields of interest. It is appropriate to mention under the several heads some areas outside the United States of America where members of the American Geophysical Union participate in work that would otherwise escape notice in the Association. However, many activities in this category in the Dominion of Canada and in the Argentine Republic will be passed over with little or no mention here, since it is understood that separate reports are in preparation for those two countries.

II. Geomagnetism Proper

Institutions--The Department of Terrestrial Magnetism of the Carnegie Institution of Washington has upheld its preeminence in the field by wide-ranging investigational and observational activities, though with decreasing stress on the latter in recent years. The coordination of activities of United States Government agencies, always outstanding in this field, is now further advanced by the Committee on Geophysical Sciences of the Research and Development Board. The U. S. Coast and Geodetic Survey continues to fulfil its basic function as the producer of source material for a vast and expanding area, and several other institutions have made important contributions, namely the U. S. Geological Survey, the U. S. Naval Ordnance Laboratory, the Office of Naval Research, the U. S. Navy Hydrographic Office, the Michigan and Colorado Schools of Mines, the Johns Hopkins and Saint Louis Universities, the Universities of California, Washington, and Toronto, the Massachusetts Institute of Technology, and various commercially supported laboratories such as that of the Gulf Research and Development Company.

Magnetic work in Mexico has been under the direction of the Observatorio Astronomico Nacional, and more recently of the Instituto de Geologia, both affiliated with the Universidad Nacional de México. In Brazil the work comes under the Observatório Nacional and the Directoria de Hidrografia e Navegação, in Uruguay under the Instituto Geográfico Militar and the Servicio Hidrográfico, and in Peru under the new Instituto Geofísico de Huancayo and the Servicio Geográfico del Ejército. There is widespread interest in magnetic work in several other Latin-American countries, generally focusing in the geographic, hydrographic, meteorological and related services of the respective states.

Magnetic surveys in the Philippines are under the Philippine Bureau of Coast and Geodetic Survey, with active planning under way.

Publications--The book "Terrestrial Magnetism and Electricity" published in 1939 has been out of print for some time, and a second printing is in press. Meanwhile, two other works of importance in an overlapping field are C. A. Heiland's "Geophysical Exploration" and J. J. Jakowsky's "Exploration Geophysics", both published in 1940. Many important publications of the Department of Terrestrial Magnetism and of the U. S. Coast and Geodetic Survey are catalogued elsewhere. The well-known quarterly journal "Terrestrial Magnetism and Atmospheric Electricity" has continued to uphold its high standing under the editorship of J. A. Fleming. Another quarterly of active interest in the field is "Geophysics", the organ of the Society of Exploration Geophysicists. The monthly (now quarterly) "Geophysical Abstracts" of the U. S. Geological Survey is in its twentieth year and has found wide acceptance in its field. Publications meeting a less technical demand are Nettleton's "Geophysical Prospecting for Oil", the Coast and Geodetic Survey's pamphlet "Magnetism of the Earth", and the publication of the American Philosophical Society entitled "Commemoration of the Life and Works of Alexander Dallas Bache, and Symposium on Geomagnetism". There has been in progress by installments since 1943 a valuable "List of Geomagnetic Observatories and Thesaurus of Values" by J. A. Fleming and W. E. Scott. The publication of hourly values of the magnetic elements has been advanced through 1936 for four of the Coast and Geodetic Survey observatories and through 1944 for the two Carnegie Institution observatories.

Observatories--The observatories at Huancayo, Peru, and at Watheroo, Western Australia, were continued in operation by the Department of Terrestrial Magnetism to the middle of 1947 and then turned over to the respective governments, which are now maintaining them. At College, near Fairbanks, Alaska, a temporary third observatory was operated by the Department in cooperation with the University of Alaska from the middle of 1941 to the middle of 1946, and thereafter by the University and the U. S. Coast and Geodetic Survey. There has since been established, at a nearby site generously made available through the University, a standard magnetic observatory of the Coast and Geodetic Survey, having the same status as the existing ones, which are located at Cheltenham, Maryland; Tucson, Arizona; Honolulu, Territory of Hawaii; Sitka, Alaska; and San Juan, Puerto Rico. The Survey is also operating on an experimental basis two unattended declination recording stations--one at Gatlinburg, Tennessee, and the other at Logan, Utah.

The Missouri School of Mines was taking steps toward establishment of a magnetic observatory at Rolla, Missouri, just prior to the war, but has not yet succeeded in commencing full-scale operation.

The established observatories in the Latin American countries have continued to function. These are at Pilar and LaQuiaca (Argentina), Vassouras (Brazil), and Teoloyucan (Mexico).

The observatory at Antipolo, maintained for so many years under the general supervision of the Philippine Weather Bureau, was continued in operation throughout most of the Japanese occupation but was completely destroyed in the closing days of the war. There is good prospect of the establishment of a new magnetic observatory under the supervision of the Bureau of Coast and Geodetic Survey.

Instruments--The past nine years have seen the introduction of several new or newly improved instruments for geomagnetic measurements. The electromagnetic primary standard being constructed at the Department of Terrestrial Magnetism is nearing readiness for final tests, after a long delay in completion resulting from war activities. A new absolute magnetometer for magnetic surveys, designed and constructed by the Gulf Company, embodies a declinometer and sine galvanometer plus a new device for electrical measurement of vertical intensity, using as a null indicator a reversible-polarity magnet.

A number of important new instruments have been devised to take advantage of the modified a-c properties of reactors having cores of high-permeability alloy (permalloy or mu-metal) when exposed to the earth's magnetic field. Aircraft compass elements using this principle (some of them gyro-stabilized) are responsive even in regions of very weak horizontal intensity. Other devices of this character have found important applications in studying the magnetic field beneath a ship, and still others hold great promise for conventional magnetic field work by ground parties. It appears that the accuracy with which electric current may be maintained and measured in the field is an important factor in this application. The greatest refinement of the saturable-core principle is seen in the magnetic airborne detector for finding submarines; this device has self-orienting and self-balancing circuits permitting highly sensitive response to space- and time-fluctuations of total intensity. Since the end of the war, this airborne equipment has found extensive use in what was originally its intended field, the reconnaissance mapping of anomalies having potential economic significance. Another war development of some interest is the odograph, a device which maps the route of the moving vehicle or craft in which it is installed.

An interesting total-intensity magnetometer uses a vibrating coil as the balance indicator to escape the disabilities of sliding contacts, while retaining the vector features of the commutator-type earth inductor. New instruments have been developed for measuring the susceptibility and polarization of rock samples and of unconsolidated sediments.

Passing to the more conventional types of instruments, the use of newer magnet steels has received considerable impetus, and one interesting development was the finding that magnets may undergo a gradual spontaneous increase of their magnetic moment. A modification of the standard surveyor's transit permits its use for measuring magnetic declination with improved accuracy and also for measuring horizontal intensity by means of a deflecting magnet.

Standard magnetographs have undergone but little modification, though at the San Juan Observatory an interesting problem arising from severe humidity-conditions was met by means of a special housing for the instrument, with drying equipment for the air entering the enclosure. There has been considerable development work on magnetographs for special applications such as long running at unattended stations, pen recording or other means of remote visual indication, response to short-period fluctuations too rapid to affect standard variometers, and recording fluctuations at semi-portable installations serving the needs of field parties at their base stations. The continued demand for precision geomagnetic instruments of all types is now being met by a manufacturer in Texas.

Studies of the main field and of its secular change--Absolute field surveys have continued, with activity particularly evident throughout North America and in Argentina, Brazil, and Uruguay. Special interest has attached to the secular-variation or "repeat" stations on account of widespread and marked shifts in the rate of secular change of horizontal intensity, which took place in about 1940, generally having the effect of arresting or retarding a long-continued trend of decreasing intensity. Repeat observations in Central and South America were made under a cooperative program financed by the U. S. Department of State and executed by the U. S. Coast and Geodetic Survey with cooperation and assistance on the part of the governments concerned. Isoporic charts of the United States for epoch 1945 have been compiled with respect to four magnetic elements (D, I, H, Z) in conjunction with the corresponding main-field patterns. The latter reflect a newly perfected technique of magnetic cartography, by means of which the local anomalies can be isolated and charted separately from the systematic general pattern.

During the war years there was intensive activity in magnetic cartography to meet the needs of shipping and flying. This took the form of a series of Coast and Geodetic Survey isogonic charts on a scale of 1:5,000,000 covering a considerable part of the earth's frequented area, and a set of charts of the world on a smaller scale showing all elements for epoch 1945. The latter series is part of the output of a large-scale undertaking, supervised by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, wherein generalized techniques were applied in order to utilize available data for all parts of the globe. This involved original studies culminating in a comprehensive system for reducing world-wide field observations to mean of day, mean of year, and mean of sunspot cycle, together with a cartographic project yielding a series of world isoporic charts for the various elements, dated at ten-year intervals. All studies of the main field and of the secular change in recent years have been sorely hampered and limited by the utter lack of current repeat data in the great ocean areas, consequent upon the destruction in 1929 of the "Carnegie".

The past nine years have brought a renewed interest and activity in the exploitation of magnetic anomalies as a means of indicating concealed structure. Surveys of moderate detail with the vertical-intensity field balance have covered several large areas such as the Florida Peninsula, and there has been much fine-scale activity by commercial firms in various parts of the Americas. Surveys of total-intensity anomalies by means of airborne instruments have been extensively prosecuted by the U. S. Geological Survey, the Naval Petroleum Reserve, and the Naval Ordnance Laboratory. Much of northern Alaska, the whole state of Texas, and several other areas have been comprised in this work, including profiles run across the Aleutian Trench and on a line from Adak to Midway Island, as well as a detailed survey of the region of Bikini Atoll. The U. S. Office of Naval Research participated in the Pacific projects. Special studies of local anomalies in the vicinity of Santa Maria Volcano in Guatemala and of El Paricutín, the new volcano in Mexico, have yielded valuable and interesting results.

Several expeditions into circumpolar areas are noteworthy for their accomplishments in geomagnetism. The Louise A. Boyd expedition of 1941 obtained numerous observations in Greenland and northern Canada, as did the late R. G. Fitzsimmons, observing in 1943 under the auspices of the Arctic, Desert and Tropic Information Service (U. S. Air Force). Operation Nanook, Exercise Musk-Ox, and other undertakings in the American Arctic added largely to our knowledge of the magnetic phenomena of that area. The U. S. Antarctic Expedition of 1939-41 operated a magnetograph at Little America for nearly nine months. Another U. S. Navy expedition in the southern summer of 1946-47 included many scientists having geophysical interests, and permitted approximate reoccupation of the 1941 station as well as extensive airborne operations. This was followed up by a smaller U. S. Navy expedition in the 1947-48 season. A different part of the

Antarctic was explored by the 1947-48 expedition headed by Commander Finn Ronne, who likewise procured much valuable magnetic data.

Turning to work having special importance in the interpretational aspects, we note first of all the striking new field of fossil magnetism that has developed with regard to varved glacial clays, on which papers are being presented before this Assembly. Investigations of the representation of the earth's residual field by means of a finite arrangement of elementary magnets have led to interesting results, such as the findings that the residual field dwells chiefly at depths more shallow than that of the core, and that the secular change is such as to result in complete alteration of the residual field in relatively brief periods. At the same time, conventional harmonic analysis of the secular change embodied in the latest world isopóric charts suggests that the seat of the change is in the mantle beneath the outer crust, or possibly at the boundary of the core. The distribution of local magnetic anomaly has been used in another study to compute the average depth to the bottom of the earth's magnetic crust. There has been active work on the problems of structural interpretation of local anomalies, as well as on the broader question of describing and analyzing fields by surface integrals. Studies have appeared on the calculation of the vertical component from observed values of total intensity, likewise from those of declination and horizontal intensity, and on the problems of attaining mutual consistency in magnetic charts. The theoretical and actual heights of magnetic anomalies have also been explored.

In a still more basic realm, experimental studies were completed in an endeavor to learn how the Curie point of rocks is affected by the tremendous hydrostatic pressures prevailing at various depths in the earth's crust; these experiments were carried to pressures of more than 200,000 atmospheres. Important astronomical studies of the magnetic fields of certain rapidly rotating stars (detected by means of the Zeeman effect) have great interest in geophysics, as does a recent development in the mathematical theory of electromagnetic interactions in a conducting fluid sphere, which holds great promise of clarifying the convective and thermo-electric mechanisms entering into much of the current speculation on the origin of the earth's main field and its secular change. The model disclosed in this development realizes a self-exciting dynamo action that seems to be free from any fundamental defect such as was found to apply to earlier modes of interaction.

The transient phenomena of geomagnetism--When we turn to the realm of short-period and irregular fluctuations in the earth's magnetic field, it is of interest to note first some contributions to the mathematical theory of harmonic dials, and to the use of punched cards and autocorrelation coefficients of the magnetic character figure in the forecasting of magnetic storms. Several studies of the annual variation have been prosecuted, leading to considerable improvement in the description of this rather obscure component and incidentally to some interesting tests of the quality of observatory results as reflected in their monthly means.

The solar- and lunar-daily variations were studied in several quarters, with special interest attaching to the anomalous S_Q and large lunar effects manifested in the region of wide separation of the magnetic and geographic equators in South America. New studies have been made of possible relations between the circulatory motions in the upper atmosphere and the seasonal and day-to-day fluctuations in the pattern and amplitude of the magnetic daily variation. The data from a number of Polar Year stations were used in a new study of magnetic bays.

The period under review is remarkable for the number of magnetic storms of great violence that took place, and likewise for the fact that, thanks to assiduous attention to recommendations of this Association, some of these great storms were much more fully recorded than were any earlier storms of comparable severity. The great storm and aurora of September 18-19, 1941, was notable as the first clear-cut instance of the wide-spread disruption of electric power transmission circuits resulting from magnetic and earth-current activity. Some other outstanding storms occurred on the following dates: March 24, 1940; March 1, 1941; March 1-2, October 28-31, 1942; August 30-31, 1943; December 15-16, 1944; February 7-8, March 24-28, September 21-22, 1946; and August 22-23, 1947.

In astronomical studies, the storms of September 18, 1941, and March 1, 1942, yielded significant new findings indicating the creation of light-absorbing clouds of charged particles between the earth and the sun, of which an account appeared in the Transactions of the American Geophysical Union for 1944.

Meanwhile, the study of older data has continued. A new understanding of the vectors of sudden-commencement fields beyond the auroral zone was gained from the study of Polar Year data.

Less spectacular aspects of magnetic activity have also been under scrutiny. In accordance with the recommendation of the Washington Assembly, there has been a general adoption of the K number or three-hour range index, which has proven its usefulness by a thorough trial. There have already been announced some interesting studies of correlations between magnetic activity and collateral phenomena, not only including solar activity but extending to microseisms recorded at Huancayo. There has been in progress for some time a study to determine whether magnetic activity shows annual recurrences. Both the K numbers and the now discontinued American half-day character numbers were valuable measures of activity and were collected and summarized regularly. Lists of five international quiet and disturbed days have also been compiled regularly and published for general use. One helpful source of correlated information on solar and magnetic activity is afforded in the quarterly reports of solar and magnetic data from the Mount Wilson Observatory. It has been found that the Cheltenham K numbers are sufficiently representative to serve in lieu of composite indices for many purposes, and these numbers are now being distributed on a current weekly basis to an inclusive mailing list, and summarized in quarterly tables in "Terrestrial Magnetism and Atmospheric Electricity".

III. Earth Currents

After the completion of about 11-1/2 years of operation it became necessary to terminate early in 1943 the cooperative project of earth-current registration at the U. S. Coast and Geodetic Survey's observatory at Tucson, Arizona. The results of this work are shortly to be issued in a single volume by the Carnegie Institution of Washington, Department of Terrestrial Magnetism. The interesting and somewhat anomalous seasonal behavior of the earth currents (as well as of the magnetic daily variation) at this station has been the subject of considerable study.

The registration of earth currents was maintained at Huancayo, Peru, and at Watheroo, Western Australia, by the Department of Terrestrial Magnetism until the latter part of 1946. These results have been likewise reduced and prepared for publication, and are available on microfilm. In conjunction with those for Tucson, they afford for the first time a coordinated record extending throughout a sunspot cycle for three widely separated stations. There have been several developments in the Schlumberger method of prospecting, in which the earth-current vector elements are recorded simultaneously at a base station and at outlying points.

There has been considerable interest in resistivity methods of exploration; some of the papers in this field have been given by members of the staffs of the U. S. Geological Survey, the U. S. Bureau of Mines, the Michigan College of Mining and Technology, the Colorado School of Mines, the Secretaria de Recursos Hidráulicos, of Mexico, and various other groups. Another recent development was in the field of induced polarization as a method of geophysical prospecting.

IV. Ionospheric Phenomena

Ionospheric investigations have lately made long strides. The stimulus of war-born needs hastened the establishment of many new stations. The world net set up by the Wave Propagation Committee of the Combined Communications Board encompassed several stations under American supervision. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington took an early lead in this, with its existing experimental station at Kensington, Maryland (now transferred to Derwood, Maryland) and other stations such as those at Huancayo, Peru; Watheroo, Western Australia; College, Alaska; Clyde River, Baffin Island; Reykjavik, Iceland; Trinidad, British West Indies; and one on the Island of Maui, Territory of Hawaii.

The recently organized Geophysical Observatory of the University of Alaska is continuing the wave propagation work at College, and some of the other stations listed above are being continued by the National Bureau of Standards. The activities of the Bureau in this field were considerably expanded under the Interservice Radio Propagation Laboratory, now an integral part of the Bureau and renamed the Central Radio Propagation Laboratory. The principal station has been removed from Meadows, Maryland, to Sterling, Virginia. The Needham Laboratory for Cosmic-Terrestrial Research, affiliated with the Massachusetts Institute of Technology, has also been active in this field.

Among expeditions there should be mentioned the Louise A. Boyd Arctic Expedition of 1941, two expeditions sent respectively to South Africa and to Patos, Brazil, to observe effects of the total solar eclipse of October 1, 1940, and a similar one to Bocaiuva, Brazil, for the eclipse of May 20, 1947. Sponsoring and participating agencies concerned in these expeditions include the National Bureau of Standards, the National Geographic Society, the Bernard Price Institute of Geophysical Research (Johannesburg), and the United States Air Force.

There have been several instrumental developments worthy of note in this field. Manually operated ionospheric equipment was developed, as well as a new panoramic apparatus for making records photographically at intervals as short as five seconds, adapted to visual presentation in motion-picture form. In connection with the experimental firing of captured German V-2 rockets and the newer "Aerobee" rockets by the Air Materiel Command, development of special ionospheric instruments is under way at the Applied Physics Laboratory of the Johns Hopkins University in collaboration with the Naval Ordnance Laboratory. These include devices for measuring the magnetic field as the rocket traverses current sheets in the ionosphere.

The store of data accruing from these manifold activities is already bearing fruit. There has been worked up by the Cruft Laboratory of Harvard University an arresting résumé of recent theoretical developments involving accumulation of space charges and the effects of solar radiation pressure in relation to the aurora, magnetic activity, and ionospheric phenomena in general. Some of the existing discrepancies and inconsistencies in ionosphere theory have been well brought out in a survey supported by the RCA Laboratories. A new "sliding-wave" theory of ionospheric propagation has recently been published. Considerable attention has been given in various studies to the interpretation of the virtual heights obtained from radio echo measurements. One study along these lines makes use of the observed difference between penetration frequencies for the ordinary and extraordinary rays, in conjunction with an assumed change of magnetic intensity with height. Observations at Kensington during the partial eclipse of April 7, 1940, yielded indications of non-uniform emanation of ultraviolet light over the sun's surface, while later studies dealt with widespread effects of the eclipses of August 1, 1943, and January 25, 1944, on the F2 layer. Studies to segregate the several major variations in this region have promoted better understanding of this topic. There has been much activity devoted to the application of current and accrued data in the forecasting of transmission conditions. The Central Radio Propagation Laboratory issues frequent bulletins and announcements in this field, and has compiled ingenious charts and tables to facilitate the application of the various relevant factors.

Other studies revealed important geographic differences in the fluctuations of ion density in the F2 region. Later, it was found with the aid of the new panoramic recorder mentioned above that during magnetic storms the ionosphere may be characterized by clouds or patches of activated particles, which advance and recede with high velocities.

Many papers published in this field reflect the remarkably close relation of certain ionospheric changes with magnetic storms, and a close parallel of F2 critical frequency with solar activity has been observed; this has extended to the exceptional solar activity recorded during the year 1947, and has also appeared as a post-perturbation reaction following severe magnetic storms. At the same time, there is a lack of detailed correspondence between the ionospheric changes at College (Alaska) and the intensity of zenith aurora at the same station. Studies at this station also confirmed the nature of the arctic type of radio fade-out previously worked out by Appleton and Builder.

An interesting longitude effect in the behavior of the F2 region has been correlated with the effect of the earth's main field.

Research at the Central Radio Propagation Laboratory has advanced several branches of ionospheric science. Propagation was studied over long paths such that there were direct data as to the condition of the ionosphere at points along the path. Propagation by two and three reflections was studied, as was the effect of backscatter of pulse transmissions on 13.66 megacycles. A strong lunar variation in electron density was recently demonstrated for Huancayo, Peru. Thanks to the unprecedented maximum in solar activity reached during the current cycle, it was possible to refine the parameters expressing the relation of electron density and sunspot number, and at the same time it was found that so far as maximum usable frequency is concerned the increased density is under some conditions largely offset by increased virtual height. The theoretical distribution of electrons in the lower parts of the ionosphere also received attention.

The type of ionization characterized as "Sporadic E" has received considerable attention. Its seasonal behavior was confirmed for the southern hemisphere by studies of the Watheroo records.

Two phenomena that seem certain to elicit additional study are those of radio noise (some of which originates on the sun) and of the ionization of meteor trails, giving rise to radar echoes.

V. Auroral Studies

The program sponsored jointly by Cornell University and the National Geographic Society has made good progress. Results include spectrograms, photographs in natural color, and statistical correlations of aurora seen at Ithaca, New York, with the three-hour range index or K number from geomagnetic records. Ingenious automatic instruments have been devised to aid in the investigations. Two spectrographic studies show indications of particularly significant results, one aspect of which is the subject of a paper scheduled for presentation at this Assembly.

More than 1600 individual auroral observations were made by the U. S. Antarctic Expedition between April 1 and September 15, 1940.

The Department of Terrestrial Magnetism of the Carnegie Institution of Washington has published a comprehensive volume on its auroral researches at College, Alaska, during the period 1941-44. One outgrowth of this work was a provocative paper on the feasibility of applying photogrammetric techniques to augment the scope and accuracy of auroral photography. A valuable list of auroras observed at the Blue Hill Meteorological Observatory of Harvard University, near Boston, Massachusetts, has also been published. It covers the period from 1885 to 1940.

New studies at the Department of Terrestrial Magnetism have resulted in improved understanding of the geographic incidence of aurora and magnetic disturbance in both the northern and southern hemispheres, and of the advance of the auroral zone to lower latitudes during magnetic storms.

Great popular interest was excited by the remarkable aurora of September 18-19, 1941, which was observed from points as far south as Florida, and was the greatest display in the memory of many witnesses.

VI. Atmospheric Electricity

The Department of Terrestrial Magnetism of the Carnegie Institution of Washington made available in 1941 the results of Fourier analysis of the data on atmospheric-electric potential gradient and conductivity obtained during the period 1924-34 at its observatory at Watheroo, Western Australia, showing the predominance of a 24-hour wave, and a seasonal change in the diurnal variation. In 1946 the results of ocean observations obtained on the Carnegie during her last (1928-29) cruise were published by the Institution. During the period now under review, observations were conducted at Watheroo, at Huancayo, Peru, and at Tucson, Arizona, those at the last-named station being made cooperatively with the U. S. Coast and Geodetic Survey. A similar program was carried on in Argentina by the San Miguel Cosmophysical Observatory. Regular observations at the Needham (Massachusetts) Laboratory for Cosmic-Terrestrial Research were instituted in 1940, but were interrupted on account of the war. Observations made in 1940 by the U. S. Antarctic Expedition were being processed at the Bartol Research Foundation of the Franklin Institute.

The instruments and procedures used in atmospheric-electric studies have been under continuing scrutiny. An inquiry into the relation of the formation of small ions and the occupancy of the laboratory room was conducted in 1939, and the effect of exhaled breath was investigated in 1943, indicating that very large particles thus accounted for play a significant role. New ionization meters were designed and constructed at the Department of Terrestrial Magnetism. Difficulties attributed to wall effect have been examined, and instruments have been developed for measuring rapid changes in atmospheric conductivity on an airplane during flight; they employ vacuum tubes in lieu of electrometers.

At Fordham University, the effect of radioactive matter in the air and in the ground has been a topic of study, affecting the ionization balance of the atmosphere. The radon content of soil gas and its exhalation from the earth are particularly significant, and show diurnal and meteorological influences. In 1945 this group announced a new determination of Eve's constant for calibrating an ionization chamber.

Investigations at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington have explored several aspects of atmospheric electricity. A 1943 paper dealt with the electrode effect in the atmosphere. The number of condensation nuclei in the atmosphere (both the total number and the number bearing electric charges) has attracted particular attention. Formulas were developed for the relation between the recombination coefficient and the mobility of ions. A study at Stanford University was concerned with the mobility spectrum of atmospheric ions, and with their diurnal variation and vertical distribution. The accumulation of radioactive matter in the lower atmosphere during calm weather and its dispersal in windy periods were found significant in a 1943 study by the Department of Terrestrial Magnetism. Other environmental effects studied were those of fog, pollution (as by smoke), and wet or snow-covered ground. There is evidence of a gradual increase in the pollution of the atmosphere, even over the remote ocean areas.

The concept of columnar resistance has been found helpful; this refers to the resistance of a vertical column of air having unit cross-section and extending from the ground to the ionosphere. The diurnal variation was expressed in terms of this index at Watheroo in a 1941 paper, and the radical seasonal change in type of diurnal variation at this station received attention in 1943. Another paper dealt with simultaneous measures at Watheroo and over the ocean. Anomalous diurnal variation at Huancayo was also studied.

The underlying mystery of the nature of the supply current by which the earth's charge is replenished remains unsolved. A study published in 1941 shows how an apparent disparity between the direct and indirect methods of determining the air-earth currents may arise partly from computational procedures. Correlated records from the College (Alaska) Polar-Year station and from Huancayo and Watheroo were studied in regard to this problem. The College records show some peculiar anomalies in daily variation.

Evidence of a latitude effect in potential gradient from ocean observations was reinforced by new studies of the original data. Relationships betwen atmospheric-electric elements and solar flares were sought in one study, with negative findings. An investigation at the Indiana State Teachers' College was concerned with barometric pressure and other meteorological elements in relation to atmospheric potential gradient.

Throughout the period under review, there were numerous studies of the electrical aspects of thunderstorms at the U. S. Weather Bureau and elsewhere. In one of these investigations, at the University of New Mexico, motion pictures of clouds were used, and the surface potential gradient was measured at varying distances. The mechanism of charge generation received attention, as did the electrical effects associated with the change of state of water, the latter being studied at the U. S. Naval Research Laboratory. During the past two years the U. S. Weather Bureau has conducted a large-scale thunderstorm research project jointly with the U. S. Navy, the U. S. Air Force, and the National Advisory Committee for Aeronautics. A correlated project dealt specifically with the electrical phenomena of thunderstorms and was carried out by the Department of Terrestrial Magnetism and the U. S. Air Force.

A project of the Department of Terrestrial Magnetism has also been the study of electrical discharges in the smoke column issuing from El Paricutín Volcano in Mexico.

VII. Cosmic Rays

The cosmic or penetrating radiation continues to excite the fascinated attention of research workers in physics, astronomy, and geophysics. Without essaying a thorough-going examination of this intriguing and intricate field, some of the developments of more direct concern to students of geophysics may be reviewed briefly. Fuller information has been assembled by the former Committee on Coordination of Cosmic-Ray Investigations in its Annual Reports, to which are appended reports of various research groups, with bibliographies. This Committee of the Carnegie Institution of Washington, formed in 1932, transferred its functions in 1946 to the Department of Terrestrial Magnetism.

Symposia on Cosmic Rays have been held under the auspices of the American Physical Society as follows: At Seattle, Washington, June 19, 1940; at Pittsburgh, Pennsylvania, April 28-29, 1944; and at Pasadena, California, June 21, 1948. Routine precise registration of cosmic-ray intensity has been maintained at the magnetic observatories at Cheltenham, Maryland; Huancayo, Peru; Christchurch, New Zealand; Godhavn, Greenland; and during part of the period, at Teoloyucan, Mexico.

<u>Field work</u>--There have been special observations in many localities, some of general applicability and others designed to answer specific questions. The U. S. Antarctic Expedition obtained valuable observations in this field under a program prepared at the Bartol Research Foundation of the Franklin Institute. The California Institute of Technology conducted a series of balloon flights in India, and a series of ship observations over a path between Seattle, Washington, and the Straits of Magellan, in addition to ground measurements at various stations in the United States and Mexico. A four-year series of sea-level observations over the route from Seattle to Juneau, Alaska, was studied at the University of Chicago, as was a program of mountain and balloon observations carried out in cooperation with investigators of the University of São Paulo and other South American institutions. This work included extensive cloud-chamber photography at an elevation of 4750 meters, at the San Cristobal mine in Peru.

Several series of observations were made at the Mount Evans Laboratory in Colorado (elevation 4340 meters) under cooperative arrangements of the University of Denver, the Massachusetts Institute of Technology, and the University of Chicago. At Fordham University, surface data collected between New York and Valparaiso were used. The University of Minnesota has sponsored a series of balloon observations by which automatic cloud chambers were sent as high as 28 km, whereas in northern Michigan, other measurements have been conducted in deep copper mines.

During the summer of 1946, a valuable new series of data was secured in a program of high-altitude airplane flights (up to 10 km) between southern Canada and the magnetic equator in northern Chile, sponsored jointly by the National Geographic Society, the Bartol Research Foundation, and the U. S. Air Force. The use of rockets has opened a new field of cosmic-ray investigation in which the U. S. Naval Research Laboratory and the Applied Physics Laboratory of the Johns Hopkins University are active. Altitudes as great as 110 km have already been reached in this work, with important new results still under study.

Instruments--The apparatus used in cosmic-ray investigations has received its share of critical attention. At the University of California a large electromagnet providing induction of more than 10,000 gauss was constructed for this work, but actually used for more urgent projects of another type. Another large magnet was completed and put into use at the California Institute of Technology.

At the Bartol Research Foundation and later at New York University, there have been significant developments in the theory of counters and quenching action. New counters using the gases methane and boron trifluoride afforded improved sensitivities and simplified, inexpensive techniques for many types of ionization measurement. Other economies and improvements resulted from the use of two wires mechanically joined by a glass bead and enclosed in a grid to reduce the operating potential. A narrow-angle wide-aperture cosmic-ray telescope was constructed, incorporating these new counters. A counter was also devised for measuring neutron intensity at sea level. A cloud chamber was constructed with arrangements for pressures as high as 200 atmospheres. This apparatus used in conjunction with a "betatron" is expected to provide a powerful research tool.

Fundamental studies--Detailed investigation and interpretation of the data resulting from these various programs and improvements were hampered in several instances by diversion of personnel and equipment to activities concerned with the war emergency. Nevertheless, there was steady progress along several lines.

An important study at the Bartol Research Foundation was aimed at observing any east-west asymmetry of the soft component such as might throw light on the identity of the primary particles that produce the mesons or hard component. The results showed no asymmetry great enough to lend color to the view that primary electrons are responsible for the production of mesons. More recently, there has been further work on this topic at the University of Chicago. An earlier study at this center dealt with the latitude effect at high altitudes, which was found only a third as great for mesons as for the soft component, thus supporting the idea that the mesons are produced by high-energy primaries which are relatively insensitive to the magnetic field.

At several research centers, studies on the disintegration of mesons brought out the extremely short life of these mysterious particles comprising the more penetrating fraction of the cosmic rays. Investigations at the University of Chicago were concerned with the production of mesons, which seems to occur at considerable altitudes, with maximum intensity found at about 16 km. They are found to be of varying masses, ranging from 25 to 300 times that of an electron, and to contain a rapidly rising proportion of "slow" mesons with increasing altitude. The production and role of neutrons, both singly and in showers, was another field of interest there and at the Bartol Research Foundation. The showers at 3000 meters received special attention at the University of Chicago, where it was found that 90 per cent of them must be produced by non-ionizing primary rays.

The mesons are too short-lived to be the primary particles, and the idea has been advanced repeatedly that protons (hydrogen nuclei) are the incident corpuscles. This hypothesis seems now to be gaining ground. The recent airplane flights to and from Chile appear to show that there cannot be electrons among the primary rays to the extent of more than about four per cent. A very recent development is the finding of heavy nuclei (e.g. hafnium) among the cosmic rays, a result of balloon flights by workers of the Universities of Minnesota and Rochester.

At the California Institute of Technology, the origin and energy distribution of incoming cosmic-ray particles claimed special attention. There has been adduced a considerable amount of evidence in support of the hypothesis that the rays are produced in interstellar space by the annihilation of atoms of certain elements known to occur there in small quantities.

A number of investigations have been concerned with the effect on cosmic-ray intensity of temperature changes (especially those at various heights in the atmosphere) and the concomitant seasonal effects. Such effects, in accordance with a basic idea advanced by Blackett in 1938, are now explained by the short lifetime and correspondingly abbreviated downward paths of the mesons, coupled with the fact that the meson-producing layer must undergo vertical shifts in response to temperature changes of the mass of air supporting it. The bearing of the effect on air-mass boundary conditions has been explored at the University of Washington. It has also been pointed out that this effect might be used in meteorology as a measure of the temperature of the air mass. The ratio of mesotron (meson) mass to lifetime has been studied at the Bartol Research Foundation, using the correlation between observed fluctuations in cosmic-ray intensity at sea level and meteorological variables throughout the atmosphere.

Another study at the Bartol Research Foundation used an automatic device to vary the relation of a counter to an arrangement of lead blocks carried by a balloon, and brought out the great abundance of the soft component.

The existence of systematic world-wide fluctuations in cosmic-ray intensity, having the character of a diminution during magnetically active periods, as though in response to the depression of magnetic horizontal intensity, was established shortly before the time of the Washington Assembly. However, it has lately been found at the Department of Terrestrial Magnetism that in three instances the continuous cosmic-ray records show a sharp increase of the incident radiation, occurring within an hour after an intense solar flare. Various considerations suggest that the source of the increment was probably the solar eruption itself. This of course raises important questions regarding possible solar and stellar mechanisms that might give rise to such increments and to the cosmic rays normally observed. On the three occasions cited, there were active sunspot groups such as might set up "tunnels" in the solar magnetic field permitting egress of charged particles.

Less spectacular results of the long-term program of routine cosmic-ray registrations at cooperating magnetic observatories, sponsored by the Committee on Coordination of Cosmic-Ray Investigations, will be found in the voluminous statistical tabulations of resulting data, which by now comprise a rich store for future investigations. A recent study has shown that the sunspot cycle is reflected in cosmic-ray intensity.

Acknowledgments

While it is manifestly out of the question to enumerate the many authorities to whom the compiler of this report is indebted, particular mention should be made of the very lucid annual reports of the Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Members of the staff of that Department, as well as the compiler's associates at the U. S. Coast and Geodetic Survey, have been most helpful, though the compiler accepts sole responsibility for any errors or omissions.

[illegible]

[illegible]

[illegible]

[illegible] of the old bases [illegible]

[illegible] throughout the [illegible]

[illegible] of the [illegible] was used.

[illegible]

[illegible]

PART IV

SPECIAL REPORTS

REPORT OF COMMITTEE TO CONSIDER EXISTING AND DESIRABLE DISTRIBUTION OF MAGNETIC AND ELECTRIC OBSERVATORIES AND THE BETTER COORDINATION OF WORK OF EXISTING OBSERVATORIES

The Committee on Observatories of the Association was initiated at the Stockholm Assembly in 1930. Its present membership includes S. Chapman, J. A. Fleming (Chairman), C. Maurain, and V. Laursen, the last named succeeding the late D. B. la Cour. Its earlier Reports at Lisbon, Edinburgh, and Washington are published in the Transactions of the Association (see Bull. 9, pp. 107-113, Bull. 10, pp. 164-174, and Bull. 11, pp. 196-204). The Committee was charged with (a) consideration and recommendation of desirable locations for observatories in the world network, particularly as regards better distribution and the forwarding of pertinent resolutions of the Association at its triennial meetings, and (b) accumulation of particulars for a Thesaurus of Observatory Values as authorized at Edinburgh in Resolution 1.

It is gratifying to report that, during ten years since the Association's meeting in 1939 at Washington, there has been increased activity in the continuance of existing, and in the establishment of new, magnetic observatories. Naturally, several observatories have been destroyed or partially interrupted because of the war, especially in Europe and the Far East. Many of these have, however, been fully re-established or partially rehabilitated. For some there is present urgent need of magnetic equipment for which, by reason of lack of instrument-making organizations, there is great scarcity. The Committee recommends that an inventory of available instruments, and of manufacturers thereof, be prepared and distributed.

As stated some long-established observatories have discontinued operation either because of damage during the war or by reason of lack of funds and personnel: for example, Stonyhurst with 1947; Koenigsburg with 1939; Hel with 1939; Nizhnedevitsk; Auhof with 1939; Bochun with 1939; Au-Tau; Antipolo; and several others. Fortunately, many observatories, partly damaged or interrupted, have been re-established: for example, Sodankylä, Manhay, Ebro. On the other hand, the decade has seen the establishment of new observatories as follows: Thule (76°32′N, 290°56′E) from January, 1947; Krasmaya Pakhra (55°27′N, 37°20′E) from 1945; Sulari (44°41′N, 26°15′E) from 1947; Ikutora (43°10′N, 142°35′E) in 1948 to replace Toyohara (46°57′N, 142°45′E) which is now under USSR; Ksara (33°49′N, 35°53′E); Hermanus (34°25′S, 19°14′E) in 1941; Heard Island (53°06′S, 73°22′E). From 1947 the temporary magnetic observatory at College has been replaced by a permanent observatory (64°52′N, 212°11′E); another of the temporary observatories of the Second Polar Year being continued on a permanent basis is the one at Castellaccio (44°26′N, 8°56′E). In the summer of 1948 a new permanent observatory will begin geomagnetic registration at Björaöya in Norway. Several additional stations in the Arctic are now planned by the Canadian Government.

There was established a Chinese observatory at Tsi-King-Sha (32°04'N, 118°49'E) which began functioning in 1937 but was lost during the war and now from March, 1948, is at a new location (32°03'N, 118°47'E). Another observatory in China functioned from June, 1943, to June, 1944, at Yenshan (25°05'N, 110°17'E) but was destroyed during the invasion.

Construction has begun at Barrow, Alaska, of a permanent magnetic observatory; it will begin work in 1949 under the direction of the United States Coast and Geodetic Survey. The Royal Astronomer of Great Britain reports that a movement is under way to resume work at the Kodaikanal Observatory and that plans are in contemplation which may permit the re-establishment and modernization of the observatory of Valentia. Dr. J. Coulomb, of the Institut de Physique du Globe, reports October, 1947, that two stations are being established in Algeria in addition to Tamanrasset at El Abiod Sidi Cheikh (32°54'N, 0°32'E) and at Beni Abbis (30°07'N, 2°11'E). He also states that the French Colonial Office of Scientific Research is making efforts to establish new magnetic observatories in addition to the one at Tahiti, which is in the course of re-installation, at M'Bour (90 km south of Dakar on the coast) which is not well advanced, and ultimately for a station in New Caledonia and one in French Equatorial Africa, either near Brazzeville or near Banqui.

The long proposed Geophysical Institute at the University of Alaska in College will soon be realized, as the Congress of the United States of America has made available $975,000 for its construction. This Institute will be a great boon to polar geophysical sciences, particularly so as the new College Magnetic Observatory of the United States Coast and Geodetic Survey is completed and has operated since 1948. Meanwhile, in anticipation, the University of Alaska established a Geophysical Laboratory in 1948.

As regards the Watheroo Magnetic Observatory in Western Australia, and the Huancayo Magnetic Observatory in Peru, it is to be noted that following the desirable policy that governments of countries should take over the determination and collection of factual data of magnetic surveys, the Carnegie Institution of Washington transferred its entire sites, buildings, and instrumental equipment at these observatories on July 1, 1947, to the Bureau of Mineral Resources, Geology, and Geophysics of Australia (also now charged with the operation of the Toolangi Magnetic Observatory) and to the Ministerio de Fomento of Peru, respectively. The Huancayo Magnetic Observatory has been redesignated the Instituto Geofísico de Huancayo. The Committee has been advised that the Australian Bureau of Mineral Resources, Geology, and Geophysics has plans for two other geophysical observatories in Queensland and Northern Australia. The Astronomer Royal of Great Britain reports that plans are now under way to transfer the Abinger Magnetic Observatory, because of electric traction disturbances, to a location in north Devonshire, which promises permanent freedom from disturbance.

Thus many of the locations which were recommended for magnetic observatories in the Committee's Report of 1933 (see Bull. 9, pp. 107-113, especially the maps on p. 111) have been or will soon be established. Those recommendations that have not yet been realized and which are important include Jan Mayen Island, Comorin, Mogadiscio, Belem (Brazil), Nairobi, St. Helena Island, Easter Island, and Kerguelen Island. In addition to these, the Committee now views favorably the establishment of observatories on the coast of the Antarctic Continent, as recently proposed by Commander Finn Ronne following his Antarctic Expedition of 1947-48. The general localities proposed as feasible are: (a) Marguerite Bay

(68.2°S, 292.1′E) in the neighborhood of the stations occupied by the United States Antarctic Service Expedition of 1939-41 and of Ronne's Expedition; (b) Queen Maude Land (about 14°E), the scene of various Norwegian expeditions; (c) American Highland (about 77°E) explored by Ellsworth; and (d) Cape Adare in Victoria Land (about 170°E) not far removed from the Magnetic South Pole. It is recommended that the Association give careful consideration to this suggestion. It is, however, to be borne in mind that the establishment of any one or more of these stations would involve considerable expense, and therefore any steps taken should be based on the assumption that the program should include all branches of geophysics as well as geomagnetism. Accordingly, if a resolution on this subject is considered and adopted by the Association it should also go before all the other Associations and eventually have final action of the Union as a whole.

There is presently a world net of some 69 active magnetic observatories. Of these, however, only 12 are in the Southern Hemisphere. Herein is the great need to establish additional observatories as recommended at such stations as Mogadiscio, Nairobi, Belem, St. Helena Island, Easter Island, Kerguelen Island, and on the Antarctic Continent.

The Committee calls attention to the publication of Bulletins No. 12 and 12-A under the auspices of the Committee on Three-Hour-Range Indices for Magnetic Characterization, prepared by H. F. Johnston, W. E. Scott, and Ella Balsam, and covering the eight years 1940-47 for both C and K. The Committee on Observatories as well as the Association and geomagneticians everywhere are greatly indebted to the authors of these Bulletins.

The recommendation has been received from the Chairman of the Committee on Registration in Iceland of Giant Pulsations, that it is desirable to establish for some years on a temporary basis a fully equipped magnetic observatory in Iceland under the auspices of the Association. Our Committee feels that very strong arguments are needed in this matter if such an observatory is to be established and maintained mainly at the cost of international funds. It is to be hoped that sooner or later the Icelandic government will consider the establishment of a permanent magnetic observatory in Iceland, and that the approval and support of the Association in such a plan might be worthwhile, although the Committee has not recommended a permanent observatory in Iceland. It is felt that with the funds already made available to the Committee on Registration in Iceland of Giant Pulsations, the necessary geomagnetic registrations for short periods may be obtained with available equipment.

Walter E. Scott, of the Department of Terrestrial Magnetism and the Chairman of the Committee, have now completed publication in the Journal of Terrestrial Magnetism and Atmospheric Electricity of eight sections of the Thesaurus of Observatory Values. In the beginning, Dr. Nippoldt assisted in this compilation, but his death unfortunately placed the burden of compilation and necessary computations upon Mr. Scott. In the preparation of Section VIII we have had the privilege of utilizing manuscript of a Thesaurus prepared by Dr. R. Bock of Germany, the successor of Nippoldt and Bartels at Potsdam. Sections I-VII of the Thesaurus have been given wide distribution and reprints of the final Section VIII have been made available for distribution at Oslo and subsequently to all of those who have received the first seven sections. The Committee feels that its responsibility as regards the preparation of the Thesaurus is now complete.

Potential improvement in methods of compiling and publishing data obtained at magnetic observatories will doubtless be reported upon by the Association's Committee on Methods of Observatory Publication. It is recognized that complete compilation and publication according to the recommendations of Resolution 10 at the Washington Assembly places a heavy burden on the limited personnel of most observatories. Since the distribution of existing observatories in some regions is quite dense, for example in Europe, the Committee thinks it would be desirable to arrange that certain key observatories compile and publish completely the material called for in Washington Resolution 10, thus relieving somewhat the demands upon other observatories less well equipped with funds and personnel to make complete publication. In this connection it must be borne in mind that investigators competent to do worthwhile analyses and discussions of worldwide features of geomagnetism have limited resources, both in finances and personnel. It is imperative, therefore, that at least certain key observatories publish the data in the form as called for in the Association's Resolution 10 at Washington.

The serious lack of sufficient funds and personnel at many observatories for preparation and complete publication of data obtained, emphasizes the real need of an intense study of methods to compile and prepare tabulations for offset printing by mechanical means. Discussions of this subject by several organizations have indicated large savings of time and funds would be quite feasible. The Association should take appropriate steps to develop this matter--perhaps at one or two central bureaus.

Another improvement, now feasible by reason of recent technological developments, would be in the design of automatic equipment for magnetic observatories to operate over a period of some months without attendance. Concentrated attack should be considered on the question of automatic recording of values so as to eliminate the great labor now connected with the reduction of photographic magnetic records--something which would go a long way in making earlier publication of hourly data available and certain.

The Committee wishes to emphasize the great need of continuing the work of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and of Dr. la Cour for intercomparison of magnetic standards at observatories throughout the world. It urges the Association to take prompt steps to insure a program of international magnetic control and determination of necessary corrections to international standards for all observatories.

It is recommended that the Committee be discharged, since its four Reports cover in sufficient detail the responsibilities assigned when it was set up at Lisbon.

Jno. A. Fleming, Chairman
For the Committee

Washington, D. C.
July 28, 1948

REPORT OF THE AURORAL COMMITTEE

By Carl Störmer, Chairman

From the period 1939-1948, since the meeting in Washington, reports have been collected from countries and persons engaged in making observations and doing work on the polar aurora. These reports, which are given below, have come from Canada, Great Britain, the Netherlands, New Zealand, Norway, Switzerland, and the United States of America.

Canada

REPORT ON AURORAL INVESTIGATIONS AT THE UNIVERSITY OF SASKATCHEWAN, CANADA

By B. W. Currie

Other demands on staff and facilities stopped all auroral investigations at the University of Saskatchewan from early in World War II until late in 1946. A study of the directional and diurnal characteristics of auroras at some places in Canada, based largely on data from the International Polar Year, 1932-33, was completed early in this period and published in the Journal of Terrestrial Magnetism, September, 1941. A large number of polar and night-sky auroral spectrograms was taken during 1938 and 1939 with the same spectrograph that was used at Chesterfield in 1932-33, but a detailed study of these has still to be made. Present activities are of two types, namely, the development of a recording meter for overhead aurora by Currie and the investigation of auroral spectra by Petrie, Associate Professor of Physics.

The directional characteristics of aurora in Canada were determined mostly from single- and double-station photographs and diagrams on star maps of homogeneous arcs and bands. In the eastern part of Canada, the average directions are about the same as the lines of geomagnetic latitude, but in central and western Canada, the directions deviate by 15° to 20° in a clockwise sense (when viewed from above), from parallelism with these lines. Maximum auroral activity occurs on an average before astronomic midnight, and is apparently not a function of the time for geomagnetic midnight. A secondary maximum occurs just before sunrise.

As nearly the same procedures as possible were followed at Saskatoon (geomagnetic lat., 60.5° N) as at Chesterfield (geomagnetic lat., 73.5° N), in obtaining polar and night-sky spectrograms in order to detect possible differences in the spectra across the auroral zone and to clarify certain confusions in the nature of some of the radiations observed at Chesterfield. A preliminary study of the spectra shows no marked differences between the two places. Typical auroral spectra were frequently obtained at Saskatoon on nights following bright displays although auroral forms were not visible, indicating that the same excitation process in the upper atmosphere persists for at least 24 hours after the main display. The use of a sodium source for comparison purposes showed that the radiation, reported as having a wave length of 5940 Å in the Chesterfield spectrograms, was actually the sodium yellow radiation. The twilight effects for this radiation, reported for the Chesterfield spectrograms, were verified by the Saskatoon spectrograms. These spectrograms also indicate that the sodium yellow radiation can be obtained at any time of the night, if the exposure is sufficiently long. However, times do occur (even in twilight), when this radiation does not appear on spectrograms, indicating that the sodium has a patchy distribution in the atmosphere and is probably of cosmic origin. A radiation of somewhat longer wave length (probably 5990 Å) appears on both the Chesterfield and Saskatoon spectrograms during times of active aurora. It is subject to considerable enhancement of intensity during twilight and moonlight for reasons that are not certain.

The development of an auroral recorder was undertaken with the hope of getting a continuous quantitative measure of overhead auroral activity that could be compared with magnetic and ionospheric records. A unit is now in operation that makes use of a multiplier photo-tube. Such tubes are subject to a "fatigue" effect when exposed to a high flux density, making their use inadvisable during twilight and moonlight unless some means is provided for either reducing the flux incident on the cathode or reducing the dynode voltage with increasing flux. The former method was adopted. A neutral filter in the form of a wedge with a linear density scale, placed in front of the photo-tube, is moved by a servo-mechanism so that the incident flux on the cathode is kept substantially constant. A pen, attached to the filter, traces a record on a clock-driven chart. The transmission range of the wedge varies from 1 to 10^{-4} for a displacement of 20 cm, and the chart moves at a rate of 10 cm per hour.

Experience with the recorder shows that it can be run from shortly after sunset to shortly before sunrise, and during moonlight periods; that it gives precise times for the occurrences and durations of overhead auroras; and that it gives relative measures of a combination of auroral brightness and extent in the zenithal sky. Some of the objections to the recorder are the large, controlled power supply (1400 volts), the electronic units to actuate the servo-mechanism, and the decreased sensitivity to aurora coincident with bright moonlight. Attempts are underway to build a modified recorder that can be used in isolated regions.

A short paper, giving most of the established facts on aurora and outlining the current methods of investigation, was prepared and published in the September-October issue of the Journal of the Royal Astronomical Society of Canada. It is hoped that this may be of some value to the many individuals in Canada who are showing a renewed interest in auroral investigations.

Plans are underway to make single and double station photographs of aurora at Saskatoon.

Dr. W. Petrie's report on his investigations of auroral spectra is added to this report.

AURORAL STUDIES AT THE UNIVERSITY OF SASKATCHEWAN

By Dr. W. Petrie

1. A number of theoretical problems dealing with the spectrum of the aurora are being investigated. A study has been made of the relative intensities of a number of atomic oxygen lines which appear in the auroral spectrum, and it is shown how these intensities may be used to give information on the temperature of the earth's upper atmosphere. Two other problems are being studied; one the source of excitation of the hydrogen lines which occasionally appear in the spectrum, and the other deals with the excitation of oxygen atoms to the levels producing the forbidden lines.

2. A laboratory investigation of discharges through oxygen and nitrogen is in progress. The purpose of this work is to attempt to reproduce the faint atomic lines of these elements which appear in the auroral spectrum.

3. Optical parts are on order for the construction of a high light gathering power spectrograph.

Published paper: Excitation Conditions in the Upper Atmosphere as Determined from a Study of Atomic Emission Lines in the Auroral Spectrum. Can. Jour. Research 25, 293, 1947.

VISUAL AURORAL OBSERVATIONS IN CANADA, 1943-47

By Frank T. Davies

Hourly observations of occurrence, direction, and relative intensity of aurora have been made at six Canadian ionospheric stations for varying periods since 1943. Cloud and light conditions were noted when no aurora was seen. This allowed estimates to be made of auroral frequency on an hourly basis as the percentage ratio of hours of aurora to total hours when it was possible to see aurora. For comparison the number of nights on which aurora was seen is also tabulated. The latter are generally used as the basis for isochasms on published auroral charts. Data have been summarized on a seasonal basis of three months each. Summer includes May, June, July; fall includes August, September, and October; winter includes November, December, and January; and spring includes February, March, and April. The seasons are therefore centered on the solstices and equinoxes and are of nearly equal length.

The practice of associating the number of aurora seen from a station with the geographic latitude of the station, irrespective of the direction of aurora, has resulted in a great extension of the north and south limits of the auroral zone on published charts. Correlation of aurora with other geophysical data such as magnetic, earth current, or vertical incidence ionospheric measurements, is not very logical unless the auroral data apply to zenith above the station. For this reason, numbers of aurora, auroral frequency, and diurnal variation of aurora, must be considered in relation to the directional distribution of aurora at each station.

The conception of an effective auroral zone is used in this discussion to mean the area over which zenithal auroral frequency is 10 per cent or more, i.e., where aurora occurs overhead at least one hour in every ten dark hours. In southern Canada there are an average of ten hours per night dark enough to allow aurora being seen, so that the effective auroral zone is the area in which aurora extends to zenith on the average at least one hour per night. Other considerations have helped in determination of this limit, particularly studies of disturbance on trans-Atlantic short wave radio circuits, so that the choice of a 10 per cent zenithal frequency limit is not entirely arbitrary. It is considered by the writer to be as reasonable a definition as can be made until a great deal more is known about auroral zone phenomena.

The comprehensive study of northern hemisphere aurora and magnetic disturbance by E. H. Vestine, was necessarily based on available auroral observations which were mainly non-directional occurrence reports on a whole night basis. The series of observations at Canadian ionosphere stations, because they were made uniformly and stressed directional data on an hourly basis, give more detailed information on the seasonal and sunspot cycle variations of position of the auroral zone in Canada.

Table 1 gives the geographic, geomagnetic, and time data for observation stations, including the times of diurnal maxima of aurora. Tables 2 to 10 give summaries of seasonal data on number, frequency, direction, and diurnal variation of aurora seen from each station. Relative intensity estimates have not been included because they are eye estimates by many different observers and are less significant in an inter-station comparison than the other data which are simpler to define.

A summary of the auroral observations made by B. W. Currie and F. T. Davies at the Canadian Polar Year Station at Chesterfield, N.W.T., during the winter of 1932-33, has been included. This is of special interest because 1932-33 was the sunspot minimum previous to that of 1944, for which Churchill and Ottawa observations are available.

Evening auroral observations at Saskatoon in 1943-44, made by B. W. Currie, are summarized in Table 10. These observations are very interesting because of the location of Saskatoon north of Ottawa and south of Churchill, and because observations of aurora are available for the three stations at sunspot minimum.

Reference has also been made in the discussion to auroral observations made during the Polar Year 1932-33 at Fort Rae, North West Canada, and at Point Barrow, Alaska. Magnetic and auroral data of the latter station were analyzed by the writer at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The observations of 1943-47 at Churchill and Ottawa are of particular interest because of the location of these stations at the center and southern limit of the effective auroral zone, and because the period of observations included sunspot minimum (1944) and the highest six month period of sunspot numbers (1947) in nearly two centuries of recorded observations. Geophysical phenomena related to solar activity may not occur again in this century as intensively as in 1947.

Discussion of Data

Churchill. Numbers of aurora, frequency, and number of nights of aurora, decreased progressively from minimum to maximum of the sunspot cycle. The decrease is very marked in the summer, fall, and winter of 1947. Auroral frequency was 25 per cent during these three seasons of 1947 compared with 57 per cent for the year 1943-44 (sunspot minimum). The relative decrease from sunspot minimum to sunspot maximum was therefore more than 50 per cent. Occurrence of aurora by all three estimates, was highest in the spring of 1944, exactly at sunspot minimum.

Thirty-seven hundred hours of aurora were recorded on 835 nights in the four and a half years of observation. Fifty per cent hourly auroral frequency is thus equivalent to an average of 186 nights per year when aurora was seen. The greatest number of nights in any one year when aurora was seen was 213 in 1943-44.

The proportion of zenithal aurora decreased, and of south sky aurora increased progressively from spring 1944 to sunspot maximum. The proportion of north sky aurora remained substantially the same during 1944-47, but was smaller in 1943-44. North sky aurora was nearly twice as frequent as south sky aurora for the whole period of observation. During the spring, summer, and fall of 1947 (coinciding with the highest sunspot numbers) south sky aurora were twice as frequent as north sky aurora.

The data on diurnal variation in direction of aurora at Churchill has been analyzed for 1943-44 only. During this year there was a slight shift of the center of the zone northward in morning hours compared with the evening and middle of the night. This may explain the fact that some residents of Churchill considered that aurora was more frequent to the south during 1947-48 than the complete data indicated, because the ordinary observer naturally bases his views on evening hours. Few people observe between midnight and morning unless it is a part of their duty to do so.

The directional data indicate that Churchill is near the average maximum of occurrence of aurora but is south of the average position of the center of the zone. A southward shift of the center of the zone occurs between sunspot minimum and sunspot maximum. All seasons show this although the zone center has also a definite seasonal displacement each year.

Winter was consistently the season of furthest north position of the center of the zone. Even in the winter of 1947-48 the zone center was north of Churchill. The center of the zone is furthest south in each year in summer and appears to be always south of Churchill in this season. The fall and spring positions of the center of the zone are intermediate between winter and summer positions. On the average the zone center for spring and fall was north of Churchill but was south of Churchill in the spring and fall of 1947.

It is clear that, although the seasonal position of the center of the auroral zone may be north or south of Churchill, this station is located near the average center of the zone and therefore the auroral frequency at Churchill may be taken as an average for a broad band at the center of the zone, i.e., in this central band aurora occurs overhead at some point during 50 per cent of the dark hours. The effective auroral zone therefore, defined as including all points at which zenithal frequency is 10 per cent or greater, is also that area in which zenithal aurora is at least one fifth as frequent as the average across this central band of the auroral zone. Actually at any single point in this central band zenithal frequency is about 30 per cent so a site at the limit of the effective zone has a zenithal frequency of one third of that at a site near zone maximum.

The field of view at the Churchill site was slightly obstructed by nearby rocky ridges so that aurora in all directions below 2° elevation would be missed.

<u>Ottawa</u>. Number of aurora, frequency, and number of nights of aurora increase progressively from sunspot minimum to maximum. Average hourly frequency was 11 per cent and the proportion of zenithal aurora was 19 per cent, i.e., zenithal hourly frequency averaged two per cent over the four and a half years of observations. Ottawa is therefore south of the average southern limit of the effective auroral zone.

Frequency and directional data show that the average southern limit must have been distant from Ottawa during 1943-45, and was closer to Ottawa in 1945-46 than in any other year. The limit was furthest south during three equinoctial seasons; spring 1946, fall 1946, and fall 1947. The proportion of zenithal aurora during these three seasons was 44 per cent, 44 per cent, and 19 per cent, respectively. The corresponding hourly frequencies were 20 per cent, 16 per cent, and 50 per cent. Thus the zenithal frequencies were 9 per cent in spring 1946, 7 per cent in fall 1946, and 9.5 per cent in fall of 1947. These three periods mark the most southerly positions of the limit of the effective auroral zone during 1943-47. The limit in these seasons was very close to Ottawa. It is estimated that the extreme southerly limit occurred in spring 1946 and fall 1947--high sunspot periods and also equinoctial periods--and was very near latitude 46° N in 75° W longitude. The corresponding geomagnetic latitude was 57° N.

The average proportion of zenithal plus south aurora at Ottawa was 20 per cent and the seasonal averages were: fall 23 per cent, spring 22 per cent, summer 13 per cent, and winter 7 per cent. Winter showed the lowest auroral frequency, 3 per cent, and fall the highest, 16 per cent. Spring and summer auroral frequency was 13 per cent. These figures indicate that the zone limit in the fall was slightly more active and slightly further south than in spring. Summer limit was further north and frequency was similar to that of spring. Winter limit was considerably further north, probably several hundred miles, judging by the few aurora seen.

The average diurnal maximum of occurrence of aurora seen from Ottawa was 0.7 hour after local midnight. Some indication of seasonal variation in time of maxima exists. Summer and winter maxima are nearer local midnight; fall maximum an hour after local midnight; and spring maximum an hour before local midnight. This adds to the previous evidence that auroral characteristics at the southern limit of the effective zone are slightly different in the two equinoctial seasons.

The observation site, five miles north of Ottawa, has a fairly clear view, obstructed slightly to the north by low hills, and to the south by the light of the city.

Comparison of Data at Four Southern Stations

The data for 1945-47 at St. Johns, Portage la Prairie, and Prince Rupert show that number of aurora, frequency, and number of nights of aurora, increase toward sunspot maximum, as was the case at Ottawa. Comparison of 1945-47 data at these four stations allows of an estimate being made for St. Johns, Portage, and Prince Rupert, through the period 1943-47.

1945-47	Auroral frequency o/o	Proportion zenith frequency o/o	Zenithal frequency o/o
St. Johns	19	4	1
Ottawa	17	22	4
Portage	28	26	7
Pr. Rupert	15	6	1

(Estimated) 1943-47	Auroral freq. o/o	Proportion zen. aurora o/o	Zenithal freq. o/o	Geomag. lat.	Geographic lat.
St. Johns	12	3	1/2	58.7° N	47.6° N
Ottawa	11	19	2	56.5	45.5
Portage	18	22	4	59.4	49.9
Pr. Rupert	10	5	1/2	58.6	54.3

All four southern stations are therefore south of the average southern limit of the effective auroral zone but Portage is the nearest to this limit and the coast stations furthest away. Ottawa data showed that the southern limit was furthest south in spring and fall of 1946 and fall 1947.

At St. Johns it was furthest south in spring of 1946, fall of 1945, and fall of 1947 but in no case was zenithal frequency as high as at Ottawa. The southern limit of the effective auroral zone was therefore north of St. Johns at all seasons. At this site the view was unobstructed.

At Prince Rupert the zone limit was furthest north in winter but at no season did zenithal frequency reach as high values as at Ottawa. Prince Rupert appears to be further away from the auroral zone than St. Johns which is at the same geomagnetic latitude. This difference is probably due to obstruction of the view at Prince Rupert by mountains to the north and east.

At Portage la Prairie the auroral zone is further north in winter than in other seasons. Data is available only for a period of very high sunspot numbers so the southern limit of the effective auroral zone at this period must be considered as the extreme southern position in the sunspot cycle. Zenithal frequency at Portage was 4 per cent in the summer of 1946 and 9 per cent in fall 1946. In spring, summer, and fall of 1947, zenithal frequency was 10, 11, and 17 per cent, respectively. Portage was therefore within the effective auroral zone from spring to fall 1947 (exactly coinciding with the highest sunspot numbers of the cycle). Comparison with Ottawa 1943-47 data indicates that this high sunspot period of 1947 was the only time when Portage zenithal frequency was above 10 per cent, although the southern limit was very close to Portage in the fall of 1946 also. The zone appears to be further south in fall than in spring though the difference is slight. The view at this station is completely unobstructed, the terrain being flat.

Aurora North of the Maximum Auroral Zone

At Clyde the numbers of aurora, frequency, and number of nights of aurora, decrease progressively from 1945 to 1947. This trend is similar to that at the center of the auroral zone and indicates a decrease in auroral activity in the northern half of the auroral zone from sunspot minimum to sunspot maximum. This is opposite to the trend in the southern half of the auroral zone.

Hourly frequency during 1945-47 at Clyde averaged 10 per cent and the proportion of aurora at zenith was estimated as 43 per cent. The zenithal frequency is therefore about four per cent so that Clyde is north of the northern limit of the effective auroral zone at sunspot maximum. Very low aurora to the south would be missed at this station because of obstruction of the view by mountains. The auroral frequency at Clyde might therefore be higher than the data indicate.

No summer observations are possible at this station because of daylight. The data for winter and spring show a surprisingly large proportion of aurora either at zenith or north of Clyde, yet observers' impressions were consistently that aurora occurred mainly in the south. It is possible that the relatively large proportion of aurora at zenith or north is due to Clyde being far enough north of the normal auroral zone to see only the very widely spread aurora associated with geomagnetic storms. It would be interesting to learn of the N-S distribution of aurora at low latitude stations. Perhaps low frequency of occurrence would also be associated in low latitudes with a relatively high proportion of zenithal aurora.

Chesterfield Auroral Observations, 1932-33

Hourly observations of aurora at Chesterfield on 51 clear winter nights of 1932-33 showed that:

1. Auroral frequency on an hourly basis was 56 per cent, i.e., ratio of hours of aurora to total number of hours that were both clear and dark (356/630).

2. The ratio of number of nights aurora was seen to total number of clear dark nights, was 92 per cent (47/51).

3. During the period analyzed, 9 October 1932 to 28 March 1933, there were 171 nights yet only 51 were clear enough to give the opportunity of observing throughout the night. Any results of analysis of visual observations of aurora must therefore be considered in relation to the amount of data available. For this reason the writer considers auroral frequency on an hourly basis to be a more reliable estimate of auroral activity than that estimated on a night basis. The former requires hourly data on whether light and cloud conditions permit of aurora being seen.

4. Diurnal occurrence of aurora was a maximum at slightly less than an hour after midnight. There was a slight indication of a secondary maximum at 06 hours.

5. Directional data were not analyzed in detail. Aurora occurred in all directions but were preponderantly in the south, i.e., Chesterfield was north of the maximum of the auroral zone.

6. The period 1932-33 was at a minimum of the sunspot cycle and this data is therefore useful for comparison with Churchill and Ottawa data for 1943-44, the next sunspot minimum.

7. Parallactic height measurements showed that the most frequent base level of aurora was at 105 km height but that the mean value of the base level of all types of aurora was 116 km, i.e., the bases of most aurora lie in the E-region of the ionosphere.

8. Direction of most arcs and bands averaged 98° E of N. The majority of aurora photographed were overhead between 60° and 65° N (geographic latitude) and between 80° and 95° W longitude.

9. Auroral frequency estimates at Chesterfield represent the values for zenithal aurora at approximately 61 - 62° N latitude and 91° W longitude.

10. A clear view in all directions was possible at this station.

Auroral Observations at Fort Rae, N.W.T., 1932-33

Auroral distribution at Fort Rae in 1932-33 indicated that the site was very close to the maximum of the auroral zone. High frequency of occurrence at this time was considered as evidence that auroral frequency did not change much through the sunspot cycle at the center of the zone. The longer series of observations at Churchill show that high auroral frequency is to be expected at sunspot minimum at the maximum of the zone. Fort Rae is at very nearly the same geomagnetic latitude as Churchill but is 4° of geographic latitude further north. Data at sunspot minimum from Fort Rae are consistent with the Churchill results that center of the zone is near 70° N geomagnetic latitude between 94° W and 116° W longitude.

Auroral Observations at Point Barrow, Alaska, 1932-33

Aurora seen at this site were mainly northeast. Point Barrow, Fort Rae, and Churchill are at very nearly the same geomagnetic latitude. The fact that aurora was mainly northeast from Point Barrow indicates that the center of the auroral zone in Alaska is further north in geomagnetic as well as in geographic latitude than it is in Canada.

Saskatoon Auroral Observations, 1943-44

Evening observations of aurora by B. W. Currie at Saskatoon during the period August 1943 to December 1944 give a basis for determining auroral frequency at this station at sunspot minimum. Auroral frequency, on an evening basis was 28 per cent. Aurora occurred on 72 evenings in the year August 1943 to July 1944. During the same period there were 213 nights of aurora at Churchill and only 24 at Ottawa. Since Saskatoon observations were for evenings only, it is reasonable to assume that the number of whole nights when aurora occurred at this station is greater than 72. The numbers 213 at Churchill, 72 at Saskatoon, and 24 at Ottawa therefore give a conservative estimate of the occurrence of aurora at Saskatoon. Aurora is at least three times as frequent at Saskatoon as at Ottawa at sunspot minimum and over one-third as frequent as at Churchill.

The hourly frequencies at Ottawa and Churchill in 1943-44 were 3 per cent and 57 per cent, respectively. Applying to these the ratios obtained above for Saskatoon with respect to Ottawa and Churchill for nights of aurora, it seems probable that hourly auroral frequency at Saskatoon in 1943-44 was between 9 per cent and 19 per cent. There are thus three estimates of auroral frequency at Saskatoon which have some value, viz., 28, 19, and 9 per cent.

Directional data on aurora is not available to allow of determination of zenithal frequency at Saskatoon. Since the geomagnetic latitude is 60.9° N and hourly auroral frequency at sunspot minimum is probably 20 per cent, it seems likely that Saskatoon is within the average southern limit of the effective auroral zone. This limit in Manitoba and Ontario is near 60° N geomagnetic latitude. Saskatoon data is consistent with a position of the average southern limit of the effective auroral zone in Central Saskatchewan at 60° N geomagnetic latitude and at 51° N geographic latitude.

The view at Saskatoon site is clear except for some obstruction in the southwest due to city light.

Diurnal Occurrence of Aurora Across the Auroral Zone

Diurnal occurrence at Ottawa at sunspot minimum was noticeably greater in evening hours than morning hours. The diurnal average maximum for Ottawa is unduly influenced by the very large number of aurora observed in fall. This causes the average time of maximum to be near that for fall.

Diurnal maximum of auroral frequency at Churchill was 0.7 hour earlier than that for numbers of aurora. Auroral activity at this station in the center of the zone is therefore a maximum about one hour before local midnight. A comparison of seasonal diurnal occurrence of aurora at sunspot minimum and maximum showed that for winter, spring, and summer, the difference was only in greater numbers of aurora at sunspot minimum. Fall data showed this and also a marked difference in the morning hours. At sunspot minimum there were proportionately far more aurora at 05 and 06 hours in the fall than at sunspot maximum. It is this effect which gives the secondary maximum at +5.7 hours in the average fall data at Churchill. The two more northerly stations, Clyde and Chesterfield, show an increase in numbers of aurora during winter at about six hours after local midnight. No southern station shows increased aurora in the morning, but this may be explained by the shorter night period for observation at the southern station.

At Churchill and Ottawa the values are averages of four and a half years and are more conclusive than data for shorter periods. These show that auroral activity reaches a maximum about one hour before local midnight at the center of the auroral zone and about half an hour after local midnight at the southern limit of the effective auroral zone. The time of diurnal maximum of aurora appears to be progressively later with respect to local midnight as distance increases either south or north from the center of the zone.

Toward the northern limit of the effective auroral zone, diurnal maxima appear to occur in the morning and evening hours. Auroral observations during 1929 at Little America, Antarctica, situated south of the maximum zone of Aurora Australis, showed maxima at three hours after and six hours before midnight. Clyde data are few but the indicated maxima in morning and evening are probably real.

Summary of Auroral Observations

Annual Frequency: Aurora were much more frequent in southern Canada at sunspot maximum than at sunspot minimum. At the center and north of the auroral zone aurora decreased from minimum to maximum of the sunspot cycle.

Seasonal Frequency: The equinoctial months showed highest frequency of aurora. In southern Canada winter is the season of lowest auroral frequency whereas at the center and north of the auroral zone summer has lowest frequency. This is considered a real effect even though daylight prevents summer observation at high latitude stations.

Annual Position of Center of Auroral Zone: During minimum to maximum of the sunspot cycle the average position of the center of the zone in Central Canada was near 70° N geomagnetic latitude. At both coasts the mean position is further north in geomagnetic latitude. In geographic latitude it is much further north on the Pacific coast. The mean annual position of the center was further south at the sunspot maximum of 1947 than in other years. During 1947 the center was well south of 69° geomagnetic latitude in spring, summer, and fall, though the winter position was still slightly north of 69° N.

Seasonal Position of Center of Auroral Zone: This is furthest north in winter and furthest south in summer. Fall position is slightly further south than spring position. During most years the spring and fall positions are very close to 69° N geomagnetic latitude, the winter position is north of 70° N magnetic latitude and the summer position south of 69° N geomagnetic latitude. The difference between winter and summer positions appears to be at least 5° of latitude.

Southern Limit of Effective Auroral Zone: The average southern limit from Central Saskatchewan to Western Quebec is near geomagnetic latitude 60° N and is furthest south in geographic latitude 49° N in Eastern Ontario. In equinoctial months near sunspot maximum the southern limit extends south to near 57° N geomagnetic latitude or 47° N geographic latitude in Eastern Ontario.

The southern limit at Atlantic and Pacific coasts is north of geomagnetic latitude 60° N at all times, and is much further north, geographically, in British Columbia than elsewhere in Canada. The southern limit appears to be relatively further south in central Canada compared with the east and west coasts than is the case with the center of the zone. It is possible that the contrast between continental high average barometric pressure and the low average pressure over the oceanic areas to the NW and NE may have some relation to this.

Seasonal variation of the southern limit is similar to that observed at zone center, i.e., it is further north in winter than in summer. Spring and fall limits, due to the zone being wider in equinoctial months are, particularly at sunspot maximum, south of the summer limit. The fall limit appears to be slightly south of the spring limit as at the center of the zone.

The southern limit is at least 3° further south at sunspot maximum than at sunspot minimum.

Northern Limit of Effective Auroral Zone: Less data are available about the polar side of the auroral zone. At sunspot maximum the northern limit of the effective zone is south of geomagnetic latitude 80° N but at sunspot minimum it is well north of geomagnetic latitude 73° N. It appears to move south from sunspot minimum to sunspot maximum as do also the center and southern limits. It is estimated that the northern limit of the effective zone is not further north than 80° N of geomagnetic latitude on the average. A seasonal shift of the northern limit is indicated. It is further north in winter than in summer and apparently further north in spring than in fall.

Width of Effective Auroral Zone: The average width of the effective auroral zone in Canada is about 1300 miles. It is wider than this during equinoctial months. The average position of the zone is between 60° and 80° N geomagnetic latitude from 65° to 115° W longitude. East and west of these limits the zone is slightly further north in geomagnetic latitude. During equinoctial months of high sunspot years the southern limit is some two hundred miles south of the average position. The northern limit is also further south at sunspot maximum so the average width of the zone does not appear to change very much.

Unique Conditions of 1947: During May to October 1947, over twice as many aurora were seen at Ottawa as at Churchill. The proportion was reversed in all other years. Churchill aurora were three to four times as many as at Ottawa during the spring of 1947 and winter of 1947-48 immediately before and after the exceptional six month period referred to.

The fields of view of aurora from Churchill and Ottawa, which are 880 miles apart in latitude, both cover the mid-latitude at 52.2° N geographic latitude. Thus for six months of 1947 there were more aurora south than north of 52° N.

The fall of 1947 was the period of furthest south extension of the effective auroral zone but its southern limit did not extend south of 46° N. The picture presented is that of an additional narrow belt of aurora between 46° and 52° N superimposed on the normal auroral zone near its effective southern limit. The effective zone during this period still extended northward to beyond Churchill at

59° N. During the summer and fall of 1947, it is difficult to determine a center of the zone as there appears to be two zones, one in the normal position, and the other a belt of more intense aurora some four hundred miles further south than the average center for summer and fall.

The period during which the unique conditions occurred coincided with the highest relative sunspot numbers in nearly two centuries. The daily average increased greatly in May 1947, stayed at an average value of 186 through the six month period to October 1947, and decreased rapidly afterwards.

In October 1947 the highest ionization densities of the F2 layer of the ionosphere ever recorded in Canada occurred at all stations. A very marked decrease has been observed since. Higher F2 densities occurred in Canada in October than at some American stations much further south. This also is an unique occurrence.

It is hoped that the ionospheric, magnetic, and auroral observations to be made on a mobile observatory of the Radio Propagation Laboratory in the southern half of the auroral zone, will extend knowledge of the phenomena of this zone. Operation of the mobile observatory will begin during the summer of 1948.

References

1. Canadian Polar Year Expeditions 1932-33, Vol. II, 1939. Terrestrial Magnetism, Earth-Currents, Aurora Borealis, at Chesterfield, Meanook, and Saskatoon. B. W. Currie, F. T. Davies, E. H. Vestine, T. Alty.

2. The Geographic Incidence of Aurora and Magnetic Disturbance, Northern Hemisphere. E. H. Vestine. Journ. Terr. Mag., June, 1944.

3. Aurora at Churchill, 1943-44. F. T. Davies, Report of Canadian Radio Wave Propagation Committee, 1945.

4. Some General Characteristics of Aurora at Fort Rae, N.W. Canada, 1932-33. J. M. Stagg, London, British National Committee for the Polar Year, 1932-33 (1935).

5. Auroral Observations at Point Barrow, Alaska, 1932-33. C. J. McGregor, Sixteenth Annual Meeting of American Geophysical Union, April 1945.

6. The Diurnal Variation in Magnetic and Auroral Activity at Three High-Latitude Stations. F. T. Davies, Journ. Terr. Mag., June, 1935.

7. Observations of Aurora Australis, Byrd Antarctic Expedition, 1929. F. T. Davies, Journ. Terr. Mag., September, 1931.

Table 1a--Coordinates of stations

Station	Period of obser.	Geographic			Geomagnetic			Total force
		Lat. N	Long. W	Time used W	Lat. N	Long. E	Incli-nation N	Gauss
Churchill, Man.	Aug. 1943	58.8°	94.2°	90.0°	68.8°	323.0°	85.0°	0.61
Ottawa, Ont.	Aug. 1943	45.5	75.8	75.0	56.5	351.0	74.0	0.57
St. Johns, Nfld.	May 1945	47.6	52.7	52.5	58.7	21.0	74.0	0.54
Prince Rupert, B.C.	June 1945	54.3	130.3	120.0	58.6	283.0	73.0	0.57
Portage la Prairie, Man.	June 1946	49.9	98.3	90.0	59.4	322.0	76.0	0.59
Clyde, Baffin Is.	Oct. 1945	70.5	68.6	75.0	81.5	1.0	85.0	0.60
Chesterfield, NWT.	Oct. 1932-Mar. 1933	63.3	90.7	90.0	73.3	325.0	86.0	0.61
Saskatoon, Sask.	Aug. 1943-Dec. 1944	52.2	106.6	105.0	60.9	310.0	77.0	0.60

Table 1b--Time data of Canadian stations

Station	Position in auroral zone	Diurnal max. of aurora	Mean local midnight	Magnetic midnight	Difference	Difference
		(1)	(2)	(3)	(1)-(2)	(1)-(3)
Churchill, Man.	center	2345	0017	0228	-0.5	-2.7
Ottawa, Ont.	south	0045	0003	0036	+0.7	+0.2
St. Johns, Nfld.	south	0000	0001	2236	0.0	+1.4
Prince Rupert, B.C.	south	0200	0041	0508	+1.3	-3.1
Portage la Prairie, Man.	south	0100	0033	0232	+0.5	-1.5
Clyde, Baffin Is.	north	0600	2334	2356	+6.4	+6.1
Chesterfield, NWT.	north	0045	0003	0220	+0.7	-1.6
Saskatoon, Sask.	south		0006	0352		

Table 2 Churchill and Ottawa

Churchill	1943-44		1944-45		1945-46		1946-47		1947-48		1943-48	
	a		b		a		b		a		b	
Fall	203	64	216	60	104	54	130	58	111	37	764	55
Winter	373	51	380	55	355	49	329	49	120	19	1557	45
Spring	408	65	294	54	305	55	234	50			1241	57
Summer	52	39	33	36	33	31	17	24			135	38
Year	1036	57	923	55	797	50	710	49	231	25	3697	50
Ottawa												
Fall	26	6	11	2	38	8	90	16	198	50	363	16
Winter	3	1	12	3	4	1	7	2	35	13	61	3
Spring	13	3	60	13	89	20	75	17			237	13
Summer	1	1	30	11	34	10	86	46			151	14
Year	43	3	113	7	165	10	258	16	233	34	812	11
Churchill Sum Ottawa	1079		1036		962		968		464		4509	
Ottawa Ratio o/o Churchill	4	5	12	13	21	20	36	33	101	136	22	22

a = Hours of aurora; b = auroral frequency o/o

Table 3 Churchill and Ottawa: number nights aurora seen

Churchill	1943-44	1944-45	1945-46	1946-47	1947-48	1943-48
Fall	51	55	36	39	39	220
Winter	64	69	65	55	34	287
Spring	70	59	65	58		252
Summer	28	19	20	9		76
Year	213	202	186	161	73	835
Ottawa						
Fall	13	8	13	24	44	102
Winter	3	2	2	4	12	23
Spring	7	15	16	16		54
Summer	1	11	14	30		56
Year	24	36	45	74	56	235
Churchill Sum Ottawa	237	238	231	235	129	1070
Ottawa Ratio o/o Churchill	11	18	24	46	77	28

Table 4 Churchill and Ottawa: direction of aurora

Churchill	1943-44			1944-45			1945-46			1946-47			1947-48			1943-48		
Season	N	Z	S	N	Z	S	N	Z	S	N	Z	S	N	Z	S	N	Z	S
Fall	38	136	29	28	155	33	32	54	18	26	83	21	11	74	26	135	502	127
Winter	91	250	32	138	214	28	123	197	35	131	156	42	55	28	37	538	845	174
Spring	78	265	65	83	180	31	75	186	44	39	124	71				275	755	211
Summer	5	21	26	8	15	10	8	17	8	0	14	3				21	67	47
Year	212	672	152	257	564	102	238	454	105	196	377	137	(66)	(102)	(63)	969	2169	559
Year o/o	20	65	15	28	61	11	30	57	13	28	53	19	29	44	27	26	59	15
Ottawa																		
Fall	22	4	0	9	2	0	38	0	0	50	40	0	160	38	0	279	84	0
Winter	3	0	0	12	0	0	4	0	0	7	0	0	31	4	0	57	4	0
Spring	13	0	0	57	3	0	47	39	3	68	6	1				185	48	4
Summer	1	0	0	28	1	1	25	9	0	78	8	0				132	18	1
Year	39	4	0	106	6	1	114	48	3	203	54	1	(191)	(42)	0	653	154	5
Year o/o	91	9	0	94	5	1	69	29	2	79	21	0	82	18	0	80	19	1

Table 5 Churchill and Ottawa: diurnal occurrence of aurora

Churchill	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	Total
5 falls			9	22	43	71	98	112	122	105	85	57	23	12	2			761
5 winters	1	18	68	86	89	113	132	149	167	150	132	109	91	95	97	60	1	1558
4 springs			5	31	75	114	161	171	168	145	125	96	73	49	26	1		1240
4 summers							9	39	46	33	6							133
1943-48	1	18	82	139	207	298	400	471	503	433	348	262	187	156	125	61		3692
Ottawa																		
5 falls			1	6	21	33	45	41	45	53	46	39	26	7				363
5 winters			1	3	6	8	5	4	10	8	8	5	2	1				61
4 springs				4	14	17	28	31	30	27	27	28	21	8	1	1		237
4 summers					2	8	18	26	33	32	26	6						151
1943-48			2	13	43	66	96	102	118	120	107	78	49	16	1	1		812
Ratio o/o Ottawa Churchill	0	0	2	9	21	22	24	22	23	28	31	30	26	10	1	2	0	

Table 6 St. John's, Newfoundland

Season	1945-46			1946-47			1947-48			1945-48		
	a	b	c	a	b	c	a	b	c	a	b	c
Summer	36	34	11	17	9	7	26	16	9	79	17	27
Fall	28	12	7	40	34	11	100	33	27	168	26	45
Winter	35	17	8	*10	15	2	14	7	5	59	13	15
Spring	*20	23	6	*16	11	6				36	16	12
Year	119	19	32	83	16	26	140	21	41	342	19	99

a = hours of aurora; b = auroral frequency o/o; c = nights aurora seen; * = one month missing in this season

Direction of aurora

Season	1945-46			1946-47			1947-48			1945-48			o/o Z or S
	N	Z	S	N	Z	S	N	Z	S	N	Z	S	
Summer	36	0	0	15	2	0	26	0	0	77	2	0	2
Fall	20	2	6	38	2	0	93	7	0	151	11	6	10
Winter	35	0	0	10	0	0	13	1	0	58	1	0	2
Spring	13	1	6	16	0	0				29	1	6	19
Year	104	3	12	79	4	0	132	8	0	315	15	12	8
o/o Z	3			5			6			4.4			

Diurnal occurrence of aurora

Season	18	19	20	21	22	23	00	01	02	03	04	05	06
3 summers				9	11	14	17	15	9	4			
3 falls		2	5	13	23	24	25	21	25	21	8	1	
3 winters	1	2	4	7	8	6	7	7	6	5	3	2	1
2 springs		1	0	2	5	5	6	6	6	4	1		
Whole period	1	5	9	31	47	49	55	49	46	34	12	3	1

Table 7 Prince Rupert

Season	1945-46			1946-47			1947-48			1945-48		
	a	b	c	a	b	c	a	b	c	a	b	c
Summer	6	13	3	20	26	7	12	14	6	38	18	16
Fall	18	6	6	31	15	5	58	50	15	107	17	26
Winter	3	1	2	62	22	16	23	12	9	88	10	27
Spring	16	10	7	61	24	21				77	19	28
Year	43	5	18	174	21	49	93	24	30	310	15	97

a = hours of aurora; b = auroral frequency o/o; c = nights aurora seen

Direction of aurora

Season	1945-46			1946-47			1947-48			1945-48			o/o Z or S
	N	Z	S	N	Z	S	N	Z	S	N	Z	S	
Summer	6	0	0	16	3	1	9	2	1	31	5	2	18
Fall	17	1	0	29	2	0	54	3	1	100	6	1	7
Winter	3	0	0	62	0	0	23	0	0	88	0	0	0
Spring	16	0	0	54	7	0				70	7	0	9
Year	42	1	0	161	12	1	86	5	2	289	18	3	7
o/o Z	2			7			5			6			

Diurnal occurrence of aurora

Season	19	20	21	22	23	00	01	02	03	04	05	06	07
3 summers				2	7	10	9	9	1				
3 falls		2	6	12	12	13	14	18	13	10	7		
3 winters	2	2	2	4	5	8	9	8	13	12	11	11	1
2 springs		3	3	4	6	9	11	13	15	10	3		
Whole period	2	7	11	22	30	40	43	48	42	32	21	11	1

Table 8 Portage la Prairie

Season	1946-47			1947-48			1946-48		
	a	b	c	a	b	c	a	b	c
Summer	*75	39	*26	111	36	37	186	37	63
Fall	150	30	38	234	49	48	384	40	86
Winter	91	15	25	75	12	21	166	14	46
Spring	163	31	31				163	31	31
Year	479	27	120	420	30	106	899	28	226

a = hours of aurora; b = auroral frequency o/o; c = nights aurora seen; * = one month missing

Direction of aurora

Season	1946-47			1947-48			1946-48			o/o Z or S
	N	Z	S	N	Z	S	N	Z	S	
Summer	*62	8	*5	76	34	1	138	42	6	26
Fall	106	43	1	152	80	2	258	123	3	33
Winter	81	10	0	70	5	0	151	15	0	9
Spring	111	51	1				111	51	1	32
Year	360	112	7	298	119	3	658	231	10	27
o/o Z	23			28			26			

Diurnal occurrence of aurora

Season	18	19	20	21	22	23	00	01	02	03	04	05	06	07
2 summers					5	25	49	46	41	20				
2 falls		5	9	17	28	44	55	61	57	48	41	19		
2 winters	1	2	4	6	5	9	18	21	22	24	23	18	10	3
1 spring			6	8	13	16	21	22	23	24	17	11	2	
Whole period	1	7	19	31	51	94	143	150	143	116	81	48	12	3

Table 9 <u>Clyde, Baffin Island</u>

Season	1945-46			1946-47			1947-48			1945-48		
	a	b	c	a	b	c	a	b	c	a	b	c
Fall	*12	20	*4	13	8	8	6	3	7	31	8	19
Winter	91	10	23	54	14	26	5	1	5	150	7	54
Spring	120	23	32	12	4	5				132	16	37
Summer	0	0	0	0	0	0				0	0	0
Year	223	14	59	79	8	39	11	2	12	313	10	110

a = hours of aurora; b = auroral frequency o/o; c = nights aurora seen; * = two months missing

<u>Direction of aurora</u>

Season	1945-46			1946-47			1947-48			1945-48		o/o N+Z
	N+Z	S	N	Z	S	N	Z	S	Z	N+Z	S	
Fall	0	12	0	6	7	1	3	2		10	21	32
Winter	70	21	3	20	31	0	5	0		98	52	65
Spring	85	35	7	5	0					97	35	74
Summer	0	0	0	0	0					0	0	0
Year	155	68	10	31	38	1	8	2		205	108	65
o/o Z				39			73		43			

<u>Diurnal occurrence of aurora</u>

Season	18	19	20	21	22	23	00	01	02	03	04	05	06	07
Equinox (4)	0	1	2	3	3	2	2	2	1	1	1	0	0	0
Winter (4)	2	5	1	1	0	1	3	2	2	3	3	5	9	3
8 months (8)	2	6	3	4	3	3	5	4	3	4	4	5	9	3

Table 10--Occurrence of evening aurora at Saskatoon, 1943-44

Season	Number evenings of aurora	Number clear evenings with no aurora	Total possible	Auroral frequency
				o/o
Fall 1943	27	40	67	40
Winter	19	38	57	33
Spring	18	39	57	32
Summer	8	62	70	11
Fall	24	48	72	33
Winter	3	22	25	12
17 months	99	249	348	28

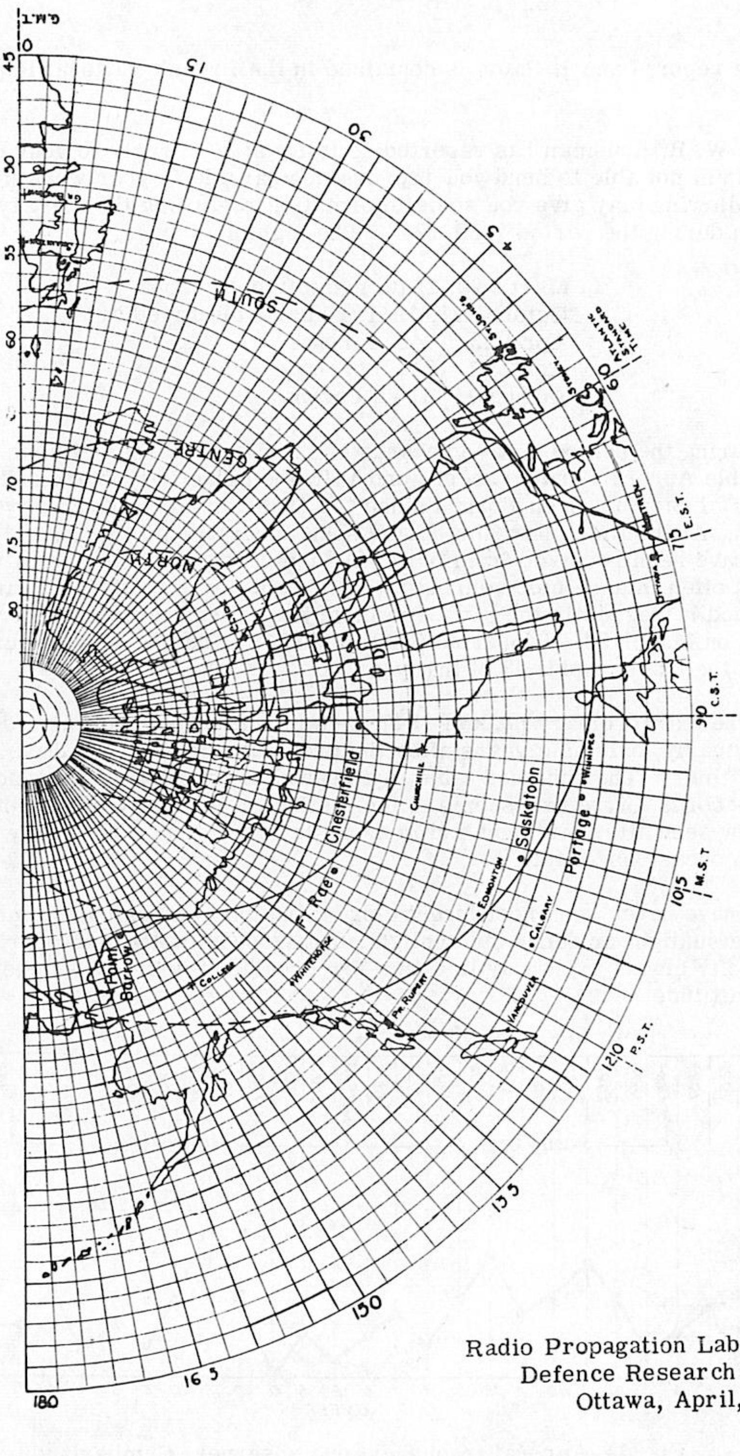
Table 11--Time of seasonal maxima in diurnal occurrence of aurora

(expressed in hours referred to local midnight at each station; + means after midnight, - means before midnight)

Station	Spring	Summer	Fall	Winter	Mean	Geomagnetic lat.
Clyde				+6.4		81.5°N
Chesterfield				-4.6 +0.7	+0.7	73.3
Churchill	-1.3	-0.3	-0.3	+6.0 -0.3	-0.5	68.8
Portage la Prairie	+2.5	-0.5	+5.7 +0.5	+2.5	+0.5	59.4
Ottawa	-1.0	+0.3	+1.0	0.0	+0.7	56.5
St. John's	+3.0 +1.0	0.0	0.0	-2.0	0.0	58.7
Prince Rupert	+2.0	-0.7	+2.0 +1.3	+2.5	+1.3	58.6

Stations are listed in order of their positions with respect to center of the auroral zone as determined from frequency of aurora at each station. This order agrees with change in geomagnetic latitude except in the case of Ottawa, and with time of maximum except in the case of St. John's.

AVERAGE LIMITS OF THE EFFECTIVE AURORAL ZONE IN CANADA



Radio Propagation Laboratory,
Defence Research Board,
Ottawa, April, 1948.

Great Britain

The report from J. Paton is contained in the British National Report, pp. 132 – 133.

Dr. W. B. Housman has reported as follows: "In reply to your postcard of June 29, I am not able to send you anything comparable to your work in Norway, but the following may give you some information regarding the activity of aurora in Britain during the period 1939-1947. The highlights were:

March 24, 1940, magnificent corona
October 31, 1941, remarkable rayed arc
April 23, 1946, corona
April 17, 1947, corona
August 16, 1947, corona

"During the period, I have records of seeing all classes of your series of Remarkable Aurora Forms except I and VIII, the galactic type arc and the divided rays. I have not seen Form I since the 1929 period. I have not yet seen divided rays. At the time of writing I have seen no aurora this year, and very few reports have been received from our BAA members. Red has been a very frequent and often intense color during the last eight years, both in streamers, rays, and in floodlit masses in the sky. The most magnificent crimson floodlighting occurred on March 24, 1946, from 0100 to 0215^h UT during a great aurora that preceded the one on April 23 of that year.

"The extraordinary peak of 1947, shown in Figure 1, appears to me to be unusually early, only nine years after the previous one. Will we have a double peak this time? The enclosed table is a record of personal observations only. Table 1 records a type that seems to me distinct, a perfectly quiescent faint white glow seen after midnight and in an eastern bearing. I have only seen it on the seven occasions stated.

"I have never seen noctilucent clouds, but only cirrus on summer nights reflecting sunlight or refracted sunlight. I have seen mother-of-pearl colors only on lofty clouds in the daytime on a few occasions, with the sun below the cloud in altitude."

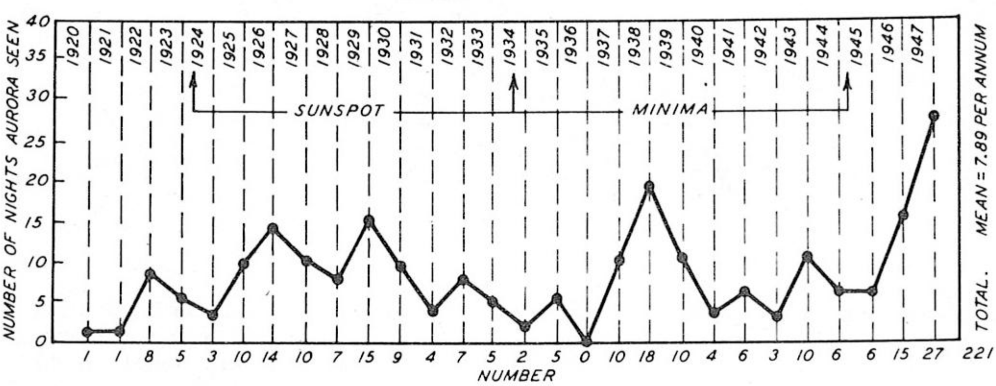


Fig. 1--Auroral frequency, one observer, Cumberland

Table 1--Luminous segments of galactic intensity

Date seen	Time, UT	Center, T.B.	Apex height	Base
Oct. 14, 1925	0040	39°	10°	100°
Oct. 12, 1926	0400	22	15	100
Oct. 11, 1929	0400	10	15	100
Jan. 27, 1941	0000	30	12	80
Nov. 10, 1942	0140	55	10	90
Jan. 3, 1943	0140	15	15	130
Nov. 13, 1947	0250	34	30	112

Prof. S. Chapman references the Report of the Gassiot Committee of the Royal Society on "The Emission Spectra of the Night Sky and Aurorae" consisting of papers read at an International Conference held in London in July, 1947, published in 1948 by The Physical Society, 1 Lowther Gardens, Prince Consort Road, London S.W.7, 140 pages, price 20s, postage 6d.

Holland

AURORAL OBSERVATIONS IN THE NETHERLANDS, 1939-1948

By J. Veldkamp

The observations of aurorae in the Netherlands have partly been published in the journal "Hemel en Dampkring" and in the publications of the Royal Netherlands Meteorological Institute entitled "Onweders, optische verschijnselen enz. in Nederland".

During the war the number of observations was reduced not only by the sunspot minimum but also by the curfew and by confusing objects like searchlights. Photographs of aurorae, photographic height measurements of aurorae and photographs of spectra have not been made systematically. The dates of auroral observations are given below, dubious cases are written between brackets.

1939. February 6, 24, 25; April (6), 18, 24; May (13), 25, 28; August 11; September 17, 19; October 3, 4, 13, 17.
1940. January 1, 3, 9, 10, 11, 12, 17; March 24, 25, 27, 29; April (17), (19); July (22); September 26, 27; October 1, 7, 25, 26; November 22.
1941. January 17; February (15), (16), (28); March 1, 21, 29, 30; April (15); May (22); July (17); September 18, 19, 20, 21, 22, 23; October 11, 22, 24, 29; November 17, 18.
1942. March (13); April 4, (7), (8), 14, 17; May 26; September 2, (25); October 11; November 8; December 9.
1943. February (1); March 29; June 13; October 2, 21, (31).
1944. September 30.
1945. No reports.
1946. January 3; February 7, 8, 19, 20; March 23, 24, 25, 28; April 23, 24; June 27; July 26, 27; August 14; September 16, 18, 22, 23, 24, 25, 27, 28, 29.
1947. January 16, 25; February 14, 15, 16, 17; March 2, 3; April 17, 18; July 17, 18; August (13), 15, 16, 17, 20; September 3, 7, 12, 13, 14, 15, 17, 18, 24, 25; October 7, 9, 10, 11, 12, 19; November 9, 10.
1948. March 15.

New Zealand

CHRISTCHURCH MAGNETIC OBSERVATORY AURORAL PROGRAM

By H. F. Baird

Although occasional reports have been received at this Observatory for many years prior to February 1946, this date marks the commencement of an auroral program here. The organization of visual observations is basically similar to that of the large group of observers, throughout New Zealand, from whom the late Mr. M. Geddes gained his data and with whom the Carter Observatory, Wellington, continues to maintain contact. The reports received by this Observatory are collected and abstracts prepared and forwarded to Carter Observatory. By this means auroral data are available to both observatories so that each may use it for its individual researches in auroral characteristics or in relationships with other geophysical phenomena. The Magnetic Observatory maintains its contact with observers by means of a monthly circular issue, through which medium are presented articles of historical and general interest, instructional notes, and reviews and lists of recent aurorae with supplementary notes of disturbances in terrestrial magnetism, ionosphere records, etc.

Results: The accumulated Canterbury observations for 1946-47 have been published in bulletin form as noted under Publications below. Twenty-two observers contributed some 200 reports of 70 displays during this period.

The observations made by H. R. Atkinson while on Campbell Island during 1945 have been analyzed and published during 1946. The Director of Carter Observatory has kindly made available the original Campbell Island logs for the period 1941-46. Progress has been made with this material and it is hoped to publish this study by 1949.

Liaison: The program maintains constant liaison with Carter Observatory, Wellington and the Ionosphere Laboratory, Christchurch. During 1946 this Observatory acted as a liaison link between observers on Campbell Island and auroral research in New Zealand.

Studies in Progress: Each of the following studies have been commenced:

a. The study of characteristics of aurorae, with a catalog of displays, over Campbell Island, 1941-46, together with a discussion of this material with relation to terrestrial magnetism and ionosphere recordings. In the latter discussion it is likely that this study will, in the first instance, be confined to magnetic K-indices, the Es ionosphere region and variations of the maximum usable frequency.

b. Commencing on January 1, 1948, observers have been contributing data on night observation conditions. It is hoped that, with the aid of this data, more accurate information of auroral frequency at a location in the southern temperate zone may be available.

c. Some experimental work has been carried out on equipment built about a Radiatron 931A photo-multiplier tube with regulated power supply. When such characteristics as sensitivity, stability, linearity, and spectral response have been tested it is hoped to use the equipment for measuring auroral illumination intensities.

d. To aid volunteer observers an instruction manual discussing features of visual observation methods and reporting procedures is being compiled This manual will be designed to meet the needs of the beginner as well as the more experienced observer.

Publications: The following have been published between July 1946 and March 1948.

H. R. Atkinson. Auroral observations, Campbell Island, 1945. New Zealand Journal of Science and Technology, vol. 28, No. 2 (Sec. B), pp. 109-116, 1946.

H. R. Atkinson. Comments on Canterbury auroral observations during 1946. Southern Stars, vol. 13, No. 2, September, 1947.

H. R. Atkinson. Catalog of Aurora Australis displays over Canterbury, New Zealand. 1946-47.

Christchurch Magnetic Observatory auroral circulars, Nos. 1-17.

Christchurch Magnetic Observatory
Christchurch, New Zealand, February 20, 1948

CATALOG OF AURORA AUSTRALIS DISPLAYS OVER CANTERBURY, NEW ZEALAND, 1946-47

By H. R. Atkinson

This catalog summarizes some 200 individual observations made by a group of 22 voluntary Canterbury observers located between latitudes 43-44° S and longitudes 171.5 to 173° E. The program is carried on in cooperation with the Director of Carter Observatory, Wellington, who maintains contacts with observers throughout New Zealand. The organization here is basically similar, although more limited in the number of observers to the group from whom the late Mr. Geddes gained his data of Aurora Australis characteristics over New Zealand. A more detailed description of the aims and organization of this Christchurch Magnetic Observatory program has been presented in an article in "Southern Stars" (1). No attempt has been made, in this bulletin, to correlate aurorae with related geophysical phenomena, or is any detailed study of general auroral characteristics pursued, but rather it comprises a description of activity over a limited area in the temperate zone.

Tabulated observations: The 70 aurorae, 17 occurrences during 1946 and 53 during 1947, have been tabulated below. All times are in Greenwich Mean Time. The standard abbreviations for auroral forms developed by Professor Störmer (2) have been used in this work with, in addition, an abbreviation Se used to note the presence of a dark segment in association with a homogeneous arc. The sequence of forms listed is not in chronological order. In the "Remarks" column the abbreviation Cld. indicates that observations were limited by the presence of cloud. The color notes are preceded by the forms to which they apply except for those aurorae where only one form was present. The notes appended to the catalog give more detailed descriptions and in these frequent use has been made of other catalogs, so that by the use of the latter some aurorae are shown to be of greater magnitude than local observations indicate.

Catalog of Aurora Australis displays, Canterbury, New Zealand, 1946-47

1946	Time of first obs.	Time of max.	Time of last obs.	Forms	No. of reports	Remarks
February 7	12.35		14.30	G. DS. R. RA.	2	
" 8	09.00		11.10	G. R. RA.	2	
March 24	08.15	09.35	10.20	G. R.	2	G., red, green.
" 25	08.55	09.30	12.19	G. DS. HA. Se. R.	7	Notes 1 and 16.
		11.40		RA. F.		
" 26	10.07		10.50	G.	4	
" 28	10.50		11.20	G. R.	5	Cld.
April 23	10.40		11.50	HA. R. RA.	2	HA., green.
" 24	08.00		09.00	HA.	1	Note 2.
July 27	07.33		07.42	G. R.	3	Cld. R., red., G., green.
September 18	08.15	09.15	13.00	G. HA. Se. R.	4	Cld. G., red, green.
		11.15				Note 3. R., red, HA., green.
" 20	12.00		15.00	G.	1	
" 22	08.15		08.40	G. RA.	2	Note 4. RA., red.
" 28	08.45		09.30	G.	1	Note 5. Cld.
October 20	09.25		09.35	R.	1	Cld.
November 25	09.00			G.	2	Note 6
" 27	09.30			G.	2	
1947						
January 25	10.00		12.00	G.	1	Cld.
" 26	12.00		14.05	G.	1	Cld.
February 9	09.50		10.15	G.	1	Note 7. Red.
" 10	09.00		10.00	G. HA. R.	2	G., red.
" 16	08.55		15.00	G. DS.	3	Cld. G., red.
" 17	12.00		13.00	G.	1	Cld. Red.
" 19	13.00		15.00	G.	1	Cld. Pink.
March 2	11.30		13.00	G.	1	Pale pink.
" 3	10.30		16.00	G.R.	2	G., red, green.
" 4	08.15		10.00	G. R.	1	G., pink.
" 15	09.30		16.35	G. (HA ?) R. RA.	4	Note 8. G., red, green. R., red.
" 22	11.30		12.15	DS. G. R.	2	DS., red.
" 27	09.00		10.45	G.	2	Red.
" 28	09.00	10.40	14.10	G. R. RA.	3	Note 3. Cld.
		13.00				G., red, green. R., yellow.
" 30	10.40		13.00	G. R.	2	
April 9	07.40		08.30	G. HA. R.	3	Note 9. R., red. G., red, green.
" 17	13.00		16.00	G. R.	2	G., yellow-green.
" 18	12.05		16.45	G. R. C.	1	Note 10. Cld. G., red.
May 24	07.30	08.54	13.15	G. HA. Se. R. RA.	7	Notes 11, 13, 15. G., red.
"		10.21 11.45		Red patches.		HA., green. R., red.
" 25	18.10		18.20	(R.?)	1	Green.

Catalog of Aurora Australis displays, Canterbury, New Zealand, 1946-47--concluded

1947	Time of first obs.	Time of max.	Time of last obs.	Forms	No. of reports	Remarks
June 17	08.09		12.30	G. HA.	3	Note 12. Cld. G., green.
" 18	09.00		11.45	G.	1	
August 6	10.20		10.50	G.	1	
" 12	07.50		08.05	G.	1	Red.
" 15	11.15	12.00	13.10	G. R. RA.	5	G., red. RA., yellow-green.
" 16	09.15	10.05 12.20	16.15	G. HA. R.	3	Cld. G., white, red.
" 17	07.33		15.15	G.	3	Note 12. Cld. Pink.
" 18	12.05		13.10	G. R.	3	Cld. G., pink.
" 19	09.45	11.15 12.20	13.30	G. R.	2	G., pink, green.
" 20	10.30		13.05	G. R.	3	G., pink.
" 21	09.15	(09.23?)	13.00	G. R.	2	
" 22	09.30	10.40	17.30	G. HA. R. RA.	12	Notes 14, 15, 16. HA., green.
		12.40		F.		G., white, red, green.
		16.27				R., white, red.
September 3	09.00	09.31	10.50	G. HA. Se. R. RA.	15	Note 17. G., pink, green.
		09.52				HA., white, pink, green. R., white, red.
" 7	10.00		15.30	G. R.	2	
" 13	07.45		14.55	G. HA. Se. R. RA.	7	Note 18. Cld. G., green, red. HA., RA., and R., green.
" 14	07.55		14.00	G. HA. Se. R. RA.	4	Note 12. Cld. G., pink, HA., green, R., white.
" 15	10.20	10.43	16.40	G. HA. R. (PS?)	2	Note 19.
" 17	12.30		16.50	G.	2	Cld.
" 18	08.55		14.00	G. R.	3	G. and R., green.
" 21	07.45		09.05	G. R.	2	G., pink.
" 24	11.35		11.50	G. R.	1	Note 20. G., red, R., green, white.
October 2	07.50		12.05	G. R.	1	G., pink. Cld.
" 6	08.45		11.30	G.	1	Cld.
" 9	09.15		15.00	G.	2	Pink. Cld. Note 12.
" 11	12.00		16.30	G.	2	Cld.
" 15	09.00		15.50	G.	2	Cld.
" 16	09.55		11.50	G.	1	Cld.
November 8	09.00		14.30	G.	2	Cld.
" 9	08.45	12.20 13.42 14.30	15.30	G. R. RA.	3	Cld. G., white, red, Note 21.
" 11	10.15		10.40	G. R.	1	Cld.
" 15	09.30		09.45	G.	2	Cld.
December 9	10.00		11.40	G.	1	Cld.
" 13	10.30	10.40	12.00	G. R.	1	

Notes:

1. Display of March 25, 1946. Occurring during the period 23-28 March 1946 which Professor Störmer (3) has described as a period of "extraordinary auroral activity," this display has been described in detail below. By dint of its frequent intense rayed arc forms, the unusually high elevations reached, the vivid coloration, the rapid changes in form and its development to the flaming aurora form, this aurora was the most active during 1946-47. A detailed description follows the series of notes.

2. Display of April 24, 1946. Times stated are approximate.

3. It is likely that the times of maxima listed may be limited in accuracy by cloud conditions.

4. Display of September 22, 1946. Seen as far north as Ohakea, latitude 40° S where, at 14^h 30^m it reached an elevation of 40°.

5. Display of September 28, 1946. This mild isolated aurora occurred during a quiet period at this latitude. However, over southern Norway on 28-29 September M. E. T. Professor Störmer (3) reports "Great aurora all over the sky with corona and draperies in green and red." Aurorae were also reported on three succeeding nights over Norway.

6. Displays of November 25 and 27, 1946. Only brief reports of these displays were received. The latter display was described as a "very small faint patch of glow."

7. There is marked coincidence between the dates listed above for February 1947 and those given in Professor Störmer's (3), viz. Aurorae over Southern Norway M. E. T. February 8-9, 9-10, 16-17, 17-18, 18-19, 19-20. Aurorae over Canterbury, N. Z., G. M. T. February 9, 10, 16, 17, 19. Further a provisional list issued by Carter Observatory, N. Z. (4), reports occurrences on February 24, 25, and 28 G. The display of February 25, observed at Campbell Island and over New Zealand, was assessed at intensity 4 and developed to the corona form.

8. Display of March 15, 1947. This display was observed over Campbell Island, N. Z., Broken Hill and Canberra, New South Wales, Australia; observations extended over nearly nine hours, i.e., 08^h 25^m to 17^h 06^m G. M. T., several maxima and corona being observed. Over Canterbury a green glow persisted from 09^h 30^m to 11^h 00^m while during the periods 11.05 - 11.15 and 15.00 - 16.35 vigorous ray activity appeared. Between 16^h 15^m and 16^h 35^m in addition to intense raying up to 40° an associated red glow made sudden and frequent changes in color from red to white and white to red.

9. Display of April 9, 1947. Unlike many of the displays described briefly in these notes this occurrence was observed during a period when Northern Hemisphere activity was low. Also its activity was unusually high for such a short duration display. Within five minutes of the time of the first appearance an arc with rays and an associated glow were present. Numerous rays reached 50-60° with the lower portion of the display green and the upper limits red.

10. Display of April 18, 1947. A red glow and corona were observed at 12^h 05^m. Cloud conditions at this time prevented detailed observations. Later when conditions improved the display remained a quiet glow with one outburst of ray activity up to 45° at 14^h 50^m.

11. Display of May 24, 1947. From $07^h\ 45^m$ to 09.00^h an intense, well defined arc with dark segment was present. The dark segment extended to 15° elevation with the arc above to 20°. The detailed reports of this aurora contain many references to bright red patches (see Note 15 below) associated with a green glow and vigorous ray activity reaching 45°. The development of forms followed the sequence:

Forms:	G.	HA. Se.	HA. Red Patch	HA. (Max.)	HA. (Min.)	R. Red patches	RA.	HA. R.	G.
Times:	07.30		08.50	08.54	09.00	09.05-10.00	-10.25	10.30-11.50	

Three phases, each ending in a marked decrease in activity, are apparent. They were 07.30 - 09.00; 09.00 - 10.30 and 10.30 - 13.15. The maxima are listed in the tabulations.

12. Observations were limited by long periods of ten-tenths cloud and although auroral forms were seen at the times of first and last observation stated, it is unlikely that the forms listed are a true indication of the development of the display.

13. It is of interest to note that Norwegian occurrences as listed by Professor Störmer (3) give the number of displays per month as 1947 May, nil; June, nil; July, 1. The number of displays over Canterbury were 1947 May, 2; June, 2; July, nil. Above it has been noted that similar periods of auroral activity have been recorded over both hemispheres; it is apparent in this case that a similar period of minimum activity has also been experienced.

14. Display of August 22, 1947. While being present for eight hours, this display had three well defined phases, viz., 09.30 - 11.00; 11.00 - 13.15 and 13.15 - 17.30. The passage of forms was:

Forms:	G.	G.RA. R.	G. R.	G. HA.	R.	HA.	RA.	G.	G.HA. F.	G.
	09.30	09.50-10.50			11.20	11.25-12.30	13.20-14.00	To 16.25	16.27	16.40-17.30

The first phase developed through G. R. and RA. forms to intense extensive patterns of these forms reaching greatest activity at $10^h\ 40^m$. At the first maximum when an intense red glow with a brilliant rayed arc and scattered ray bundles were present, the following observations were made at the Wigram Meteorological Station using a balloon theodolite. The arc extended over 90° of azimuth with the lower limit of the arc at 12° elevation. The upper limit of the display was 54°. In the initial stages of decline from this maximum the red glow tended to transform into several red patches. At $10^h\ 55^m$ the decline in activity was marked, a complete fading of all forms being apparent. During the next phase, instead of the usual steady building up of forms, rather erratic interchanges of a single bright red patch, ray bundles to 20°, a faint, weakly colored glow and a quiet homogeneous arc took place. At 12.32 an observer at a coastal location reported "Suddenly the whole sky was lit by brilliant pale green and red rays which gave the sea and buildings a reddish appearance." This activity persisted for 13 minutes, again being followed by a sudden decline in which the rapid disappearance of coloration was marked. For the next three and a half hours activity more feeble than that present during the previous minimum occurred. Apart from a slightly more intense R.A. at 13.20 the display was composed of sporadic faint rays (these confined to the first hour of this period) and a glow whose intensity underwent only small fluctuations. At the time of the final maximum, $16^h\ 27^m$ the glow suddenly brightened, a homogeneous arc appeared for 15 seconds and then a flaming aurora appeared. (See note 16.) The aurora ended as a fading glow.

The above summary is based on written reports contributed by 12 observers.

15. Red patches. Some attention has been given to the observations of red patches which have been reported on several occasions during 1947. Their appearance seems to be in keeping with the remarks of Professor Störmer (5) regarding red patches observed from southern Norway. "From auroral observations during the last century it is a well known fact that red aurora forms in middle latitudes appear almost exclusively during the years of maximum frequency of aurora." Geddes (6), discussing the predominance of red coloration of displays during sunspot maximum years, found the most common type to be the diffuse red patch. The present observations tend to agree with these conclusions, viz., the predominance of red forms, particularly diffuse red patches at or near the sunspot maximum.

16. The flaming aurora form. The two occurrences of the flaming aurora form during 1946-47 are in agreement with the statement by Geddes (6): "Generally it is only during the final burst of activity for the night that flaming takes place." Geddes continued, "If the display flames it commences to do so just before the decline from the D or C stage, although there has been one case where it flamed during the HA. stage." Noting the last statement, the sudden transition from the HA. to the F. form at $16^h\ 27^m$ during the display of August 22 (summarized in Note 14 above) is unusual.

17. Display of September 3, 1947. Following a quiet commencement with G. and HA. forms, and later fine sporadic raying, this aurora between 09.28 and 09.40 rose to vigorous activity when rays reached 50-60°. A brilliant double arc (lower borders at 10° and 20° approximately, and eastern extremities merged) lasted for one minute before transforming into a brilliant rayed arc, white in color, to 20° and above this, to 60°, red. A confusion of forms then ensued. Fragments of RA., red and white G., and isolated rays were observed until a rapid fading occurred between 09.40 and 09.46. During this low activity period a glow to only 5° and a few feeble rays appeared. An HA. was then observed; it brightened and within three minutes ray structures were active up to 60°, red at this elevation, and green nearer the horizon. Again a final decline through sporadic raying and a faint glow was observed.

Comparison with two characteristics of aurorae over New Zealand, 1933-38.

The above display, typical of many recent aurorae over this latitude, exhibits at least two characteristics noted by Geddes (6), viz., (a) Double arc occurrences have been observed from this latitude only twice during the period under discussion. (See also Note 19 below.) Geddes, discussing the homogeneous arc in New Zealand observations 1933-38, writes: "Frequently it becomes double and occasionally multiple, or it may fold." Neither of the latter two types have been reported. (b) Discussing the developments following the maximum Geddes writes: "There is then a rapid decline to hazy ill-defined forms which may be classified very incompletely as DS. consisting of cloudlike patches, segments of arcs and bands, isolated rays, etc., frequently pulsating. From this a new HA. gradually emerges, initiating the next burst of activity." This confusion of forms and the subsequent renewal of the HA. is a characteristic pattern of the above and several other recent displays.

18. Display of September 13, 1947. Possible times of maxima were 07.50, 08.15, and 11.45. The sky was overcast for several periods. Although raying occasionally reached 30-40°, in general activity was confined to low elevations.

19. Display of September 15, 1947. At the time of the first observation, 10.20, two observers noted a double HA. composed of a lower arc, intensity 2, at 5° and an upper arc, intensity 1, at 10° extending from SSE to WSW. After feeble intermittent raying, at 10.43 extensive ray bundles up to 30° appeared. At 10.50 the upper arc faded to a dim glow, the raying ceased and the lower arc remained at intensity 1. Six minutes later observers reported continuous quick variations in the glow. This is the form which has been listed as a queried pulsating surface. Mention is made of the continued appearance of the lower arc of original double HA. as late as 11.15. With the exception of two periods, each of a few minutes of faint raying, the remainder of the display consisted of a fading glow.

20. Display of September 24, 1947. The descriptions of this aurora are based on a newspaper report.

21. Display of November 9, 1947. Cloud seriously limited observation until 12.00 but for the next three and a half hours notes were made every five minutes. The maxima for which times are listed in the tabulations are well defined peaks in ray activity, but are limited to the period 12.00 to 15.30.

The most developed aurora over Canterbury, 1946-47
Display of March 25, 1946.

New Zealand records (7) state this display was observed as far north as New Plymouth, latitude 39° S and that for the period March 24-26 aurorae were visible "over the whole of New Zealand at some time or another." The above display developed to the flaming aurora form in two distinct phases. The combined observations by several observers follow:

Phase I.	08.55	HA. with dark segment, the latter to 5°, centered in the south.
	09.00	Diffuse red R. formations, with green RA. appearing almost simultaneously.
	09.04	Only single R. present.
	09.05-07	Intense patches of green G.
	09.10	Further intense raying accompanied by a spreading green G.
	09.11-14	Green G. fading, decrease in elevation and all traces of red coloration absent.
	09.21	Very weak green RA.
	09.23	Intense green RA. with east to west movement apparent.
	09.24	RA. persisting for 30 seconds up to 40° elevation.
	09.30	Weak low F. composed of wavering horizontal arcs.
	09.35	This time apparently marked the end of the first phase.
Phase II.	10.45-11.23	Pale green quiet G.
	11.25	Individual parallel rays extending to 70° from S to WSW. Extreme western rays had marked red coloring which spread to the rays in the south. The rays were broad and diffuse.
	11.30	R. structures faded and F. commenced.
	11.38	F. to 30° continued with red rays present, one of these almost reaching the zenith.
	11.43	F. midst diffuse RA. F. continued steadily until 11.48.
	11.48	F. present but faint.
	11.49	Only a quiet G. remained.
	11.53	G. with faint raying and sporadic appearance of F.

Phase II.	11.54	Sporadic single rays.
(concluded)	11.54-12.19	Display slowly subsiding to DS.
	12.19	Observations ceased

Aurorae reported as doubtful:

The following observations are provisionally marked doubtful. This list will be amended when grouped with New Zealand, Campbell Island, and Australian observations. The principal reasons for these observations being placed in this category are (a) observations restricted almost continuously by cloud, and (b) the possible confusion of early evening quiet glows with twilight. Each was reported by one observer.

1947		Duration	Form
August	24	08.20	G.
September	4	08.20 - 09.10	HA.
,,	10	09.00	G.
,,	12	09.05	G.
,,	19	08.15 - 08.25	G.
October	19	13.00	G.
November	4	11.30	G.
,,	6	12.30 - 14.30	G.
,,	13	08.45 - 08.50	G.
,,	17	09.50 - 10.05	G.
,,	18	09.20 - 09.50	G.
December	3	09.50 - 10.00	G.
,,	5	12.10	G.
,,	14	09.27 - 09.30	G.
,,	16	10.20 - 11.00	G.

Acknowledgments:

The writer wishes to acknowledge the services and assistance to this program contributed by the following: The Canterbury observers who by maintaining keen interest and constant vigilance provided the observations summarized in this catalog, the Director of the Carter Observatory, Wellington, the Officer-in-Charge and staff of the Ionosphere Laboratory, Christchurch, the Meteorological Office, Wigram, and the Director and staff of the Christchurch Magnetic Observatory.

References:

1. H. R. Atkinson. Southern Stars, vol. 13, pp. 30-32, 1947.
2. Photographic Atlas of Auroral Forms, International Geodetic and Geophysical Union, Oslo, 1930.
3. Carl Störmer. Aurora Borealis displays over southern Norway, September 1945 to July 1947, Flammarions Annuaire.
4. I. L. Thomsen. Provisional list of aurorae, January - April 1947. Carter Observatory, May 1947.
5. Carl Störmer. Remarkable aurora forms from southern Norway. Geofysiske Publikasjoner XIII, 7, 57, Oslo, 1942.
6. M. Geddes. Terrestrial Magnetism, vol. 44, pp. 189-193, 1939.
7. I. L. Thomsen. Aurora Australis circular No. 30, Carter Observatory, October 1947.

Christchurch Magnetic Observatory
Christchurch, New Zealand, February 18, 1948

REPORT OF NEW ZEALAND WORK ON THE AURORA AUSTRALIS

By I. L. Thomsen

The position of New Zealand as an inhabited land mass in relation to the southern auroral zone is such that it should be incumbent upon scientists residing there to take the fullest opportunities of observing the Aurora Australis. With the exception of Tasmania, it is perhaps the only land mass from which suitable base lines can be permanently established for the purpose of a long program of parallactic photography. Antarctic expeditions are generally only for a season, and while the results of auroral studies are of considerable importance they are perhaps too broken and spasmodic for a complete time-base picture. The sub-Antarctic islands, while not being very hospitable, are in a cloud and rain zone and are not large enough for the setting up of base lines. Unfortunately, lack of funds up to the present time has prevented the fullest use being made of the unique position of New Zealand, and what work has been done up to the time of this report has been carried out under considerable difficulties.

Up to 1939 the fundamental work on the Aurora Australis in New Zealand had been done by the late M. Geddes. Besides the collection of visual observations he had taken many photographs with auroral cameras kindly loaned to this country by Professor Carl Störmer. The great bulk of this work was single station photography, using assumed heights based on the Norwegian results for various auroral forms, and about only 18 duplicate sets giving definitive heights were obtained.

In some respects the war upset the auroral work in progress up to 1939, while in other ways it assisted the expansion of the work by virtue of the observations commenced on Campbell Island to the south of New Zealand by the scientific parties established there.

Since 1939, apart from a very few single station photographs, the principal work has been based on visual observations supplied by observers of all degrees of training, experience, and skill.

There are approximately 300 active voluntary observers in New Zealand, reporting to the Carter Observatory. Of this number a few have formed a special group in Canterbury under the guidance of the Magnetic Observatory at Christchurch, which is doing all in its power to assist the Carter Observatory in auroral work. The Tasmanian Astronomical Society has specialized in auroral observing and reports regularly to the Carter Observatory. Such reports have been found to have considerable value when used in conjunction with the New Zealand observations. The scientific party on Campbell Island makes detailed records of cloud conditions during the dark hours and produce valuable data on displays as they occur. Measurements are made with a theodolite as required. Contact has been made with the Australian Antarctic Expedition, and arrangements have been made to receive copies of their observations. On the mainland of Australia, Mr. J. Fraser Paterson gives considerable assistance in obtaining observations from people in Australia.

The work of reducing all the information gathered is proceeding very slowly, and is certainly not up to date owing to shortage of staff, but it is hoped that this may improve as time goes on. The Campbell Island data are at present being dealt with in a most able manner by Mr. H. R. Atkinson of the Magnetic Observatory.

Apart from general auroral data, is is believed that one of the most important results that will emerge from a detailed study of all the data, is that the auroral zone in the south shows a considerably greater expansion and contraction in sympathy with the sunspot cycle than is the corresponding case in the northern hemisphere. The urgency of having all data on hand at present, which covers a period of at least one and a half sunspot cycles, reduced to some homogeneous form is very great.

Auroral phenomena are planetary phenomena and the writer respectfully submits that the time has come when this aspect should be considered on an international basis for both the northern and southern hemispheres. At present New Zealand is, by virtue of its shortages in funds and men for such work, not in a very good position to take an active stand in such a suggestion. Norwegian scientists, headed by Professor Störmer, are doing as much as possible to assist New Zealand in this respect.

Norway

REPORT ON AURORA WORK SINCE 1939

By Carl Störmer

The work on polar aurora has continued in four different directions:

I. Photographic work of the aurora stations.
II. Measurements and studies of the accumulated material of aurora observations and photographs.
III. Results of an expedition to Northeast Greenland 1938-39.
IV. Theoretical work.

I. A series of aurora stations in Southern Norway has been in action during all years since 1939. The stock of pictures obtained can be seen from the following table.

Year	N	I	II	III	IV	Sets	S	Σ	n
1939	39	1529	254	101	8	363	26	2372	8
1940	39	2261	263	138	28	429	30	3313	10
1941	36	2361	445	187	46	678	50	3996	6
1942	24	706	251	220	57	528	21	2096	5
1943	12	542	89	90	22	201		1078	6
1944	8	166	29			29		224	5
1945	9	282	48	16	6	70		450	6
1946	15	503	128	81	60	269	10	1242	6
1947	32	1161	210	212	93	515		2589	7
Total	214	9511	1717	1045	320	3082	137	17360	

Here N is the number of aurora nights, I the number of usable single pictures, II, III, and IV the number of sets of pictures taken simultaneously from 2, 3, or 4 stations. Further, "Sets" is the number of usable sets, S the number of spectra, Σ the total number of usable pictures taken and n the number of stations in action. Moreover, visual observation of aurora have been collected during the same period.

II. The material collected since 1911, more than 35,000 usable aurora pictures with corresponding observations, have been subject to a detailed study. Monographs on remarkable aurora forms have been published and all height determinations, more than 12,000 have been studied by statistical methods.

III. The results of the cooperation between the French-Norwegian expedition by Comt. Micard and the Danish expedition 1938-39 by Ebbe Munck and Eigil Knuth, regarding aurora--all the aurora photographs were measured out and the results published.

IV. Theoretical work--The very extensive calculations of electron orbits in the magnetic field of a dipole, found by numerical integration of the corresponding differential equations, during the period 1930-1932 have been presented for publication. Only the first of three extensive papers (80 folio-pages with calculations) have hitherto been published.

List of published papers on Aurora:

1939

1. Red auroral lines on September 14-16, Nature, Lond., v. 143, p. 117.
2. Blue auroral rays situated in the sunlit part of the atmosphere, Terr. Mag., v. 44, 8 pp.
3. Auroral work in Southern Norway in the year 1938. Ibid., v. 44, 10 pp.
4. Aurora photographed in Southern Norway 1939. The Sky, New York, 2 pp.

1940

5. Sur une recherche qualitative et quantitative d'un système d'équations différentielles jouant un role important dans la physique cosmique. (Grave DA) Shornik posvjascenny pamjati akademica Moskva. 6 pp.

1941

6. Some auroral spectra from Southern Norway 1940. Astrophysica Norvegica, v. 3, No. 9, Oslo.
7. Types remarquables d'aurores boréales observées dans la Norvège méridionale, Comptes Rendus d. séances de l'Acad. d. sc. Paris, v. 213, 2 pp.
8. Remarkable aurora-forms from Southern Norway III-IX. Geof. Publ., v. XIII, No. 7, 82 pp, 34 plates, Oslo.
9. Merkelige nordlys iagttat og målt i det sydlige Norge i de siste 30 år, Nordisk astronomisk tidsskrift, B. 23, Köbenhavn, 10 pp.

1943

10. Results of the photogrammatric measurements of the aurora borealis during the Norwegian-French expedition to Northeast Greenland 1938-39. Geof. Publ., v. XIII, No. 13, 41 pp., 4 plates.

1945

11. 10000 nordlyshöyder målt fra det sydlige Norge i tidsrummet 1923-1944, Fra fysikkens verden, 1945, hefte 3, 8 pp.

1946

12. Preliminary results, auroral photographs Southern Norway, March 1946. Terr. Mag., Sept. 1946, 2 pp.
13. Frequency of 12330 measured heights of aurora from Southern Norway in the years 1911-1944. Terr. Mag., Dec. 1946, 4 pp.
14. Resultats des calculs numériques des trajectoires des corpuscules électriques dans le champ d'un aimant élémentaire VI Trajectoires par l'origine. Faisceau fondamental. Skrifter utgitt av Det Norske Videnskapsakademi i Oslo. Math.-Naturv. klasse 1947, No. 1, 80 pp., 3 plates.
15. Aktuelle problemer i forbindelse med nordlyset. Naturen, 1947, Bergen, 12 pp.
16. Polar aurora in Southern Norway, the Halley Lecture for 1947. The Observatory, v. 67, No. 840, 14 pp., 2 plates.
17. Dano-Norwegian cooperation on polar auroras in Northeast Greenland 1938-1939. Meddelelser om Grönland, v. 127, No. 3, 61 pp., 13 plates.

1947

18. Auroral activity in Southern Norway from the middle of August to the middle of October 1947, Nature, London, v. 161, p. 208.
19. A series of annual reports on visual observations of Aurora in Southern Norway published in Annuaire astronomique et météorologique Camille Feammarion, publié par l'Observatoire de Juvisy, France.

Institute of Theoretical Astrophysics,
Blindern, Oslo.

For additional reports on auroral studies in Norway, see Report of Research in Aurorae by Leiv Harang, in the Norwegian National Report, pp. 186-187, and Report of Investigations on the Physics of the Ionosphere and its Relation to Solar Phenomena by L. Vegard, pp. 366-368.

Switzerland

AURORAL REPORT

By F. W. P. Götz

The profit of big aurorae is a modest one in a middle European latitude of 47 degrees; yet, the difference of spectra (conditions and altitude of excitation) in high and moderáte latitudes is a sufficient reason for research of those rare chances. A first beginning in Switzerland was made when Professor C. Störmer kindly loaned us for several years some of his well-known aurora-cameras; they were recently replaced by Contax cameras f/1.5.

A considerable number of auroral nights made it possible to determine the general shape of apparition [1] in our latitudes. Even diverse "bright nights" [2] deserve consideration though they have no proper auroral spectrum; sometimes they resemble faint homogeneous auroral arcs with dark segment, show remarkable recurrence tendency of 27 days and have enhanced magnetic disturbance which seems to point out a solar control. The aurora of September 18, 1941, supplied especially comprehensive exposures [3,4].

On this night, we also obtained the first sure height-measurements [5] with a mean top of the rays at 530 kilometers. As a result of a simultaneous exposure, Professor Störmer was able to use the unusually long base-line Oslo-Arosa, and obtained an altitude of 800 km above Stockholm. At the International Conference "Relations entre les Phénoménes Solaires et les Phénoménes Géophysiques" at Lyon, 1947, a number of middle European observatories agreed [6] to open the aurora-exposures at the exact beginning of each minute with 20 seconds time of exposure; thus it is to be hoped that in cases where no direct communication between the observatories exists, this synchronization will increase the chances for simultaneous exposures useful for height determinations.

In the spectrum, the nebular atomic lines are characteristic of the more "southern" aurorae. Besides the red oxygen line 6300 Å, the line 5199 Å of atomic nitrogen discovered at Arosa [3,7] is most interesting, as, until now, it cannot yet be found in northern latitudes. Every doubt in the reality of this identification must be repelled, since recent observations show that the excitation of this line persists during hours [8].

We can mention only briefly the traditional sun-research of the Federal Observatory, with the effort to predict [4] aurorae from the emission domains of the corona at the east border of the sun, and of course from big eruptions; the continuous magnetograms of the magnetic station Regensberg of the Swiss Meteorological Office; and the ionospheric studies of Lugeon [9] and of the Swiss P.T.T. Administration [10].

References

[1] F. W. P. GÖTZ, Vor einer "Saison" starker Nordlichter. Prisma 2, 243, 1947.
[2] F. W. P. GÖTZ, Bright Night Sky. Conf. Scient. Intern. Lyon, 1947.
[3] F. W. P. GÖTZ and PH. CASPARIS, Das Nordlicht vom 18, bis 20, Sept. 1941. in Arosa. Zeitschr. f. angew. Met. 58, 337, 1941.
[4] M. WALDMEIER, Die Nordlichter vom 25, January 1938, und 18, September 1941, und ihre solare Ursache. Vierteljahrsschr. Naturf. Ges. in Zürich 87, 253, 1942.
[5] F. W. P. GÖTZ and F. SCHMID, Höhenmessungen des Nordlichts vom 18, September 1941. Verh. Schweiz. Naturf. Ges. Sitten 1942, p. 88.
[6] F. W. P. GÖTZ, Eine Anregung zur Nordlichtphotographie. Archiv für Met., Geoph. und Biokl. (Wien) 1948.
[7] F. W. P. GÖTZ, Deutung einer weiteren grünen Nordlichtlinie. Naturw. 30, 752, 1942.
[8] F. W. P. GÖTZ, Zum Nordlichtspektrum des 17 April 1947. Experienta 3, 185, 1947.
[9] J. LUGEON, Nordlicht und Radio. "Schweiz. Radioztg.", 1941.
[10] W. GERBER and A. WERTHMÜLLER, Nahschwundtätigkeit der Rundspruchsender Techn. Mitt. P.T.T. (Bern), 1947, S.1.

United States of America

REPORT OF WORK ON AURORA SINCE 1939

By C. W. Gartlein

The National Geographic Society-Cornell University Study of Aurora was set up in 1938 and has collected data on auroral activity since then.

Up to fifty observers have sent in descriptions of visual phenomena on certain displays so we have some record from northern United States or southern Canada for nearly every display since 1938, especially in the hours 7-12 p.m. (75th meridian time).

From these data we have made a correlation between aurora magnitude and magnetic K figures. The coefficient of correlation is .82. Further analysis is started using punched cards. There is a suggestion that southern extent of the aurora is an important measure of its size.

A pair of aurora cameras with coated lenses F/2, 45 mm focus was built and installed at Ithaca and Colgate University, Hamilton, New York. A total of about 2000 photographs have been taken of which there are at least 200 pairs for height measurement. Preliminary measurements indicate nothing unusual. The measuring networks are made by direct photography, with the aurora camera, of a quadrant of a circle, fifteen feet radius, having degree marks, turning the camera one or two degrees between exposures.

As aurora photographs are made a "secretary" camera records a pair of pictures showing times, azimuths, elevations, etc.

About 200 exposures at F/1.5 have been made on color film. About twenty of these are good enough to show that good color pictures would be of scientific use. A simple optical photometer, using a standardized lamp and sets of apertures, allows the measurement of brightness of any part of the aurora and ensures determination of necessary exposure time for photographs.

A set of filters have been developed for visual observation. One isolates the green aurora line and others show the blue or red end of the spectrum. They greatly facilitate the observation of aurora in moonlight and twilight. In addition, they have shown that the absence of flames in the aurora when low in the sky is due to the fact that the green light does not flame. We suppose that the pulsations are produced in the nitrogen bands or possibly hydrogen. They appeared in deep red or blue.

A sequence camera has been used to photograph nearly the entire sky reflected in a convex mirror with exposures of one to two minutes. This idea is worthwhile but the present camera is not reliable, so this project has been set aside.

A 16 mm motion picture camera has been arranged to take automatic exposures of 30 seconds duration and then immediately start another exposure. The lens is 15 mm focus aperture F/1.5. Quite satisfactory photographs have been made of the principal auroras since 1939. About 300 feet of this film is very exciting.

Photoelectric recording of the north sky light, about 50° each way, was begun in 1941 giving over 2000 records. The apparatus uses a sector disk, photomultiplier tube, A. C. amplifier, rectifier and pen recorder. These records show that auroras often consist of gradual rises with sudden outbursts superposed. These outbursts may double the total light intensity in one to two minutes and then fade out in fifteen to forty-five minutes. The sudden outburst occurs when the rayed arc brightens and expands. Some of these outbursts occur in step with sudden changes in the earth's field. Comparisons with Cheltenham magnetograms are being made. One of these characteristic outbursts occurred at 6^h 35^m G.M.T., March 28, 1946. The magnetic disturbance coinciding has been pointed out as of special interest by H. W. Newton [Terr. Mag., v. 52, No. 4].

The precision spectrograph was placed in operation in March 1939. It has a collimator of 381 mm focus 61.7 mm diameter, two prisms with 10 cm focus, and camera lens 10 cm focus F/1.65. The spectra are 16 mm in length from 6800 to 3900 Å and the dispersion is 180 Å/mm at H_β. The resolving power is sufficient to separate the sodium D lines when a narrow slit is used. The usual slit width gives lines about 5-10 Å wide at 5000 Å. Microphotometer traces 165 cm long have been made from the ten best. These have been compared and wavelength measurements made on them. From the plates of March 24, 1940, September 17 and 18, 1941, February 25, 1943, March 1943, and March 23, 1946, we can draw certain important conclusions. The lines H_α, H_β, and H_γ often appear. H_α is on top of one of the first positive nitrogen bands but its presence can be easily detected. On 103aF plates this N_2 band is one of the strongest features. The H_γ line is superposed on two weak second position N_2 bands and cannot always be detected through them. The H_γ line always appears broad. The H_β line appears on the red side of a Vegard-Kaplan band and is thus nearly clear. On two plates it rises sharply out of the background. Wavelength measurement indicates that H_β and H_γ occur at 4861 ± 2 Å and 4341 ± 2 Å. H_β is always broad, obviously wider than the line at 5003 Å which is a multiplet on N II. Making allowance for the slit widths of the spectrograph and microphotometer indicates the natural H_β line width is 3 Å to 10 Å depending on how one defines width. Except for some possibility now overlooked we must conclude that hydrogen radiation is present in nearly all auroras, especially in outbursts (more on this later) and the radiations are broad indicating random motions of 100-200 km per second. This would seem to indicate an influx of protons and radiation after collision. Efforts are being made to obtain a spectrograph of equal speed and greater dispersion. A spectrograph with speed at least F/2 and resolving power of at least 2000 is urgently needed on this problem and astronomers should be urged to turn their nebular spectrographs on any aurora.

Two patrol spectrographs have been used. One with camera lens 5 cm focus aperture F/1.65 and having one prism gives a spectrum 3.6 mm long. This takes a single exposure during the whole night. Over 2500 exposures have been made and have been studied only for detection of aurora. The "second green line", the 5003 lines and H_β are easily distinguished. H_β appears to be present in every aurora of any size.

The sequence patrol spectrograph was put in operation in October 1941 and about 2300 records have been taken. It uses a long focus collimator, a dense prism and a camera lens of 37 mm focus and aperture F/.73. However, a field flattener lens was added so effective aperture is about F/.8. Spectra of bright displays can be obtained in a few minutes. The length of spectrum is 4.7 mm. The slit on this instrument (as well as the F/1.65 patrol) is curved so the image on the plate is straight. The plate is moved by an electric motor through the focal plane parallel to the lines at about 4 mm per hour. The usual slit lengths give exposures of one hour or thirty minutes. The spectrograph has been aimed at about 6° above the north horizon and includes about 9° field of view. All conclusions based on these spectrograms are therefore characteristic of this limited field of view. Only a brief study of these plates has been made. We are now studying the appearance of the hydrogen lines on the plates. Two conclusions are apparent from study of only about sixty plates taken in September and October 1947. Using 103aF Eastman plates sensitive to 6800 Å we find the green line blacker than the red oxygen lines on nights of no aurora. In the early stages of an aurora the red oxygen lines come up and then the green line. In several cases the H_α and H_β lines have appeared strongly before an outburst of aurora and continued strongly in the outburst, dying away before the other lines decrease. This strongly suggests that hydrogen (probably as protons) plays an important role in the aurora and may supply the energy for the outburst. The cases where the hydrogen appears as the outburst grows are probably cases where the hydrogen influx was out of the field of the spectrograph. These conclusions will probably be reinforced by examination of the plates showing strong aurora. The number of plates to be examined in detail is probably about 400. This work will be done in the spring and summer of 1948.

This relating of hydrogen spectrum appearance in the aurora, the relation of this to aurora outbursts and the coincidence of certain magnetic disturbances should provide important aids to identifying the regions on the sun responsible for these outbursts.

A graduate student, Miss Dora Sherman, has just studied the second green line and finds it composed of four narrow bands which appear with different relative intensities at different times. The line 5198 Å is a forbidden line of N I. The band at 5228 Å is due to positive bands of N_2^+. The other longer wave lines appear to be oxygen bands.

Mr. Leon F. Graves in 1940 used data for years 1830-1871 to see if the appearance of the aurora is cyclic as indicated by F. E. Dixon [Terr. Mag., v. 44, pp. 335-338]. The data here indicate a small cyclic tendency but this can be attributed to the influence of certain data over a short time. Thus the cyclic tendency cannot be considered as strong as the seasonal effect

National Geographic Society-Cornell University
Study of Aurora
Cornell University
Ithaca, New York

REPORT ON AURORAL WORK OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON, SINCE 1939

By E. H. Vestine

The work of Fritz on auroral frequencies for the northern hemisphere which covered a long period preceding the year 1871 was tentatively revised to include results of various polar expeditions including those of the First and Second International Polar Years. The daily frequency of aurora was extended, taking into account the influence of cloudiness, daylight, and other factors. The isochasms of Fritz were redrawn on this basis in relation to the later more extensive observations, especially for very high latitudes. These isochasms were also prepared for days with clear, dark nights.

A tentative derivation was also made of the isochasms for the southern hemisphere which, although unlikely to be very accurate because of obvious sparsity of observing sites, nevertheless should prove valuable for the planning of new observing programs. Actually, as in the case of the northern hemisphere, the zone of maximum auroral frequency was defined mainly from geomagnetic rather than auroral data.

The diurnal variation of various forms of aurora was derived for stations of the First and Second International Polar Years, the frequencies found being corrected for the influence of cloudiness and poor seeing conditions on a tentative basis. The hourly isochasms have been drawn for 0^h, 6^h, 12^h, and 18^h GMT for the northern hemisphere.

The material on daily frequency of aurora has been published in two papers in the Journal of Terrestrial Magnetism and Atmospheric Electricity [v. 49, pp. 77-102, 1944; v. 50, pp. 105-124, 1945] and that on hourly frequency of aurora in CIW Publication 580 [''The Geomagnetic Field, Its Description and Analysis'' by E. H. Vestine, I. Lange, L. Laporte, and W. E. Scott, 1947].

The Department also operated an automatic auroral camera designed by Wells over a period of some months at College, Alaska.

Washington, D. C.
January 1948

APPENDIX TO THE REPORT OF THE AURORAL COMMITTEE

By Carl Störmer

A. Distribution of Auroral Cameras belonging to the Committee:

2 Astrocameras used in 1939 by Dr. Gartlein, Cornell University, U.S.A., are still used by him.
1 Astrocamera used in 1939 on my station Askim, is still in use on the same station.
2 Astrocameras used in 1939 in Tromsö are still in use there.
2 Astrocameras used in 1939 on my stations Oslo and Lillehammer are still in use on the same stations.
2 Astrocameras used in 1939 on the French-Norwegian expedition to Greenland are now distributed as follows: The first went to my station Tuddal and is now in use on my station Vålåsjö on Dovrefjeld. The second is in use on my station Kongsberg.
2 Astrocameras used in 1939 in Canada are still in use there.
3 Astrocameras used in 1939 in Copenhagen, Greenland, and Edinburgh are distributed as follows: The two first ones are in Copenhagen and the third in Edinburgh.
2 Meyer-cameras used in 1939 by Professor Götz, Arosa, are distributed as follows: One on my station Vålåsjö, Dovre and the second sent to Edinburgh.

Moreover, one Astrolens used in 1939 in a private aurora camera on my station Kongsvinger is now in Oslo and is placed in a cino-camera to take moving pictures of the aurora.

Another Astrolens used in 1939 on my station Oscarsborg was destroyed by war action in April 1940. However from the Norwegian insurance fund "Krigsskade erstatning" I received 941 Norwegian crowns which are deposited in a bank for the purchasing of a new lens when available.

B. Distribution of Pocket Spectroscopes belonging to the Committee:

Regarding the spectroscopes mentioned in my report from 1939 the distribution is now as follows:

2 Spectroscopes on my station Oslo.
5 Spectroscopes on my stations Askim, Holmestrand, Kongsberg, Lillehammer and Vålåsjö.
5 Spectroscopes in the Institute of Theoretical Astrophysics, Oslo.

Moreover two spectroscopes returned are now used by one of my assistants and by myself.

C. Distribution of Auroral Atlases, Supplements, Starmaps, and Covers:

Since the Washington meeting, A. W. Bröggers boktrykkeri, Oslo, has made a new inventory of the stock of Atlases, etc., stored in their building Karl Johansgate 12, Oslo, and have sent me the following report on the number of copies available:

Photographic Atlas of Auroral Forms	29
Supplements	134
Sets of maps (7 leaves, northern sky) about	4000

Sets of maps (7 leaves, southern sky) about	1000
Covers northern sky	29
Covers southern sky	6

To these must be added four Atlases and one supplement and also 4900 big starmaps of the northern sky stored in the Institute of Theoretical Astrophysics at Oslo.

A comparison with the list from A. W. Brögger in 1939, published in the Transactions of the Washington Meeting shows that a great number of maps of the northern sky were overlooked in preparing that list.

The difference, 23, in the number of Atlases, corresponds to the following distribution:

United States of America	7 copies
France	1 copy
Sweden	1 copy
Great Britain	5 copies
Norway	9 copies

A similar distribution is available for the 21 supplements.

Account for Auroral Cameras, Atlases, etc.
(All amounts are in Norwegian crowns.)

Voucher	Date	Item	Received	Paid	Balance	Remarks
	1939					
	July 3	Cash			4.50	See my report to Dr. la Cour, July 3, 1939
	29	From the Union	203.98		208.48	
	Aug. 1			0.50	207.98	
	22			9.73	198.25	
1	Sep. 2			6.50	191.75	
2, 3	Oct.27	Sale of Atlases	151.66		343.41	
	1940					
	Jan. 1	Interest 1939	3.14		346.55	
4	June 20	Postage		6.80	339.75	
	Dec. 5		941.00		1280.75	Refund for auroral camera Oscarsborg destroyed by war action April 9, 1940
5	17	Insurance		135.00	1145.75	
	1941					
	Jan. 1	Interest 1940	6.46		1152.21	
	25			2.04	1150.17	
	1942					
	Jan. 1	Interest 1941	2.14		1152.31	
6	Apr.15	Sale of Atlases, etc.	90.00		1242.31	
	1943					
	Jan. 1	Interest 1942	5.60		1247.91	
	1944					
	Jan. 1	Interest 1943	5.45		1253.36	

Account for Auroral Cameras, Atlases, etc. (Concluded)
(All amounts are in Norwegian crowns.)

Voucher	Date	Item	Received	Paid	Balance	Remarks
	1945					
	Jan. 1	Interest 1944	3.13		1256.49	
	1946					
	Jan. 1	Interest 1945	3.14		1259.63	
7	Nov. 2	Tveter		13.65	1245.98	
8	8	Tveter		7.00	1238.98	
9	23	Wischmann		24.00	1214.98	Focusing of aurora cameras
10, 11	Dec.23	Postage		7.30	1207.68	
	1947					
12	Feb.10	Brynildsen		42.35	1165.33	Tripod for camera
13	Aug. 8	Intertransport limited A/S		89.25	1076.08	
14	Sep. 23	Postage		5.00	1071.08	
	1948					
15	Mar.18	Postage		2.50	1068.58	

REPORT OF COMMITTEE FOR STUDY OF RELATIONS BETWEEN SOLAR ACTIVITY AND TERRESTRIAL MAGNETISM

The Committee for the Study of Relations between Solar Activity and Terrestrial Magnetism was appointed at the Lisbon Assembly in 1933 and was reappointed at the Edinburgh and Washington Assemblies in 1936 and 1939. Its members are Bartels, Chapman, Fleming (Chairman), and Maurain. Its last two reports appear in pp. 187-189 and on pp. 224-226 of Bulletins 10 and 11 of the Transactions of the Association.

In the interval since the Washington meeting two publications have been issued which summarize much of the research concerned with the relations of solar and terrestrial phenomena, particularly as concerns geomagnetism. "Geomagnetism", in two volumes by Sydney Chapman and Julius Bartels, was published in April, 1940, at Oxford [Vol. I relates to geomagnetic and related phenoména (xxiii + 542 pages) and Vol. II to analysis and physical interpretation of phenomena (x + 507 pages + 77 tabular pages)]. This is an outstanding treatise and summarizes admirably the progress in the results of research up to 1940 on the relationship between solar conditions and geomagnetism and is a source-book of inestimable value to the investigator. "Terrestrial Magnetism and Electricity" [The original edition of 1500 of this volume is exhausted; the National Research Council is now preparing an additional edition of 3000, with some minor corrections, by the offset method.] published in August, 1939, is a compilation in one volume of authoritative papers on various aspects prepared by 15 contributors as Volume VIII in the series Physics of the Earth sponsored by the National Research Council of the United States at Washington. This volume (x + 794 pages) is a reference book which may stimulate and enlist the interest of a larger group of investigators in terrestrial magnetism and electricity. Solar and terrestrial relations are noted in the various chapters and particularly as regards ionospheric phenomena.

For current progress reports during the past eight years it is understood there will soon be published the Sixth Report of the Commission for the Study of Relations between Solar and Terrestrial Phenomena of the International Council of Scientific Unions. There have appeared meanwhile numerous articles in various scientific journals on various aspects. Among these have been articles on progress in cosmic-ray relations, particularly the investigations by S. E. Forbush of the material accumulated by the network of precision cosmic-ray meters (see Bull. 11, p. 225) which showed there had been three considerable increases of cosmic-ray intensity in ten years of record at times of intense solar flare. Another important contribution is that by Sydney Chapman on the importance of solar observations designed to detect corpuscular emissions from the Sun such as are supposed to produce geomagnetic storms presented at the conference in Lyons in September, 1947; unfortunately this and other papers in that conference are not yet published. Chapman enlarges upon the detectability of such emissions by their production of Doppler-displaced absorption lines especially as soon as possible as a solar flare has begun and when the lines should be more intense. Pioneer and extremely difficult observations during a few magnetic storms have been made at Mt. Wilson by Richardson and at Cambridge (England) by Brück and Ruttlant. Alfvén has proposed in his theory of geomagnetic storms a method of emission of a solar stream which, however, seems untenable. Another symposium of the Commission of the International Council of Scientific Unions was to be held in Rome in April, 1948, but no report has been received.

The Department of Terrestrial Magnetism of Carnegie Institution of Washington will report to the meeting its program involving the following items: (a) The possible origin at the Sun of cosmic rays on the occasions when there were considerable increases in intensity over an hour or more noted at times of intense solar flares; (b) developments in the study of solar relationships through improved technique of ionospheric multifrequency methods; (c) proposed measurement of magnetic fields beyond the atmosphere of the earth using polarized radio waves; (d) statistics of geomagnetic observations at observatories showing magnetic effects of solar origin; and (e) cooperation in statistical examination of measurements of Zeeman separations to indicate the solar magnetic field.

During the war numerous problems which involved relationship of solar and geomagnetic activities were studied and the results of much of the classified work have now been declassified and may now soon be reported.

Because of the thorough coverage by the Commission for the Study of Relations between Solar and Terrestrial Phenomena of the International Council of Scientific Unions of the field of your Committee, it is recommended that the Committee be discharged and that a reporter be designated on behalf of IATME to keep in contact and to report upon the work of the Commission.

Jno. A. Fleming, Chairman
For the Committee

Washington 25, D.C.
July 31, 1948

REPORT OF COMMITTEE ON MAGNETIC SECULAR VARIATION STATIONS

By E. H. Vestine, Acting Chairman

The Committee has continued to function since the time of the Washington Assembly, members now acting being Messrs. Fleming, Johnston, Jolly, Maurain, Spencer Jones, and Vestine (Acting Chairman).

The Committee has solicited information respecting magnetic surveys at repeat stations of various nations. An exceptionally good response to a circular letter was received, and a short summary for surveys since 1939 is included here.

There have been no magnetic surveys over the oceans since 1929. The Committee finds a serious deficiency in the present data giving secular change over all oceans. This deficiency can be overcome by resumption of magnetic observations aboard the non-magnetic ship "Research" of the British Admiralty. The results obtained by a ship such as the "Research" will no doubt eventually be supplemented by magnetic observations in airplanes. However, at this writing the instruments for magnetic surveys in aircraft have not been developed for certain necessary components of field. Hence, it is not at present desirable to abandon the use of non-magnetic ships for ocean determinations of secular change, and probably for a considerable time to come.

The Committee has arrived at the following comments and recommendations:

(1) In order that information on secular change required for constructing world and other isomagnetic charts be more efficiently and effectively available, it is recommended that each country maintain or establish whenever feasible frequently occupied magnetic repeat stations not less than 1000 km apart, counting each magnetic observatory as one repeat station. The positions of stations of adjacent countries should be noted in defining locations. These stations will be those with most advantageous coverage and permanence of site selected from existing repeat stations throughout the area, and that they be designated International Repeat Stations. Where feasible, it is recommended that they be reoccupied about once every two years while operating a portable recording magnetograph for from one to several days, at or near the site, giving the reduction to mean of a Greenwich day.

(2) It is further recommended that both the observed and reduced results be promptly forwarded in duplicate to two central bureaus of the IUGG's Association of Terrestrial Magnetism and Electricity, one designated for the Western Hemisphere and one for the Eastern Hemisphere, so that the results for these special repeat stations would be currently available to those in need of data for construction of isomagnetic charts or for other purposes.

(3) In view of serious present deficiencies in our knowledge of secular change over the oceans, the Committee urges that the Admiralty complete the non-magnetic ship "Research" so that magnetic observations at sea may be undertaken at the earliest possible time. It is further urged that attention be given to establishing new stations at islands of the oceans, or the frequent reoccupation of existing stations on such islands, by the various governments responsible.

(4) It is further urged that emphasis be placed upon the probable permanence of such selected sites of stations, and that these sites be adequately marked so that their probable utility may be assured for several decades.

(5) It is likewise urged that there be established at least one secondary station near the main station to ensure continuity of values referred to the main station site, should the latter site later be lost. Areas of marked local disturbance should be avoided, if possible, and special care exercised where local disturbance is unavoidable.

(6) It is recommended that repeat stations additional to the International Repeat Stations be occupied as in the past, even though it may not be necessary or possible in practice to there execute measurements at such frequent intervals of time, and that their results be likewise forwarded promptly in duplicate to one of the two central bureaus.

(7) It is urged that final reduction from mean of day to mean of year, and to a suitably specified norm for the sunspot cycle, be executed at a central bureau, the results of such reductions to be available to those in need of these results.

(8) The Committee requests the Committee on Observational Technique to consider and make specific recommendations to the end that there be attained a form of portable magnetograph or magnetographs for recording time variations in declination, horizontal intensity, and vertical intensity for use at or near repeat stations.

The following abstract gives a short summary of magnetic survey activities of various countries responding to our request for information:

Africa

Belgian Congo--The President of the Comité Spécial du Katanga, Brussels, Belgium, reports that the magnetic observatory at Elisabethville was transferred on January 1, 1947, to the Ministère des Colonies, Brussels. However, observations of declination were being obtained at numerous triangulation points by the Service Géographique et Géologique of the Comité.

Egypt--Dr. M. R. Madwar, reporting for 1939-47, states that, in addition to those field magnetic stations listed on page 73 of Bulletin No. 11, five stations have been occupied during the period. They were established in October and November, 1939. Declination observations were made at Port Said, Daba, Matruh, El Dekhela and El Mandara.

French Africa--M. J. Dubief, Acting Director of the Institut de Météorologie et de Physique du Globe de l'Algérie, reported reoccupations of magnetic stations during the period 1939-47 as follows: In Northern Algeria, 24 stations; Algerian Sahara, 45 stations; French West Africa, 11 stations; Tunisia, 5 stations; French Equatorial Africa, 6 stations; Cameroon, 10 stations; Togoland, 1 station; and Tripolitania, 9 stations; total, 111 stations. In the near future a magnetic survey is planned of the western Sahara between Tindouf and Saint Louis, as also additional work in Northern Algeria. Later it is hoped that it will be possible to send expeditions via camels into the central part of western Sahara, where at present the declination is not known to any degree of accuracy. It is likewise desirable to make additional measurements in Morocco, in French West Africa, and in French

Equatorial Africa, particularly in the northern and eastern parts of the latter region where information regarding the secular change is especially lacking.

East Africa--W. A. Grinsted reports for the period 1939-42 that magnetometer-inductor DTMCIW No. 13, on loan from the Carnegie Institution of Washington, was used for regular observations of D, H, and I at the Nairobi permanent station at Kabete and for a series of field observations. Monthly observations commenced at Kabete in January 1939 were continued until August and thereafter approximately twice per annum. Field observations were obtained at 18 stations in Uganda, 4 in Kenya, 2 in Tanganyika, and 1 in Seychelles. Declination observations were also made at 4 stations in Southern Tanganyika in 1942 with a declinometer.

At present no serviceable magnetometers are held by the East African Meteorological Department and some time is likely to elapse before observations can be resumed. In addition, the permanent Nairobi station is being rendered unusable owing to building in its immediate vicinity and a new site will have to be found.

Union of South Africa--P. G. Gane, Deputy Director of the Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Johannesburg, reported that a brief investigation was carried out recently by Dr. A. L. Hales of the Institute and Mr. D. I. Gough to test Professor Blackett's theory of the magnetism of the Earth. This was reported in "Nature" [v. 160, p. 746, 1947] and the investigation may be taken up again in a larger way. The Institute has done no secular variation work, and has no immediate plans to carry out magnetic surveys.

Asia

Ceylon--The Surveyor General's Office reports periodical determinations of declination at the Colombo Observatory on the following dates: October, 1941; March and April, 1943; June, 1945; January and February, 1948.

China--Dr. Parker C. Chen, Chief of the Division of Geomagnetism, Institute of Meteorology, Academia Sinica, Pei-Chi-Ke, Nanking, summarized the magnetic observations in China made by the Chinese Geological Survey (1940-43, 67 stations) and by the Academia Sinica (1939-47, 104 stations). Of the total of 171, all on land, 66 were repeat stations. The stations were distributed in different provinces in southern and western China, mostly in latitude 23° to 31° north. These surveys in China were started by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, and then maintained by various institutions.

Japan--Dr. Kiyoo Wadati, Director of the Central Meteorological Observatory, Tokyo, reported the annual mean (provisional) values at Kakioka, 1935-1947, and Toyohara, 1935-39. On September 9, 1940, the Toyohara site was moved 1' south. Reductions for the old observatory data to the new observatory data, were given. No immediate magnetic survey of Japan is planned.

Netherlands East Indies--The Director of the Meteorological and Geophysical Service, Dr. M. W. F. Schregardus, reports that the self-recording instruments (X, Y, and Z) at Kuyper, have not been in operation since March 1, 1942, and that the absolute observations (D, H, and I) at Batavia, have not been made since August, 1945. The Service expects to resume measurements at both stations before the end of this year. A tabulation of results through 1944 was submitted. A survey on land of D, H, and I in the whole archipelago has been planned for this year.

Australasia

Australia--Information was received from J. M. Rayner, Chief Geophysicist, Bureau of Mineral Resources, Geology and Geophysics. Field observations have been carried out in all Australian states except Tasmania, including in addition, Cocos Islands (Indian Ocean), and in the sub-antarctic areas on Kerguelen, Heard and Macquarie Islands. In this work emphasis was placed on the reoccupation of stations for obtaining data on secular variation, but a number of new stations had also been established. It is planned to observe in New Guinea and Tasmania in the near future. In Australia and the antarctic areas it is proposed to make use of the airborne magnetometer.

As of July 1, 1947, the Bureau took over the control and operation of the Watheroo Magnetic Observatory, Western Australia, from the Carnegie Institution of Washington. An expansion of activities is planned. Recently, the Bureau also took over the Mount Stromlo Observatory (which had recently taken over from the Melbourne Observatory) the control and operation of the Toolangi Magnetic Observatory in Victoria. Only magnetic work is carried out at present, but it is proposed to expand the program to include other geophysical observations. Plans are being made for the construction of several geophysical observatories to be located at New Guinea, Heard Island, Macquarie Island, and at least one on Antarctica, possibly at Commonwealth Bay or Cape Freshfield.

Results of ten field observations taken in 1946, 1947, and 1948, were submitted, as well as a tabulation of 27 stations occupied in 1945.

New Zealand--Mr. Baird, Director, Magnetic Survey, Christchurch, advised that work in New Zealand has been quite extensive and reveals considerable new knowledge on the systematic trend of secular changes in that part of the globe. Resurveys show that the rate in declination is more rapid in the south than in the north. Much of new Zealand is of igneous geological formation and therefore magnetically disturbed. Many disturbed areas were used in the original survey by Messrs. Farr and Skey, but with the opening of new roads more suitable areas are now available. The present plan is to keep land observations up to date by repeating 20 suitably spaced and mostly different stations each year. At the time of writing 144 reoccupations at 102 stations had been carried out. During January to May, 1948, a total of 22 stations were occupied in the South Island, and in the Auckland and Campbell Islands. Further reoccupations are being contemplated for the Chatham and Kermedec Islands.

Europe

Austria--Report by Dr. F. Steinhauser, representing the Director of Zentralanstalt für Meteorologie und Geodynamik. Registrations are on hand for the magnetic station Wien-Auhof, in operation until April, 1945, when it was destroyed by war. At the present time a new station cannot be put into operation because of the lack of instruments.

Belgium--Reports by L. Koenigsfeld of the Institut d'Astrophysique and Prof. E. Lahaye of the Institut Royal Météorologique de Belgique. In 1944 all the apparatus and the registrations (1944) of the Manhay Observatory were partially destroyed. On January 1, 1946, the variometers were put in operation. Absolute measurements were begun March, 1946. In October, 1946, the CIW magnetometer No. 17 was brought from Elisabethville (Belgian Congo) and was used to standardize the instruments at the Observatory.

In 1941 and 1942 a magnetic survey at 2000 stations for vertical intensity was completed in the valley of Lienne (Belgium). The results have been published in the Annals of the Belgian Geographical Society. Measurements of gradient of potential (with altitude) will be made soon, if certain instruments being devised, are successful. Tabulation of values of Z, 1936-1947, at Manhay, D, 1946-47, at Uccle, D, 1936-1947, at Manhay, and H, 1936-1947, were reported.

The magnetic station at Uccle will soon be transferred to Dourbes (Namur Province). A research center of the Physique du Globe will be established there. Observations will be made in the field of terrestrial magnetism, earth currents, ionosphere, electrical state of the atmosphere, and cosmic rays. The station will serve as a base for a detailed magnetic survey of Belgium to consist of about 600 stations. (There will be one station per 50 km square.) The project is expected to begin some time in 1949.

The complete reorganization of the Magnetic Service of the Royal Meteorological Institute permits the establishment of a network of stations (6 to 10) for observing secular variation. These observations are expected to begin in 1948.

Czechoslovakia--Dr. Otto Seydl, Director, National Observatory of the Czechoslovak Republic (Budečska ul. 6, Prague XII) reported that work in magnetism was transferred in 1924 to the State Geophysical Institution, Prague II, Dittrichova ul. 13, of which Dr. B. Šalamon is the Director.

Denmark and Greenland--Dr. Helge Petersen, Director Danske Meteorologiske Institut, reported that 10 repeat stations established in Denmark in 1928 were reoccupied in 1940 and 1945. The results were published in the "Annuaires Magnétiques" for the years in question. As heretofore, observations at repeat stations will be made in years ending in "0" and "5". The Rude Skov Observatory continued in operation. The Godhavn Observatory (ϕ = 69° 14′ N, λ = 53° 31′ W) in Greenland was maintained, and a new, permanent magnetic observatory has been operated in Thule (ϕ = 76° 32′ N, λ = 69° 04′ W) since January 1, 1947. The new observatory is not in exactly the same locality as the temporary magnetic observatory operated during the Polar Year 1932-33, but control observations have been carried out at the site of the old observatory in order to obtain values for secular variation. The program for a general magnetic survey of Greenland is under preparation and will include the establishment of a net of secular variation stations.

Germany--Report by Dr. Böhnecke, Director of the German Hydrographic Institute. Since 1946, the magnetic observatory, Wingst, has been operated by the German Hydrographic Institute. Short reports for the years 1939-1942 have been issued. Year books are to be published, that for 1943 now being printed. Repeat surveys at stations of the 1935 magnetic survey of the Reich are planned. Values for 1935 (554 stations) have been tabulated and distributed on request to various organizations. In 1938 and 1939, underwater observations of H had been made in the Baltic Sea. Annual mean values at Wingst of D, H, Z, and I for the years 1939-1946 were submitted.

Numerous additional detailed magnetic surveys were also performed during World War II.

Great Britain--H. Spencer Jones, Astronomer Royal, Royal Observatory, reports that a land magnetic survey of Great Britain within the next few years is under consideration at the present time, and serious attention is being given to the making of new magnetic observations at sea and in the air.

Latvia--A general land survey for 235 stations in D, H, and Z, a sea survey of 102 stations, and repeat station survey at about 15 places was undertaken during 1937-1943.

Monaco--Vice-Admiral J. D. Nares, President of the Directing Committee, International Hydrographic Bureau, Monaco, stated that the Bureau did not occupy any magnetic stations on land, sea, or in the air during 1939-1947, nor do they contemplate doing so in the near future. The Directing Committee of the Bureau urged that the question of establishing non-magnetic ships, similar to the Carnegie, for magnetic and oceanographic observations at sea, be discussed at the forthcoming Oslo meetings. He also reported that the question of international agreement regarding publication of magnetic charts at regular intervals was considered at the Fifth International Hydrographic Conference held in April-May, 1947, and it was resolved that the International Hydrographic Bureau consider this question and see how it could be settled. A letter regarding this matter was circularized under date of November 26, 1947.

Netherlands--Between the years 1942 and 1947 a new magnetic survey of the Netherlands was undertaken. A number of the 378 stations were divided over the country, the distance between two stations being about 10 km. For the most part, all three elements (D, H, Z) were measured. All measurements have been reduced to the epoch 1945.0 by means of the variations and annual values obtained in the magnetic station Witteveen. The new magnetic atlas of the Netherlands will probably be issued during the year 1949. A preliminary account of part of the magnetic values and anomalies has been published in Hartmann's doctor thesis (Ph. C. P. Hartmann, Aardmagnetische anomalieën in Nederland, 1945). In the near future this survey will be extended to some interesting areas of the Netherlands, where considerable magnetic disturbances are found.

Norway--Prof. B. Trumpy, Director, Det Geofysiske Institutt, Bergen, has prepared an extensive report entitled "A magnetic survey of Norway", based on numerous stations. Dr. K. F. Wasserfall, Det Magnetisk Byrå, Bergen, advised that he has worked up Hansteen's old material for Oslo between 1843-1930. The declination and horizontal intensity results were published in "Geofysiske Publikasjoner". A similar study is under preparation for inclination between 1870-1910.

Poland--Dr. S. Kalinowska, Director of the Geophysical Observatory, Swider, communicated that during the war secular variation work was limited to observations made at the Swider Observatory. However, prior to the war, Prof. St. Kalinowski, established six stations for the study of secular variation. At present, as a result of the change in boundaries, three of these stations are outside of Poland. At the remaining three places, measurements of D, H, and I were made in 1946, two of which were repeated in 1947. Besides these, repeat observations connected with the magnetic net of Poland of order 1 were made at more than 20 stations. These were exact reoccupations so far as it was possible, and comparison of the recent and previous results should serve as material for obtaining secular variation. The establishment of new secular variation stations in Poland is contemplated.

Roumania--In 1939, 31 stations were observed for D, H, I (I at only 16 of the stations) in Transylvania, Bucovina, and Moldavia; D and H were observed in 1941 at 9 stations in Transylvania; in 1942 at 7 stations in Transylvania and in 1943 at 12 stations in Southern Moldavia. The Geophysical Section plans on continuing the network in Western Transylvania and also along the Carpathian Mountains. It is hoped that some old stations will be reoccupied and that some secular variation stations will be established. Three publications by Stefan Procopiu were "Valeurs des Elements Magnétiques et des Variations Seculaires à Jassy, pendant 16 Ans, de 1931 à 1947", published 1947, "Mesures magnétiques en Roumanie, de 1931 à 1940, et Cartes magnétiques de la Roumanie, dressées pour le 1er Juillet 1940", published 1940, and "Détermination des éléments magnétiques en Roumanie et Cartes magnétique de la Roumanie, dressées pour le 1er Juillet 1934", published 1935. The first publication contains annual values at Jassy, 1931-1947. The second contains a list of stations and values observed at each of D, H, and I for the years 1931-1940, also isomagnetic charts of Roumania (D, H, I reduced to 1940.5). The third is a discussion of earlier surveys in Roumania and contains a list of results at numerous stations for each of the survey and isomagnetic charts (D, H, I) reduced to 1934.5.

Spain--Captain W. Benítez, Director, Instituto y Observatorio de Marina, San Fernando (Cádiz), advised that the Hydrographic Service was assumed in 1944 by the new Instituto Hidrográfico. Unfortunately, however, the new Instituto Hidrográfico was severely damaged by a terrific explosion at Cádiz in August, 1947, with loss of nearly all the archives.

Sweden--Report by Nils Ambolt of the Kungl. Sjökarteverket. The Swedish secular net containing nearly 100 stations was measured again in 1942-43. The result of this survey will be published together with the result of a survey of the same net which will be carried out in 1948-49. During the first two surveys (1928-30 and 1936-37) the height of the magnetometer was not taken into account. However, during 1942-43, and for the future, magnetometers will be used at the same height over the fixed marks.

Switzerland--E. Wanner, Director of the Station Centrale Suisse de Météorologie, reported that the Regensberg Magnetic Observatory was founded for the purpose of a base station for a more precise magnetic survey of Switzerland. The recorded values have not been published. Two publications by P. L. Mercanton and E. Wanner, dealing with magnetic anomaly in the Jorat for the epoch 1943.5 (Part I, vertical intensity, 1943, and Part II, horizontal intensity, 1947) were published. It is expected that this work will be continued. At Regensberg the baseline values are controlled regularly with la Cour QHM and BMZ instruments.

North (including Central) America

Canada--During 1939 to date a number of observations were made at repeat stations and several local magnetic surveys by airplane carried out.

Greenland--See report under Europe, Denmark.

Guatemala--Dr. Claudio Urrutia E., Director, Observatorio Nacional Meteorologico y Seismologico, Guatemala City, reported that in April and May, 1944, the U. S. Coast and Geodetic Survey occupied six stations in Guatemala as follows: Guatemala City Base, Quezaltenango, Guatemala City Airport, Flores, Zacapa, and Coban.

Mexico--Ing. Ricardo Monges López, Director, Instituto de Geologia (Geología, Geofísica y Geodesia), Mexico City, reported the following: (1) Results of D, H, and I for 40 reoccupations at 33 stations during 1939-1946; (2) annual values of D, H, and I for the years 1939-1946 at Teoloyucan Observatory; and (3) list of present magnetic stations numbering 125. The Department of Terrestrial Magnetism of the "Observatorio Astronómico Nacional" is now under the Instituto de Geologia.

United States--The U. S. Coast and Geodetic Survey, Washington, D. C., summarized the magnetic observations made by their observers at repeat stations, July 1, 1939, to December 31, 1947, in the United States (399 stations), in Alaska (68 stations), in Mexico (11 stations), in Central America (34 stations), in the Canal Zone (2 stations), in Panama (7 stations), in South America (121 stations), in the West Indies (23 stations), in Bermuda (3 stations), in the Bahamas (2 stations), and in Antarctica (1 station), totaling 671 stations. [see Appendix 1] In regard to future surveys, it is expected that approximately 100 land (repeat) stations will be occupied in the United States and Alaska during 1948 and 1949. Efforts are being made to provide, through cooperative arrangements with other Federal agencies, for aerial magnetic surveys at sea. In lieu of portable magnetic observatories, two declination recording stations have been established in areas not adequately covered by observatories, and it is expected that additional stations of this type will be established within a few years.

South America

Argentina--Captain G. O. Wallbrecher, Director, Observatorio Astronómico de la Universidad Nacional de la Plata, communicated that plans are being made to install two magnetic observatories, one in the southeast of the province of Buenos Aires at approximately 38° S and 61° W and the other in the territory of Santa Cruz at approximately 50° S and 72° W. Some serious thought has been given to undertaking a magnetic survey of the entire country, dividing the work between the Servicio Meteorológico Nacional and the Commission for Measuring the Meridian Arc.

A large number of excellent observations at both regular survey and repeat stations were made since 1939 by Dr. O. Lützow-Holm and co-workers.

Peru--The Huancayo Magnetic Observatory, operated since 1922 by the Carnegie Institution of Washington, has been transferred to the Peruvian Government and its general geophysical program increased in scope, and continues to afford estimates of secular change. In a cooperative effort with the U. S. Coast and Geodetic Survey, a total of 16 repeat stations were reoccupied since 1939.

Uruguay--Report by Colonel Alberto Bergalli, Acting Director of the Servicio Geográfico Militar. Magnetic observations were begun in 1940, observations of D only, being taken until a magnetometer and earth-inductor were borrowed from the Carnegie Institution of Washington. A tabulation of results of D, H, and I for 1940-46 from 76 stations and one base station was submitted. An isogonic chart of Uruguay and surrounding areas, indicating isogonic lines at 1° intervals, reduced to epoch 1944.0 (and 1948.0 for a limited area), as well as magnetic stations occupied and disturbed areas, was constructed.

Other countries--See Appendix 1 listing station totals in cooperative effort with U. S. Coast and Geodetic Survey under North America (United States).

Appendix 1

Magnetic observations at repeat stations
July 1, 1939, to December 31, 1947
By observers of the U. S. Coast and Geodetic Survey

Country	New		Old	
	Complete	D only	Complete	D only
United States	76	16	191	116
Alaska	13	1	50	4
Mexico	7		4	
Canal Zone	2			
Costa Rica			4	
El Salvador	1		3	
Guatemala	2		7	
Honduras	3		4	
Nicaragua	5	1	4	
Panama	2		5	
Argentina			2	
Bolivia	4		6	
Brazil	15		20	
British Guiana	3		1	
Chile	7		11	
Colombia	4	1	6	1
Ecuador	2		3	
Paraguay	1			
Peru	7	1	8	
Uruguay			3	
Venezuela	4		10	1
Antigua	1		2	
Bermuda			2	1
Bahamas			2	
Cuba	3		5	1
Dominican Republic	1		2	
Haiti	2			
Jamaica	1		2	
Trinidad	1		2	
Antarctica			1	
Totals	167	20	360	124

REVIEW OF THE LITERATURE ON THE ION BALANCE OF THE LOWER ATMOSPHERE SINCE 1939*

By W. D. Parkinson

The object of this review is to present the most important recent publications on the subject of the ion balance of the lower atmosphere. Most of these have been written since the last meeting of the International Union of Geodesy and Geophysics in 1939, at which Gish and Sherman [see 1 of "References" at end of paper] presented a thorough discussion of the subject with a comprehensive bibliography and extensive tables of values of combination coefficients and the ratio of charged to uncharged nuclei.

The equation of small ion balance--This equation is sometimes written

$$dn_1/dt = q - \alpha n_1 \cdot n_2 - \eta_{1a} n_1 \cdot N_a$$

where n_1 and n_2 are densities of positive and negative small ions, respectively; q is the rate of ion formation (called "ionization" in this paper); N_a is the density of total nuclei; η_{1a} is the appropriate combination coefficient; and α is the recombination coefficient between small ions of opposite signs. If we neglect the usually small difference between positive and negative ions, the equation may be written

$$q = \alpha n^2 + \eta_{1a} \cdot n \cdot N_a$$

when, as is usually the case, the ion density is in equilibrium. Although most authors agree that this is applicable in homogeniously ionized air, J. J. Nolan [2] maintained that a formula more appropriate to the atmosphere is obtained by replacing αn^2 by a·n (where "a" is the appropriate coefficient). He considered that this is due to the fact that ionization takes place in columns of high ion concentration, and not homogeniously. Jaffé [3], however, considered that the formula is unaffected by columnar ionization. Wait [4] found a term in the formula directly proportional to n for cold weather in Washington, but he considered it due to the diffusion of small ions to walls and large dust particles. P. J. Nolan [5,6] using purified air found, after determining and allowing for the effect of diffusion, that the n^2 law holds for fairly large values of q, and for all values of q if these are measured in such a way as to discount ion pairs which recombine as soon as formed. He pointed out, however, that if q is measured in a strong field, so that this immediate recombination cannot take place, the term is $a \cdot n^p$, where p varies from 2 to 1, as q varies. Wait [4] gives the value 4×10^{-3} for a/q in cold weather in Washington, and zero in warm weather. J. J. Nolan's values for a/q (derived for various places) vary from 17×10^{-4} to 7×10^{-4}. Nolan and Galt [7] later confirmed the n^2 law.

Atmospheric pollution--The strong effect of atmospheric pollution has been brought out by a number of authors [8,9,10,11,12]. Ashford [13] found a logarithmic relation between visibility and potential gradient at Lerwick. He concluded that

* No formal report was submitted by the Committee on Ionic Equilibrium because of the diversion of several of its members, including the Chairman, to other fields of activity during the period 1939 to 1948. The review by W. D. Parkinson is presented since it gives an indication of some of the activities in the field of ion balance during the past decade.

there should be a minimum value of potential gradient of 130 volts per meter in clear weather. Considerably lower values have been measured at other places. Wait and Torreson [14] have pointed out the need of measurements of pollution and ionization as well as conductivity and potential gradient, for obtaining a complete picture of atmospheric electric conditions. Jones and Ledig [11] found that the density of condensation nuclei at Huancayo increased greatly in the early morning simultaneously with a decrease in conductivity.

Electrode effect and space charge--If the positive and negative small ion densities were everywhere equal, there would be no net space charge and the potential gradient would be constant throughout the atmosphere. This, however, is not the case. One of the causes of the excess of positive over negative ions usually found near the ground is the electrode effect of the ground. This effect is due to the repulsion of the negative ions by the negatively charged ground. Gish and Sherman [15] have given a detailed discussion of this effect. They found that the negative conductivity at Fairbanks (Alaska) is strongly affected by it in winter and Wait and Torreson [16] found it important in atmospheric electric elements at Watheroo (Australia). Sherman [17] found that the ratio of positive ion density in a strong positive field to that in a weak positive field is controlled by η and the mobility of small positive ions. From the fact that a positive field exerts little influence on the positive small ion density he deduced

$$\eta = 5.4 \times 10^{-6}$$

which is in good agreement with values obtained by other methods [1] (see Table 1).

Chalmers [46] has shown that a constant potential gradient and varying conductivity in the lowest meter of the air can be reconciled if q varies by a factor of 5 in this distance. Hogg [53] found that at Kew Observatory both the conductivity and potential gradient are nearly independent of altitude near the surface. Gish [47] showed that this may be attributed to an increase with altitude of the concentration of nuclei.

Herovanu [45] found that the ratio of positive to negative small ions depends on vapor tension. This may be due to an associated change in the properties or number of nuclei. Ogasahara [19] found that the positive space charge increases during a fog. He attributed this to the greater diffusion of negative small ions. It must be remembered that any feature which gives rise to a gradient of conductivity will affect the space charge. Thus a fog lying on the ground with clear air above it develops a positive space charge under normal conditions. Wait and Torreson [16] found a similar effect at Watheroo due to smoke.

The close connection of space charge and potential gradient is well brought out by observations made aboard the Carnegie [29].

An interesting instrument for determining space charge was developed by Mecklenburg and Lautner [48]. It consists of an electrometer which records potential gradient and which can be thrown from an airplane.

Values of parameters--Wait [4] has found an interesting empirical relation between the coefficient of recombination and the mobilities of several different types of ions. It is

$$\alpha = k^{3/4} \times 1.22 \times 10^{-6}$$

Jaffé [3] presented a thorough discussion of the theory of recombination coefficients in which he states that the recombination coefficient for small ions varies with their concentration.

Nolan and Galt [7] measured η_a and found that it varied with the age of the nuclei. Making the assumptions

$$\eta_{12}/\eta_{10} = \eta_{21}/\eta_{20}$$

and

$$\eta_{12} = \eta_{10} + 4\pi k_+ e$$

where k_+ is the mobility of positive small ions, they gave values of parameters quoted in Table 1. Nolan and Fahy [18] also noted the influence of the age of nuclei on values of parameters. Ogasahara [19] found $\eta_{10} < \eta_{20}$, a fact which he attributed to the greater diffusion of negative small ions.

The following table summarizes recent determinations of the combination coefficients.

Table 1

Observer	Remarks	η_{10}	η_{20}	η_{12}	η_{21}	η_{1a}	η_{2a}	η_e
		in units 10^6 cc/sec						
Gish and Sherman	least value	0.4	0.6	2.2	2.5	0.5		3.2*
quoted in [1]	greatest value	6.8	7.6	8.7	9.7	8.2		25.7*
	median value	0.6	1.1	2.4	4.5	1.6		3.9*
Nolan and Galt	new ions	4.0	5.0	6.0	7.5			
[7]	old ions	11.2	12.3	13.4	14.7			
Nolan and Fahy	new ions					2.4	2.9	
[18]	old ions					8.4	9.2	
J. J. Nolan [2]	Watheroo					15.0		
	Huancayo					0.5		
	median of 8 places					3.4		
Sherman [17]	from electrode effect					5.4		
Present author	at Huancayo							5.0

* These values have been computed from $\eta_e = \eta_{12} + (N_o/N_2)\eta_{10}$ assuming (N_o/N_2) to be 2.5.

Symbols for the various coefficients have the following meanings: η_{10} is the combination coefficient between positive small ions and neutral nuclei; η_{20} is that between negative small ions and neutral nuclei; η_{12} is between positive small ions and negative large ions; η_{21} is between negative small ions and positive large ions; η_{1a} is between positive small ions and all nuclei; η_{2a} is between negative small ions and all nuclei and η_e is between small ions and large ions neglecting uncharged nuclei.

P. J. Nolan found that the ratio of all nuclei to uncharged nuclei varied considerably with the age of the nuclei during the first 17 hours of their life, but remained fairly constant after this time [20]. The ratio also varied somewhat with concentration. Sherman [21,22] repeated the experiments of Torreson and Wait [23] with careful observational and statistical considerations and under varying conditions, such as time of day and locality. He confirmed the low value of this ratio previously reported. Sherman's value was 1.33 ± 0.04 for N_a/N_o. The present author found practically no correlation between simultaneous determinations of large ion concentration and Aitken nuclei counts at Huancayo, but a fair correlation between Aitken nuclei and intermediate ion concentrations.

Nature of condensation nuclei--Considerable work has been done on the nature of condensation nuclei. Aliverti and Lovera [25], Wright [24], and Dessens [26] stated that salt particles play an important part. Dessens has found droplets of supersaturated salt solution far inland. He considers that these drops remain stable above a certain relative humidity, and below this they evaporate suddenly. These considerations have been criticized by Simpson [27] who maintained that nuclei cannot in general be salt particles. He has based this conclusion on variations with visibility. He considered that particles of sulphuric acid were more likely material for nuclei. Neither Simpson nor Wright specified to what mobility range these particles corresponded. Hogg investigated intermediate ions in London, and concluded that they were composed of sulphuric acid [28]. The salt nucleus conception is not supported by nucleus counts made at sea on board the Carnegie [29] which were found to be very low, and to increase on approach to land.

Linke [30] obtained photographs of condensation nuclei with an electron microscope. He found two kinds of nuclei, one a porous felt-like structure with a central part opaque to electrons, the other with a hexagonal crystalline structure. Both have radii between 2.5 and 10×10^{-6} cms. J. J. Nolan and P. J. Nolan [31] investigated the balance of nuclei content of the atmosphere. They found a velocity of fall of 15×10^{-5} cms/sec and a diffusion coefficient of 12×10^{-6} cms^2/sec, from which they deduced a radius of 3.6×10^{-6} cms. P. J. Nolan [20] investigated the coefficients in the formula for large ion balance of the air, viz.

$$dN/dt = Q - \gamma N^2 - \lambda N$$

He determined that $\gamma = 2.0 \times 10^{-9}$ and $\lambda = 7.2 \times 10^{-6}$, with the greater part of λ being due to diffusion. Gilbert [32] considered that there should be an additional constant term P_o to be added to N_o for what he calls non-condensation nuclei. In this case $n_2.N_1/n_1.N_o$ [see 1] should not be a constant, but a function of N_o/P_o.

Slow ion "mobility spectrum"--In recent years the importance of the mobility of slow ions (i.e. ions other than small or molecular ions) has been realized, and the conception of a "mobility spectrum" has come into significance. Hogg [28] determined the mobility spectrum of ions with mobilities between 0.01 and 0.001 cms^2/volt.sec. He obtained a "fine-line" spectrum, with distinct values of mobility throughout this range. Yunker [33], on the other hand, using Zeleny's method of mobility determination, found a continuous distribution with a steady increase in ion density per mobility interval from about 1.0 to 0.04 cms^2/volt.sec. The frequency density of this histogram, in the interval 0.94 to 0.47 increases as the number of small ions decreases. Apart from this, the ratios of frequency densities of any two parts of the spectrum remains constant, thus leaving the general form of the spectrum unchanged. The whole distribution decreases with increasing nucleus count. This contradicts the observations of Wait and Torreson [52] who found a positive correlation between intermediate and large ions. Clay [34] obtained a continuous distribution of mobility at sea.

Time and space distribution of condensation nuclei--Bradbury and Meuron [35] found a diurnal variation of condensation nuclei with the following characteristics: a sudden rise after sunrise to a mid-morning maximum, a subsidiary minimum in the evening and a steady decrease throughout the night to the principal minimum before sunrise. They suggest that this is due to a vertical gradient in nuclei concentration which varies with the extent of convection currents. Yunker [36] has measured such a gradient by making nuclei counts at two different levels.

Jones and Giesecke [37] measured condensation nuclei concentration as well as potential gradient and conductivity at Huancayo during a partial eclipse. All these elements reverted toward night-time conditions during the period of the eclipse.

Mrs. Phillips [38] compared large ion densities with occurrence of fog. She found higher large ion concentrations on days immediately before and during the fog.

Ionization--Although ionization is an important factor in the ion balance of the atmosphere, it is generally fairly regular, and variations in it are rarely the controlling influence on variations in the ion density at ground level. It is the controlling influence, however, on the ion density above the first few kilometers of the atmosphere. Between this surface layer and the ionosphere, cosmic rays are almost the only source of ionization. This has been shown by Gish and Sherman [40] from balloon flights using Regener's measurements of cosmic ray intensities. This work has been summarized by Sayers [39]. Korff [41] has shown that neutrons in cosmic rays play only a minor role.

At the surface over land, however, the principal source of ionization is radiation from radioactive materials all of which originally come from the ground. Cullen [42] found that radon was exhaled from the earth more strongly in hot than in cold weather, and that it was choked off by snow on the ground. Kovach [43] found a slight diurnal variation of radon content in soil gas, it being greatest at time of lowest atmospheric pressure. Clay [34] found a high ionization at sea during heavy rain. This may be similar to the thunderstorm effect found by Wait and McNish [44] in Washington.

Of some popular interest is the question whether atomic bombs have a world wide effect on atmospheric electric elements. Herzog [51] in Houston (Texas) claimed to have detected the effect of the Bikini bomb, but Hess and Luger [49] in New York and E. D. Weeks and D. F. Weeks [50] in San Antonio (Texas) failed to detect any effect.

It is a pleasure to express my thanks to Mr. O. H. Gish, who made several valuable suggestions which I was pleased to adopt.

References

[1] O. H. Gish and K. L. Sherman, Trans. Washington Meeting 1939, Internat. Union Geod. Geophys., Ass. Terr. Mag. Electr., Bull. 11, 460-491 (1940).
[2] J. J. Nolan, Proc. R. Irish Acad. A, vol. 46, No. 7, 77-90 (1940).
[3] G. Jaffé, Phys. Rev., vol. 58, 968-976 (1940).
[4] G. R. Wait, J. Wash. Acad. Sci., vol. 36, No. 10, 321-343 (1946).
[5] P. J. Nolan, Proc. R. Irish Acad. A, vol. 49, No. 5, 67-90 (1943).
[6] P. J. Nolan, Nature, vol. 148, p. 26 (July 5, 1941).
[7] P. J. Nolan and R. I. Galt, Proc. R. Irish Acad. A, vol. 50, No. 5, 51-58 (1944).

[8] S. M. Mukherjee, Jour. Univ. Bombay, No. 11, 45-55 (1942).
[9] G. R. Wait, Terr. Mag., vol. 48, 49-63 (1943).
[10] G. R. Wait, Trans. Amer. Geophys. Union, 24th Annual Meeting, part 1, 219-220 (1943).
[11] M. W. Jones and P. G. Ledig, Trans. Amer. Geophys. Union, 23rd Annual Meeting, part 2, 301-304 (1942).
[12] G. R. Wait, Terr. Mag., vol. 47, 243-249 (1942).
[13] O. M. Ashford, Q. J. R. Met. Soc., vol. 67, No. 288, 51-54 (1941).
[14] G. R. Wait and O. W. Torreson, Trans. Washington Meeting 1939, Internat. Union Geod. Geophys., Ass. Terr. Mag. Electr., Bull. 11, 460-466 (1940).
[15] O. H. Gish and K. L. Sherman, Terr. Mag., vol. 45, 173-190 (1940).
[16] G. R. Wait and O. W. Torreson, Terr. Mag., vol. 46, 319-342 (1941).
[17] K. L. Sherman, Trans. Amer. Geophys. Union, 24th Annual Meeting, Part 1, 221-222 (1943).
[18] P. J. Nolan and E. F. Fahy, Proc. R. Irish Acad. A, vol. 50, No. 14, 233-256 (1945).
[19] K. Ogasahara, Taihoku Inst. Met. Geophys., Taihoku Imp. Univ., 15 pp. (1939).
[20] P. J. Nolan, Proc. R. Irish Acad. A, vol. 47, 25-38 (1941).
[21] K. L. Sherman, Terr. Mag., vol. 45, 191-204 (1940).
[22] K. L. Sherman, Trans. Amer. Geophys. Union, 23rd Annual Meeting, part 2, 316-317 (1942).
[23] O. W. Torreson and G. R. Wait, Terr. Mag., vol. 39, 47-64 (1934).
[24] H. L. Wright, Q. J. R. Met. Soc., vol. 66, No. 283, 3-11 (1940).
[25] G. Aliverti and G. Lovera, Accad. Sci. Torino, Atti. 74, Disp. 5a, 573-590 (1939).
[26] H. Dessens, Paris, C.-R. Acad. Sci., vol. 223, No. 22, 915-917 (1946).
[27] G. C. Simpson, Q. J. R. Met. Soc., vol. 67, No. 290, 163-169 (1941).
[28] A. R. Hogg, Proc. Phys. Soc., vol. 51, No. 288, 1014-1027 (1939).
[29] O. W. Torreson, W. C. Parkinson, O. H. Gish, and G. R. Wait, Scientific results of cruise VII of the Carnegie during 1928-1929, Oceanography III, Carnegie Institution of Washington Publication 568 (1946).
[30] F. Linke, Naturwiss., vol. 31, Heft 19-20, 230-231 (1943).
[31] J. J. Nolan and P. J. Nolan, Proc. R. Irish Acad. A, vol. 45, 47-59 (1938).
[32] G. Gilbert, Paris, C.-R. Acad. Sci., vol. 224, No. 8, 585-587 (1947).
[33] E. A. Yunker, Terr. Mag., vol. 45, 127-132 (1940).
[34] J. C. Clay, Proc. 6th Pacific Sci. Cong., Berkeley, Calif., 1939, 1, 91-98, Univ. of Calif. Press (1940).
[35] N. E. Bradbury and H. J. Meuron, Terr. Mag., vol. 43, 231-240 (1938).
[36] E. A. Yunker, Terr. Mag., vol. 45, 121-126 (1940).
[37] M. W. Jones and A. A. Giesecke, Terr. Mag., vol. 49, 119-122 (1944).
[38] M. L. Phillips, Terr. Mag., vol. 47, 295-299 (1942).
[39] J. Sayers, Reports on progress in physics IX, 52-61 (1942-43), London Phys. Soc. (1943).
[40] O. H. Gish and K. L. Sherman, Nat. Geog. Soc., Contr. Tech. Papers Stratosphere Ser. No. 2, 94-116 (1936).
[41] S. A. Korff, Terr. Mag., vol. 45, 133-134 (1940).
[42] T. L. Cullen, Terr. Mag., vol. 51, 37-44 (1946).
[43] E. M. Kovach, Terr. Mag., vol. 51, 45-55 (1946).
[44] G. R. Wait and A. G. McNish, Mon. Weather Rev., vol. 62, 1-4 (1934).
[45] M. Herovanu, Soc. Roumaine de Physique, Bull. 40, 74, 57-76 (1939).
[46] J. A. Chalmers, Q. J. R. Met. Soc., vol. 72, Nos. 312-313, 199-205 (1946).
[47] O. H. Gish, Trans. Amer. Geophys. Union, 21st Annual Meeting, part 2, 314-316 (1940).
[48] W. Mecklenburg and P. Lautner, Zs. Phys., vol. 115, 9-10, 557-570 (1940).
[49] V. F. Hess and P. Luger, Phys. Rev., vol. 70, No. 7-8, 564-565 (1946).

[50] E. D. Weeks and D. F. Weeks, Phys. Rev., vol. 70, 565-566 (1946).
[51] G. Herzog, Phys. Rev., vol. 70, 227-228 (1946).
[52] G. R. Wait and O. W. Torreson, Terr. Mag., vol. 40, 425-431 (1935).
[53] A. R. Hogg, Canberra, Mem. Solar Obs., No. 7 (1939).

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

REPORT OF COMMITTEE ON MAGNETIC CHARTS --ORGANIZATION OF THE WORK

By Sir Harold Spencer Jones, Chairman

The appointment of a Committee on Magnetic Charts (organization of the work) was made in consequence of the Report of the Sub-Commission on the Uniformity of Magnetic Charts, presented at the meeting in Edinburgh in 1936. There has since been created a Committee on Magnetic Charts--Methodology. A clear line of demarcation between the functions of these Committees does not seem possible. Both Committees are small and it seems preferable that they should be combined into one single Committee which can deal with all aspects of the problem of magnetic charts. However, the present report covers work undertaken in close cooperation with the Committee on Magnetic Charts--Methodology.

The findings and recommendations submitted at the Washington meeting in 1939 have been amplified somewhat, and it has been possible to render these recommendations in slightly more specific form.

The following resolutions of the Sub-Commission on the Uniformity of Magnetic Charts may be recalled here:

"(1) For the making and improvement of all-world magnetic charts and the charts of regions comprising more than one country, it is recommended that the results of all such actual magnetic measures on land or at sea as are available should be collected as far as possible in one place.

"This collection is intended to be at the disposal of scientific institutions and individual scientists, both for cartographic and other practical and scientific purposes."

"(2) To ensure that this material is kept up to date, it is very important to organize a net of repeat stations, in order to investigate secular variation all over the globe and to make determinations at such stations at common and as far as possible equidistant epochs.

"The common epochs of these world-wide observations may be considered as International Magnetic Years.

"For special researches into the peculiarities of secular variations in certain regions, more frequent observations at repeat-stations are necessary."

"(5) The most effective method of collecting in one place the observational material that has been mentioned would appear to be the organization of a special bureau.

"A further purpose of this bureau should be to form a collection as complete as possible of the registrations from the magnetic observatories.

"This part of the work of the bureau would therefore consist of a direct continuation of the archives of registering-copies from the International Polar Year 1932-33, collected at Copenhagen by Dr. D. la Cour.

"The main purposes of the proposed bureau would therefore be as follows:

(a) To keep the archives of actual world-wide material of magnetic observations.
(b) To keep the corresponding archives of copies of the registering material."

As before, the Committee fully endorses resolution No. 1, and considers that it is essential that the results of all magnetic observations on land or sea should be collected as far as possible in one center which would make them available to those who require to use them. This Committee does not endorse resolution No. 5, but considers that, in the first place, the bureau should be limited to collecting and making available the relevant magnetic data.

The Committee considers that suitable places for the bureau would be either at the Danish Meteorological Institute, Copenhagen, or the United States Coast and Geodetic Survey, Washington, D. C.

There would be many advantages in having two centers where the observations would be collected, one in Europe and the other in the Western Hemisphere. To communicate results to two centers would not entail much additional work on the part of the observing organizations, but it would be a distinct convenience for any person or organization in the Western Hemisphere, desiring to obtain observational material, to be able to apply to a center in that hemisphere.

The Committee therefore expresses the hope that it may be possible to arrange for the collection of the observational material in two centers. It is recommended that the matter should be discussed at the meeting of the Association in Oslo, when the financial aspect can be considered.

The organization making the observations should be responsible for all data necessary for their reduction by a bureau.

The results should be supplied in the form of actually observed quantities, without any correction for diurnal or annual variations, together with the place, date, time of observation, and instrumental corrections. Corrections for diurnal or annual variation, if known, should be given separately. Published charts, if any, should also be provided.

Though it is not recommended that the bureaus should attempt to collect magnetic observatory records, it is important that they should keep a file of published results. These provide datum points to which the magnetic charts must be anchored.

In order that the bureau may function efficiently it is important that the results of all observations should be communicated with as little delay as possible. It is therefore recommended that as soon as the establishment of such a central bureau or bureaus is arranged, all bodies responsible for making magnetic observations should be informed and requested to collaborate in supplying the results of observations with as short a time-lag as possible.

The method to be used for distributing the results to interested parties must necessarily depend upon the resources of the bureau. The material might be duplicated or photographed on films.

Magnetic data are much more extensive and more frequently determined over some portions of the surface of the Earth than over others. The regions where observations are particularly needed for the purpose of constructing charts are (a) regions where there have been few observations for several years; (b) regions where the secular change is known to be changing, even though there have been recent observations.

The ocean areas where the data are most uncertain at the present time are the southern Indian Ocean, the region of the Atlantic Ocean to the south and west of Cape Town, and the South Pacific. The Committee hopes that the first two of these regions will be covered by the R.R.S. Research on her first cruise.

The constructing of magnetic charts for a given epoch necessarily involves extrapolation from past observational data. For this extrapolation to be reasonably satisfactory it is necessary to take into consideration not merely the secular changes of the magnetic elements, but also the secular changes of the secular changes. Data for such purposes are provided by the permanent magnetic observatories, but the distribution of such observatories over the Earth is far from uniform. The resolution No. 2, given above, would result in much more detailed and accurate knowledge of the secular variations and their changes.

The Association has appointed a separate Committee on Secular Variation to consider this and other matters affecting secular variation. The Committee on Magnetic Charts is accordingly not concerned directly with resolution No. 2, but endorses the importance for the construction of magnetic charts of the work of the Committee on Secular Variation.

The preparation of charts to be used for practical purposes involves extrapolation from observational data. For scientific purposes it is much preferable to have maps for a preceding epoch based only upon observational data, without any extrapolation. In revising a magnetic chart for a certain epoch in order to prepare a chart for a subsequent epoch one of the first steps is the comparison between the chart and observations, using the most accurate values of the secular changes that can be assigned in the light of later observations. This process is equivalent to the preparation of a correct chart for a preceding epoch.

If the preparation of such charts could be undertaken at one or other of the central bureaus, where the complete observational material is available, they would be of value for scientific purposes and would avoid the present considerable duplication of work on the part of the various organizations concerned with the preparation of charts required for practical purposes. The prediction of secular-variation changes, which involves the exercise of judgment, may be left to those responsible for preparing charts required for practical purposes.

The preparation of such charts raises the question of the considerable gaps in the observational data and the long absence of ocean data. The question of financial provision for the work would need also to be considered.

The Committee does not consider that it is in a position to make a definite recommendation on the matter of preparation of world magnetic charts without the use of prediction, but is of the opinion that the question should be discussed at the meeting of the Association in Oslo.

The Committee accordingly makes the following recommendations and comments:

(1) That all magnetic observations on sea, land, or in the air should be collected in at least one central bureau, which would place the material at the disposal of those who desire to use it for practical or scientific purposes. The Committee recommends that one of these central bureaus be the United States Coast and Geodetic Survey, and is pleased to learn that the United States Government has authorized such activity by the Coast Survey for this purpose.

(2) That observing organizations should be asked to cooperate by communicating the results of all magnetic observations on sea, land, or in the air, with as little delay as possible, to the central bureaus. Original data should be furnished whenever possible.

(3) That observations are urgently needed, especially over all the oceans, in Africa, and in the north and south polar regions.

(4) The Committee stresses the importance of the work possible of performance by the non-magnetic ship R.R.S. Research and urges that it be outfitted and assigned to magnetic observations at sea at the earliest possible time.

(5) That countries with air facilities and equipment for making magnetic observations by air take immediate steps to coordinate and plan efforts to secure data over the oceans to supplement the work of the Research, and also to secure magnetic-survey data by air over the various land areas of the Earth.

REPORT OF COMMITTEE ON MAGNETIC CHARTS--METHODOLOGY

By E. H. Vestine, Acting Chairman

The work of the Committee on Magnetic Charts--Methodology, appointed at the Edinburgh meeting in September 1936 and reported upon by Dr. J. Keränen at the Washington meeting in 1939, has been continued. The Committee has considered a number of proposals but has not succeeded in drafting more than a few specific recommendations upon which full agreement has been achieved.

An important question which remains to be resolved is that of the extent to which isomagnetic charts should be smoothed for various purposes and the associated problem of indication of local magnetic anomalies. Another problem which has to be resolved is the matter of specific indication of positions of stations on world isomagnetic and other charts so that the user may readily note those areas on which the magnetic information shown by isomagnetic lines is based on extrapolated or interpolated data. Another important question which would seem best considered in future years rather than at present is that of the most effective use of results of magnetic surveys by air in the construction of isomagnetic charts. Finally, although the increased use of spherical harmonic analysis in magnetic-chart construction has been looked on with high favor by all members of the Committee, it has not been possible to make detailed and specific recommendations on this point.

A division of opinion among members of the Committee has been noted with respect to the feasibility of constructing isoporic charts in various field components mutually consistent with one another and with the known character of the geomagnetic field. One member of the Committee, who has used certain suggestions of Chapman, has maintained that such adjustments yielding zero value of curl and closure of line intervals offer no special difficulties in methodology provided large-scale graphs of the charts along parallels of latitude and meridians of longitude are used, and that the procedures probably facilitate the construction of more accurate isoporic charts in certain areas. Two members of the Committee have agreed that consistency tests are useful as a general check, but question the advisability of application of such tests as an adopted standard procedure.

The Committee accordingly makes the following recommendations:

(1) That graphs of measured values at repeat stations and observatories, corrected for extraneous variations, be drawn to suitable scale for field components D, H, and I, or D, H, and Z, to permit estimates of secular change.

(2) That world isoporic charts in D, H, I, and Z be drawn at intervals not less than ten years apart in each of these elements.

(3) That the isoporic charts in D, H, and Z be adjusted to mutual consistency and with the known properties of the geomagnetic field, at least for areas where obvious benefit probably conveniently results.

(4) That there be undertaken exhaustive and independent construction of world isomagnetic charts to large scale for the field components D, H, I, Z, X, Y, and F at intervals several decades apart.

(5) That world charts of D at five-year intervals beginning in 1950 and of H, I, Z, and F at ten-year intervals beginning with epoch 1955 be drawn.

(6) That increased use be made in future years of the techniques of spherical harmonic analyses in facilitating construction of world isoporic and main field charts.

(7) It is further recommended that the technical qualifications of the individual constructing world isoporic and main field charts must be adequate to comprehend and utilize existing theory of the properties of isomagnetic lines, especially near singular points in the surface fields.

Washington, D. C.
May 27, 1948

REPORT OF THE COMMITTEE ON REGISTRATION IN ICELAND OF GIANT PULSATIONS

By Johannes Olsen, Chairman

It is well known that the quick run records from the temporary observatory in Iceland during the Polar Year 1932-33 showed a frequency of giant pulsations corresponding to 28 a year. According to a proposal by S. Chapman and D. la Cour [Trans. Edinburgh Meeting, 1936, p. 441] the Association at the General Assembly at Edinburgh 1936 established the Committee on Registration in Iceland of Giant Pulsations and allotted a grant of Ł 400 to organize temporary quick run magnetic registrations in Iceland at four stations separated by distances of about 15, 50, and 100 kilometers. It was assumed that the instrumental equipment could be borrowed from the International Polar Year Commission.

As already reported to the General Assembly at Washington 1939 [Trans. Washington Meeting, 1939, p. 263] a preliminary trial was made in Iceland during four months in 1937 with two quick run stations separated by 15.5 kilometers, but the result was a negative one, no giant pulsations occurring at all. With the exception of Ł21 used for overhauling of the instruments, this trial was paid by Danish and Icelandic authorities and as the negative result comported a postponement of further investigations Ł379 out of the original grant was still unused at the time of the General Assembly at Washington 1939. Of this sum Ł29 were in the hands of Dr. la Cour, whereas the resting Ł350 were never drawn.

The war prevented new trials, but as the Association's grant to Dr. la Cour for photographic reproduction of records was surpassed in the following years on account of the war conditions the above-mentioned Ł29 were used for this purpose before the death of Dr. la Cour in 1942.

The amount available for further work is consequently the above-mentioned Ł350 not yet drawn and the Ł29 if this sum may be voted again by the Executive Committee of the Association.

Due to the present price level the originally planned enterprise will demand a greater amount than now available. Further, it seems unwise to start this experiment just a full sunspot period after the unsuccessful trial in 1937, whose lack of success may be due to a scarcity of giant pulsations in Iceland in disturbed years.

As the occurrence of giant pulsations in Iceland seems rather capricious the Committee has considered the following three possibilities for further work:

1. The establishment in Iceland of a temporary quick run station for some years in order to see how the frequency of giant pulsations in Iceland varies with time.
2. In the northern part of Scandinavia we have three observatories (Tromsö, Abisko, and Sodankylä) in the auroral zone, lying so near each other that more than ten per cent of the recorded giant pulsations (six a year) are common for at least two stations. If a quick run was running continuously at each of these stations it would be reasonable to place a part of the grant available at the disposal of a reporter to study these common giant pulsations.

3. If at some time to come a frequent occurrence of giant pulsations in northern Scandinavia promises a good result the Committee might further establish out-stations with quick runs in convenient distances from one of three stations.

ad 1. This plan may be realized without much money. From a discussion with the Director of the Meteorological Institute in Iceland the Chairman got the impression that a member of the staff of that Institution might be willing to operate such a station for a reasonable pay. If an appropriate room could be found for the instruments, the only extra expenditure would be the charge for photographic paper. With this station running it would be possible for the Committee to establish three other quick run stations if it should happen that a frequent occurrence of giant pulsations was prevailing in Iceland.

ad 2. For the time being the quick runs at the three stations are not in regular use and the Committee recommends that the Association by a resolution stresses the importance of continuous quick run records from the three stations. As reporter to the Association about giant pulsations, Dr. E. Sucksdorff is recommended.

The Committee suggests that it should be continued and hopes that the Association also in future will be willing to support investigations relating to giant pulsations. It hopes further that the Association will support an application to the temporary Commission for Liquidation of the agenda of the International Commission for the Polar Year to leave temporarily the necessary equipment for three quick run stations at the disposal of this Committee.

REPORT OF COMMITTEE ON METHODS OF OBSERVATORY PUBLICATION

By Elliott B. Roberts, Acting Chairman

1. Considerations.

The principal facts to be considered are:

(a) The importance of publishing observatory data in detail remains great, in view of many continuing investigations based thereon and because of new requirements resulting from recent technical advances.
(b) Published data in complete detail are seriously needed from a small number of suitably located observatories comprising a chain of key stations, and it is not of great importance to have such complete data from all other existing observatories.
(c) Many of the presently existing magnetic observatories of the world do not have the means to publish detailed reports.

2. Recommendation on Types of Data to be Published.

To make the performance as simple and economical as possible, the requirements should be only for basic data in their most widely used form, with a minimum of derivative data or that which involves great labor and serves few investigators.

The following are considered of primary importance and should be published regularly, at least by the designated key observatories. They include for three elements the following in order of importance:

(a) Hourly values, with notations regarding interpolated values.
(b) Monthly and yearly means, at earliest availability.
(c) K-indices, and C-figures where previously reported.
(d) Information and data regarding reliability of values and proper performance of absolute and variation instruments, such as the orientation of magnets, data on absolute observations or the consequent base-line determinations, scale-value determinations, temperature coefficients, comparisons of absolute instruments with others and with standard instruments, etc.
(e) With (a) or separately, daily sums and means, and sums and means by hours for each month and for the selected five quiet and five disturbed days.
(f) Composite daily variation or hour-by-hour departures of the general and selected-day means by months, Lloyd's seasons, and years.

The following other desirable but secondary data should be published by all observatories which find it possible:

(g) Reproduction of magnetograms or in lieu thereof maxima, minima, and individual-day ranges and descriptions of magnetic activity.
(h) Noncyclic changes for the data of (f) above.
(i) Harmonic analysis of daily variations.
(j) Accounts of equipment and records available.

3. Processing by Punch-Cards.

An important consideration is the possible use of a punch-card process. It should be noted that hourly values may be designated by pencil marks on special cards suited to subsequent mechanical interpretation. This should be no more laborious than the usual tabulation. It permits automatic completion of most subsequent operations such as application of scale-value adjustments, addition of base-line value, computation of comprehensive and selected means, daily variation, harmonic analysis, lunar variation, etc. Automatic tabulation in form for direct reproduction is also an important feature.

The performance of the foregoing processes requires an installation of punch-card machines, which, however, need not be maintained by each observatory. On the contrary, the tremendous capacity of such machines indicates the desirability of having such an installation at only one or two central stations, quite properly one in Europe and one in America, where the processing and preparation of small editions of data could easily be performed on a cooperative basis.

4. Committee to Organize Work.

It is recommended that a committee be designated whose purpose shall be

(a) to review the circumstances regarding all existing observatories and to indicate a selection of key observatories which by virtue of geomagnetic and geographic location and by willingness and ability will satisfy the primary requirements listed above.

(b) to arrange if possible for the establishment of one or two central stations, preferably in America and Europe, which are able and willing to receive data in the form of suitably marked cards from contributing observatories, to process them, and to cooperate in dissemination of the results.

U. S. Coast and Geodetic Survey,
Washington, D. C., U.S.A.

REPORT OF THE COMMITTEE ON CLASSIFICATION OF MAGNETIC LITERATURE*

Previous action.--In accordance with a resolution adopted at the Edinburgh Meeting in 1936, the Committee on Classification of Magnetic Literature was instructed to expand the pertinent sections of the Universal Decimal Classification for the purpose of bringing it into line with modern developments without altering the original framework of the classification. These instructions were followed; but when the expanded classification was presented at the Washington Meeting in 1939, it was concluded that a unified classification embracing the entire field of geomagnetism would be advantageous. The Committee was instructed to draw up such a classification, having full authority to disregard any existing classification at its discretion. In fulfilment of these instructions the appended classification is presented.

The place of geomagnetism in the decimal classification.--The aim of the Committee has been to develop a scheme that would meet the pressing needs of the science of geomagnetism and at the same time would have a maximum prospect of acceptance among users of both the Dewey and Universal versions of the Decimal Classification. In general, the second of these two versions is an expansion or development of the first, but with some difference in detail. In the Dewey Classification, including the latest or fourteenth edition, terrestrial magnetism is consistently treated as a branch of Physics, bearing the number 538.7. In the current form of the Universal version, this number is retained only for instruments and methods of observation, whereas the descriptive topics are set up at 550.38 under "Sciences allied to Geology". Unfortunately, the smaller topics under 550.38 are so defined and so ordered as to vitiate any attempt to use them as a framework for a comprehensive arrangement. Several obvious considerations have led to general accord on the proposition that the entire field of geomagnetism should be brought under a single heading. The selection, however, of one of the above two numbers presents a vexing issue.

Detailed consideration of all factors has led the Committee to adopt 538.7 rather than 550.38, although the situation of the latter number in the schedules exerts a potent appeal because of its closer association with geology, meteorology, and seismology. The requisite departure from the U. D. C. is a matter of relative position and assignment of numbers, but entails no violation of its general principles, whereas the use of 550.38 would run counter to one of the basic principles of

---

* Present membership: H. D. Harradon, Chairman; M. Bossolasco, A. H. R. Goldie, D. G. Knapp.

the Dewey version since the cipher in this number conflicts with the Dewey "form" division 550.3 (dictionaries of geology).

As for the logical aspects, it may be argued that the affiliations between pure physics and various geomagnetic phenomena such as the field of large rotating masses, the underlying secular change, Doppler and Zeeman effects on solar and auroral spectrum lines during magnetic storms, studies of Curie point, et cetera, are too intimate and too extensive to be overlooked. While not having the force of a ruling consideration, these relations point up the fact that this branch of geophysics is perhaps not so highly differentiated from the general field of physical phenomena as are some others.

The choice of 538.7 also permits more concise notations for its various subdivisions, since it is shorter by one digit than 550.38. This feature is of particular advantage, for example, when place numbers are used in association with the basic number for survey results. Finally, of course, the choice of 538.7 offers the advantage of facilitating research in the many libraries that adhere to the Dewey plan of notation, without the encumbrance of an existing subdivision that impairs the analogous argument for 550.38.

General principles.--A basic shortcoming of many schemes of classification is that the divisions of a given class fail to exhaust the whole scope of that class. In the present scheme, considerable pains have been taken to broaden the headings so as to avoid this pitfall so far as possible, and vacant numbers have been left in many cases to provide for future intercalation of new divisions. In a number of instances, the subdivisions have been merely lumped together in the form of a note appended to the larger heading, leaving the numerical treatment to some future date when the particular topics involved shall be more firmly crystallized.

A classification less detailed than that here presented may be required for many purposes. It is a simple matter to dispense with the numbers assigned to the fine divisions of any class; the small headings would then serve merely as a supplementary delineation of the scope of the whole class.

A few guiding principles have been rather rigorously followed. One of these stipulates that each topic is limited not only by its own wording but also by the terms of every larger class of which the one in question forms a part. Thus, at 538.715.1 the heading "Electrical measuring instruments and methods" is to be understood as being delimited by its superior class 538.715 to the geomagnetic applications of such apparatus and such technique. Another rule has been that in accordance with the later expansions of the Dewey Classification, the digit 1 would not generally be used unless the topic to be so designated possessed overall significance with respect to the remaining subdivisions, though perhaps requiring a breakdown of its own. This usually means that "1" denotes instruments and equipment, technique of observation or analysis, or basic theory. In other words, the digit 1 is assigned to "generalities" of a specified kind, apart from the overall discussion of the group, which of course goes under the basic number for the group with no added digit at all.

Care has also been taken to avoid using "0" or "9" in any way that would conflict with the use of these digits in the Dewey Classification or the U. D. C. Where the zero is used it refers to one of the Dewey special subdivisions for form, etc., and it carries the implicit suggestion that the corresponding U. D. C. auxiliary notation be considered as an alternate, just as has been explicitly noted in connection with the local divisions of 538.78. This is not to imply that the Committee advocates one or the other method. These auxiliary symbols are a general feature of the U. D. C. and hence in that scheme would not appear as scheduled divisions of any topical heading. The specific numerical designation afforded a means of inserting these headings where they would be most useful and would not be overlooked, and at the same time they provided specific places for the auxiliary topics for the benefit of those users of the decimal classification for whom adoption of the U. D. C. devices would prove inconvenient.

Inclusion of borderline topics.--We have included certain borderline topics in the scope of the classification, in accordance with the indicated desire that the Committee produce a complete classification. One of these topics concerns the electricity of the earth's crust, primarily the galvanic currents that are induced in the lithosphere by overhead currents through the medium of the magnetic fluctuations, the latter being influenced in their turn by the induced currents, which are in fact secondary currents in a vast transformer wherein the overhead conducting zone forms the primary circuit, with a transient magnetic flux coupling the two circuits.

Immediately following the main group dealing with transient magnetism (including earth currents) we have a main heading numbered 538.76 and entitled "Other Phenomena of Overhead Activation". This heading may at first seem rather inappropriate as a subdivision of geomagnetism. The justification for including it is again the close relationship between magnetic transients and the topics assigned to this heading, namely, ionospheric activation and its visual counterpart, the polar aurora (aurora borealis and australis). This relationship has been the theme of innumerable studies, going back (in the case of the aurora) almost as far as the first recognition of transient magnetic phenomena. With the recent access of new knowledge flowing from the study of radio-wave propagation, the literature of overhead excited layers has rapidly branched and multiplied, and is more than ever permeated with the basic sense of the unity of these phenomena with geomagnetic activity. By providing a place for these phenomena in proximity to geomagnetism proper, the classification and bibliographies based upon it may be expected to forward actively the pursuit of the group of studies having to do with these layers, and accommodate the many papers that are concerned with the whole field, without resort to compounded numbers. The consequent moderate broadening of the scope of the main class, originally confined to geomagnetism in the narrow sense, seems not objectionable and indeed is typical of the adjustments that are required of any basic classification if it is to conform to the needs of a vigorous and expanding field of learning.

Collateral relations and compound numbers.--One matter that received much study was that of the collateral relations and applications of geomagnetism--that is, the bearings of the subject upon other fields of inquiry or utility. It would be possible to avoid scheduling any such interrelations, since they can be described by coupling the respective numbers together by means of the colon of relationship in accordance with the admirable scheme perfected by the sponsors of the U. D. C. Essentially, this device provides that every class may be subdivided with respect to its collateral relations using the whole decimal classification, yet the use of all or any part of this dormant array of subdivisions does not hinder or obstruct in any sense the future expansion of the primary class from the viewpoint of its own subject. Your Committee recommends the use of this device in all cases not specifically provided for in the schedules. When this coupling method is used, it should be borne in mind that the two coupled elements may often be transposed to form a second entry.

Specific provision has been made, however, for one important group covering most of the commonly recurring "interrelation" topics, namely, the close connections of the transient fluctuations with solar and kindred phenomena. While these much-studied interrelations may likewise be treated by the coupling method if preferred, it is felt that the provision of special numbers for them offers certain distinct advantages. To illustrate: The regular compound number for the relation of sunspots and magnetic variations would be 538.74:523.746. Now, this would not differentiate among the many kinds of magnetic variations related to sunspots. If such differentiation were obtained by using the finer divisions of 538.74, one would lose the benefit of a grouping of such relations, since the compound numbers would then have to be dispersed among the various primary numbers; that is, 538.742:523.746 would come in sequence in a group following 538.742, whereas 538.744:523.746 would be in a similar group following 538.744, and so on. On the other hand, if the compound numbers were inverted so as to place the sunspot element first, they would form a single consecutive series but it would fall in the Astronomy section of the classification and would be entirely removed from geomagnetism.

By using 538.747.23 and coupling to this the numbers for the several kinds of magnetic variations, one obtains a consecutive sequence of all the relations of magnetic transients with sunspots, assembled in their most useful position in the classification. The numbers under 538.747 would be used only when classifying from the geomagnetic point of view. They afford a more orderly arrangement of the several commonly encountered collateral topics than is secured by picking them out of the main classification, and a more concise notation in many cases.

Some of the instrumental classes and certain others as well (e.g. 538.742.6) may be deemed to require further subdivision according to the particular magnetic element or component. This may be accomplished by coupling to the number in question the appropriate "element" designation selected from those scheduled under 538.711.1, leaving the primary number open for future topical subdivision. Thus, 538.742.6:538.711.16 denotes the solar-daily variation of vertical intensity.

Conclusion.--The Committee's primary objective at all times has been a coherent and practical subject classification, suitable for bibliographical and library use. It was the desire and hope of the Association and of the Committee that a similar classification of Atmospheric Electricity might be presented at this meeting. Under present conditions, however, the Chairman has not found it feasible to bring about the formation of a suitable and active international committee for this purpose. In this connection, attention is called to the section dealing with electrical phenomena of the atmosphere in the excellent classification of meteorology of the International Meteorological Organization, now part of the U. D. C. schedules.

The arrangement here presented should be considered as the composite product of numerous contributions, although the actual formulation of the tables was largely worked out by one member of the Committee (Knapp). It embodies many revisions and improvements resulting from criticisms and suggestions by the Chairman and other members of the Committee as well as by outstanding experts in the various special fields that fall within the scope of the classification. Your Committee asks to be now discharged, having completed its assignment. Further action rests with the Association, including decision in the matter of a recommendation to the respective sponsors of the two versions of the Decimal Classification.

A COMPREHENSIVE DECIMAL CLASSIFICATION OF GEOMAGNETIC LITERATURE

538.7 GEOMAGNETISM AND CLOSELY ALLIED PHENOMENA

538.702 Handbooks, Outlines, Compends Alternate form 538.7 (02)

538.703 Dictionaries, Encyclopedias Alternate form 538.7 (03)

538.704 Essays, Addresses, Lectures Alternate form 538.7 (04)

538.705 Periodicals Alternate form 538.7 (05)

538.706 Collective Bodies Alternate form 538.7 (06)

538.707 Study and Teaching Alternate form 538.7 (07)
Includes research establishments, laboratories

538.709 History and Early Works (Before 1800)

538.71 Equipment and Methods. Includes technique and instruments for obtaining and reducing observations or for utilizing the Earth's magnetic field

.710.2 Manuals for Observing. Not classed here if primarily concerned with technical details of a particular instrument or method

538.711 Geomagnetic Technique of General Utility
.711.1 Systems of Coordinates and Notation. Selection and designation of the actual or derived magnetic elements
.711.11 Schemes of notation. For glossaries with explanations of terms, see 538.703
.711.12 Direction of horizontal component, however shown
.711.13 Horizontal intensity
.711.14 Azimuthal components of horizontal intensity
.711.15 Inclination or dip
.711.16 Vertical intensity
.711.17 Total intensity
.711.18 Potential and curl of the field
.711.19 Indices and elements not elsewhere classified
.711.2 Coordination of Neighboring Observations (e.g., for determining station difference and instrumental corrections). Divide like 538.711.1. See also 538.718.12
.711.3 Reducing Results to Mean of Day, Month, etc. See also 538.726.1 and 538.741
.711.4 Forms for Recording and Processing Results. (Forms in general; those for particular measurements go with the instrument or method for which they are designed.)

538.71 Equipment and methods (continued)

538.712 Magnetic Observatories. Fixed structures for magnetic observations
.712.000.3 Administration
.32 Finance
.33 Contracts--Specifications
.34 Designs--Drawings
.35 Executive--Administrative
.36 Working--Maintenance (Incidental operations). For technique of operating instruments, see 538.714/8; for technique of processing results, see 538.712.5
.363 Personnel
.364 Operating--Running
.367 Repairs--Renewals (Administrative point of view; a specific repair belongs with part repaired.)
.38 Patents
Note: Additional 000 subdivisions may be taken from the "Decimal Classification" by Dewey.
.712.1 Objective and Scope of the Work
.712.2 Selection of Site. Includes encroachment of disturbing influences
.712.3 Distribution of Observatories
.712.4 Institutional Reports about Particular Observatories
.712.5 Processing of Results for Distribution. For the results see 538.79
.712.52 Scaling variations from traces. Includes conversion to absolute value, choice between instantaneous and integrated readings
.712.53 Revision and adjustment of scaled values
.712.55 Coordination of results from different variometers
.712.57 Tabulating results for publication
.712.58 Dissemination of results by microfilm, photostat, etc.

538.713 Operations Incidental to Magnetic Surveys
.713.1 Objective and Scope of the Work
.713.2 Organization and Outfitting of Parties
.713.3 Problems of Sovereignty and Jurisdiction
.713.5 Selection of Site and Marking of Station
.713.6 Determination of True Meridian. Includes adjustment of azimuth observations. See also 526.63. To be classed here only if incidental to magnetic work.
.713.7 Preparation of Description of Station. For the descriptions see 538.78
.713.8 Vessels, Aircraft, and Incidental Technique for Sea and Air Surveys

538.714/8 Magnetic Instruments and Special Methods

Notes: (1) Instruments intended for special topics of investigation go with such topics. (2) There is no special class for gradiometers (differential instruments); class them with other magnetic instruments, according to mode of response or operation. (3) Each number under this heading is intended to be used collectively for the description, theory, and technique pertaining to the class of instruments covered by that number, except in so far as specific provision is made for those separate aspects.

538.71 Equipment and Methods (continued)

538.714 Devices with Indirect Response or Indication. Includes remote-indicating and integrating systems, e.g. repeating compasses, automatic steering systems, dead-reckoning computers, odographs, bore-hole survey tools. The field-responsive unit does not go here if it can be classed under 538.715.4/9

538.715 Electromagnetic Instruments for Geomagnetic Determinations

.715.1 Electrical Measuring Instruments and Methods

.715.2 Instruments with Nonelectrical Mode of Response. Includes sine and tangent galvanometers, Schuster-Smith and Watanabe coil magnetometers

.715.3 Geometry of Coils. Includes Helmholtz-Gaugain, solenoid, and other coil forms used for modifying or simulating geomagnetic components

.715.4 Stationary Loop. Crichton Mitchell Loop. Includes harbor patrol applications as well as recording of natural pulsations

.715.5 Dynamo-Electric Instruments. Earth inductor, la Cour intensiometer, and Uljanin vertical-intensity instrument

.715.6 Instruments Using the Thrust Upon a Current. Includes Bates magnetometer, Dye and Tanakadate vertical-intensity methods, and magnetron and other discharge-tube devices

.715.7 Instruments Dependent Upon Nonlinearity of Magnetization Curves. Includes saturable-core devices such as flux-valve compasses and recent airborne magnetometers, also use of Barkhausen effect

.715.8 Instruments Using Skin Effect

.715.9 Instruments Using Miscellaneous Physical Effects. Includes those using Magnetostriction, Hall and Nernst effects, and kindred pheonomena

538.716 The Compass and Mobile Magnetism

.716.2 Magnetic Compass (mariner's, surveyor's, etc.) Development and refinement; various improved forms. Includes compass cards, compass declinometer, azimuth compass, prismatic compass, accessory azimuth circle, liquid compass, spherical compass, declinating circle, vehicular compass, pocket compass, etc. For repeating and electromagnetic forms of compass, odographs, etc., see 538.714/5. For "variation of the compass" see 538.78

.716.4 Deviation and Compensation. Pertains to any field-responsive device on board a craft. Includes "northerly turning error"

.716.5 Magnetism of Mobile Craft in Relation to Detection, Mine Detonation, and Countermeasures

538.71 Equipment and Methods (concluded)

538.717 Other Movable-Magnet Nonrecording Instruments
.717.1 Theory. Properties of Instrumental Components.
.717.11 Analysis of forces acting upon a magnet
.717.13 Effect of ambient field upon magnetic moment. Includes induction- and demagnetizing-factors
.717.14 Effect of aging on magnets. Includes pre-aging, etc.
.717.15 Effect of temperature on magnets. See also 538.2 and 538.718.14
.717.17 Magnetic properties of structural parts
.717.18 Properties of suspensions
.717.3 Orientation of a Pendent Magnet. Collimating systems and arrangements of scale and cross hair. Determination of the magnetic meridian
.717.4 Gaussian Methods. Includes constituent and derivative techniques, e.g., various resultant-field methods using stationary deflector magnets. Covers theodolite magnetometers and their manipulation and general theory.
.717.42 Measurement of intensity by timing oscillations. Moment of inertia and other factors affecting the period or its measurement
.717.43 Theory of deflections. The schematic magnet; pole distances, distribution coefficients, positions of Gauss and Lamont
.717.44 Use of deflector with compass. The transit magnetometer
.717.5 Instruments Employing Two Freely Interacting Magnets. Double compass for intensity measurement
.717.6 Opposed-Torque Instruments with Azimuthal Mobility. Chiefly the quartz horizontal magnetometer (QHM)
.717.7 Dip Circle or Dip Needle
.717.71 Theory of errors
.717.73 Modification for sea observations
.717.74 Modification for intensity observations
.717.8 Magnetic Balance. Lloyd, Hotchkiss, Schmidt, BMZ, and other forms
.717.84 Locators for ferrous objects. Includes pipe finders
.717.86 Applications to mine detonation
.717.9 Miscellaneous Devices. Includes astatic magnetometers for detecting and testing magnetized objects

538.718 Recording Variometers: Magnetographs
.718.1 Theory and Operating Technique--All Types. See also 538.715.4
.718.12 Base-line determination. Coordination of traces with routine control observations
.718.13 Scale value. Displacement of magnet and of trace as function of magnetic elements, including problems of orientation, stability, and interaction of different variometers
.718.14 Effects of temperature. Determination and compensation of same
.718.17 Registration. Includes optical systems, time-marking devices, drive mechanisms, etc. See also 538.714
.718.3 Unifilar Type. Design and construction
.718.4 Bifilar Type. Design and construction
.718.5 Balance Type. Design and construction

538.72 Magnetism of the Earth's Crust and Interior. The steady field and the secular change

538.722 Surface Features of the Field. Includes theory of geophysical prospecting by the magnetic method. For instrumental topics and observing technique see appropriate divisions of 538.71. See also 622.15 for prospecting technology. [For a decimal classification covering all methods of geophysical prospecting, see the detailed and comprehensive scheme by C. A. Heiland, Geophysics, 7, 1 (1942) (Soc. Exploration Geophysicists, Tulsa)]

.722.1 Magnetic Cartography. Includes evaluation of regional trends, methods of smoothing iso-lines, properties and permissible disposition of singular points, and problems of mutual consistency among charts

.722.3 Magnetism of Rocks and Minerals. Permeability, susceptibility, polarization as characteristic of various rocks and minerals

.722.4 Fine Structure or Texture of the Field. Includes interpretation of airborne surveys. See 538.78 for surveys accomplished.

.722.42 Theoretical effects of formations. Line, pole, and induction theory, induced and permanent magnetization of structures

.722.44 Level of survey. Effects of displacing survey level away from determining structure or above ground surface or ocean floor

.722.45 Relation to Topography

.722.47 Relation to Anomalies of Volcanism, Gravity, Conductivity, etc.

.722.7 Extensive Anomalies. Relation to ocean basins, continents, etc.

.722.8 Specific Anomalies not Elsewhere Classified.

538.723 Underlying Plan. Organic conceptions

.723.2 General Geographic Character. Nonanalytical treatment; magnetic equator, relation of dip to latitude, etc.

.723.3 Magnetic Poles of the Earth. Principal dip poles, intensity foci, and other polar conceptions; effect of transient variations on positions of poles. See also 538.726.5

.723.4 Properties of Dipole Field. The uniformly magnetized sphere

.723.7 Numerical Analysis. Earth's magnetic axis and magnetic moment, Gaussian coefficients, field with external source, field not having a potential, etc.

538.725 Origin of the Field and of its Secular Change

538.726 Secular Change. Discussions not concerned primarily with origin

.726.1 Technique of Analysis. See 538.78 for resulting tables and charts

.726.2 Evidence of Archives and Artifacts

.726.3 Evidence of Natural Deposits (lava, varves, etc.)

.726.4 Long Chains of Data for Exceptional Localities

.726.5 Migration of Poles, Apparent or Real

538.72 Magnetism of the Earth's Crust and Interior
538.726 Secular Change (continued)

.726.6 Distribution over the Globe. Includes isoporic patterns, migration of foci, effect of local irregularity upon secular change, etc.
.726.7 Changes of Magnetic Axis and Moment

538.74 Manifestations of Transient Magnetism. Divisions 2/4 relate to transient effects in their unitary aspects, whereas divisions 5/8 refer to statistical and collateral aspects of the phenomena

538.741 Technique of Analysis. Includes techniques of description, correlation, and prediction by means of Fourier or similar analysis or other statistical treatment, e.g., superposed-epoch method, folding, separation of noncyclic change, and isolation of other extraneous variations. See also 538.711.3

538.742 Local-time and Kindred Fluctuations. Those related to motions of earth, moon, and planets
.742.1 Theories. Current functions, dynamo action, atmospheric tides; role of heating, resonance, diamagnetism, drift current
.742.4 Periodic Fluctuations not Elsewhere Classified. Lunar, seasonal, annual. See also 538.747.23
.742.5 Lunar-Daily Variation
.742.6 Solar-Daily Variation as a Whole (or limited to quiet-day features). Includes actual values at specific stations. See also 538.747.7
.742.7 Amplitude and Form of Daily Variations in Relation to Disturbance
.742.8 Disturbance-Daily Variation

538.743 Fluctuations Not Elsewhere Classified
.743.5 Crochets
.743.6 Bays and Isolated Perturbations. See also 538.747.28
.743.62 Character and Measurement. Includes iterative tendency
.743.68 Records of the Phenomena
.743.7 Pulsations. Includes giant pulsations, micropulsations, and so-called geomagnetic noise
.743.72 Character and Measurement. Includes periodicity and amplitude
.743.78 Records of the Phenomena

538.744 Magnetic Storms. See also divisions of 538.747
.744.1 Theories. Activated corpuscular streams, ring-current hypothesis, ultra-violet light theories
.744.3 Onset and Subsequent Course of the Magnetic Disturbance
.744.33 Precursor disturbances. See also 538.747.28
.744.34 Sudden commencements. Character of initial impulse, simultaneity, etc.
.744.36 Irregular fluctuations
.744.37 Storm-time variation and recovery phase. Includes post-perturbation and noncyclic change. For technique of statistical treatment of noncyclic change as a spurious factor see 538.741. For local-time effects of disturbance see 538.742.8

538.74 Manifestations of Transient Magnetism

538.744 Magnetic Storms (continued)

.744.6 Spatial and Stereometric Aspects
.744.62 Disturbance-vector aspects
.744.64 Distribution over the globe. Includes current functions, zonal and interzonal currents, spherical harmonic analysis, asymmetrical component, etc. See also 538.745.2
.744.7 Kinds of Magnetic Storms and Disturbances. Relative magnitude, Birkeland's categories, equatorial and polar types, etc.
.744.8 Records of Specific Magnetic Storms. Catalogues including auroral displays may be classed here. See also 538.768.85

538.745 Magnetic Activity in General
.745.2 Diurnal Fluctuations of Activity
.745.3 Lunar, Seasonal, Annual Fluctuations of Activity. See also 538.747.23
.745.4 Tendency for Conservation in Degree of Activity
.745.6 Activity Scales. Character numbers, K-indices, etc. For activity records see 538.791

538.746 Quasi-Persistence. Chiefly 27-day recurrence feature
.746.8 Records of Fluctuations with Special Regard to Quasi-Persistence. Suggested arrangement: Chronological

538.747 Fluctuations in Relation to Collateral Phenomena. Class here when no single geomagnetic effect is dominant, or when the significance of the work lies in the association rather than in the special kind of geomagnetic effect involved. (This heading or any of its chief categories may with advantage be further subdivided by using the divisions of 538.742/.746 or of 523, Descriptive Astronomy, coupled with the primary number by means of the colon. Such division may be used in lieu of, or in addition to, the scheme of division which follows.)
.747.2 Effects Associated with Solar Phenomena
.747.22 Eclipses, transits, incursions of cosmic debris
.747.23 Sunspot activity and sunspot cycles
.747.24 "M" regions on the sun
.747.25 Solar corona
.747.26 Light-absorbing substances in space
.747.27 Solar manifestations not elsewhere classified. Includes prominences, faculae, and flocculi
.747.28 Solar flares or chromospheric flares
.747.4 Fluctuations in Relation to Ionospheric Phenomena. See also 538.767.7
.747.6 Fluctuations in Relation to Cosmic Rays. See also 538.744.1
.747.7 Fluctuations in Relation to Aurorae and Auroral Zones. See also 538.768.45 and 538.744.64
.747.8 Fluctuations in Relation to Earth Currents
.747.9 Studies Involving Meteorological and Miscellaneous Collateral Effects

538.74 Manifestations of Transient Magnetism (concluded)

538.748 Electricity of the Earth's Crust (Telluric Electricity)
Note: A considerable part of the literature bearing on this field reflects the duality common to all electromagnetic phenomena and might equally well or better be classed in the preceding divisions of the class 538.74. Class such items here if their chief interest or contribution is concerned with the galvanic manifestations.

538.748.1 Instruments and Methods of Measurement
.748.12 Installations at observatories
.748.13 Field measurements
.748.14 Measurements in bodies of water
.748.16 Spurious effects
.748.2 Earth Currents--Variations
.748.22 Local-time phenomena. Daily and lunar variations
.748.23 Fluctuations not elsewhere classified
.748.24 Earth-current storms. Effects on communication and power circuits, including effects attributed to magnetic transients
.748.25 Earth-current activity in general. Measures and time-dependence of activity
.748.26 Quasi-persistence of earth-current phenomena
.748.27 Associations with collateral phenomena (geomagnetic, solar, etc.)
.748.3 Regional and Local Aspects of Earth Currents
.748.32 World-wide circulation
.748.34 Geologic and topographic relations. Includes earth-current prospecting
.748.36 Currents generated in bodies of water
.748.4 Effects on Underground Installations. Includes natural earth-currents and leakage currents.
.748.45 Protective measures. Use of sacrificial anodes
.748.5 Radioactivity in the Ground
.748.55 Prospecting as guided or affected by radioactivity
.748.58 Surveys and measurements accomplished
.748.6 Earth Resistivity or Conductivity
.748.65 Association with geological features. Mineral resources
.748.68 Resistivity surveys accomplished
.748.8 Results of Earth-Current Observations

538.76 Other Phenomena of Overhead Activation. For electricity of the lower atmosphere see 537.4, also 525.23 and 551.594

538.767 The Ionosphere. Includes relevant activation phenomena not elsewhere classified.
.767.1 Sounding Technique and Equipment
.767.15 Exploration with missiles, rockets, etc.
.767.2 Theories. Access, diffusion and recombination of ions. See also 538.767.62
.767.22 Ozone layer
.767.23 D region
.767.24 Layers having direct-current conductivity and not elsewhere classified
.767.25 E region. Kennelly-Heaviside layer. Includes E-2 and sporadic E
.767.26 F region. Appleton layer. Includes F-1 and F-2 layers

538.767 The Ionosphere (continued)

.767.3 Influence Upon Radio Waves. Includes descriptive aspects and modus operandi. See also 621.384.11

538.767.31 Calculation of propagation conditions

.767.32 Polarization and magneto-ionic effects. Includes wave and group velocity, gyro frequency, "O" and "E" waves, "Z" wave, and cross-modulation of signals

.767.33 Sky-wave propagation. Absorption, refraction, reflection; field intensities and coefficients

.767.34 Skip effects and maximum usable frequency

.767.35 Fading and self-interference of signals

.767.36 Directional variations in propagation or reception

.767.4 Radio Noise

.767.43 Atmospherics. Static

.767.45 Cosmic and Solar radio noise

.767.5 Distribution Over the Globe

.767.6 Fluctuations and Vertical Distribution of Ion Density

.767.62 Statical or average aspects. Includes heights, critical frequencies, and other attributes of the several strata. See also 538.742.1. Divide like 538.767.2

.767.63 Variations with solar cycle. Other long-period variations

.767.64 Variations with time scales in days or months

.767.65 Day-to-day and diurnal variations. Includes sunrise and sunset fluctuations

.767.66 Sudden, brief ionospheric disturbances. Includes blackouts and fade-outs. See also 538.747.28

.767.67 Irregular variations. Includes those associated with magnetic storms and activity

.767.7 Associations with Collateral Phenomena (Solar, Geomagnetic, etc.) See also 538.747.4

.767.8 Comprehensive Ionosphere Observations Accomplished. Note: Those pertaining chiefly to specific topics go with such topics.

538.768 Luminous Manifestations. Chiefly Aurora Borealis and Australis. See also 523.59 and 551.594.5

.768.1 Observing Technique and Equipment

.768.12 Photographic, parallactic, and stereometric techniques

.768.14 Classification of auroral forms and intensities. Includes atlases of forms and standards of intensity

.768.2 Auroral Theory. Includes studies with models. See also 538.744.1, Theories of magnetic storms

.768.4 Descriptive Auroral Topics

.768.42 Height and structure. Includes sunlit aurora and accounts of aurora accompanied by sound

.768.45 Distribution over the globe. Isochasms--lines of equal auroral frequency

.768.47 Photometric and spectroscopic studies. Green auroral line

.768.5 Luminescence not elsewhere classified (e.g., nonpolar aurora or luminosity of night sky, zodiacal light, gegenschein)

.768.7 Associations with Collateral Phenomena (Solar, Geomagnetic, etc.)

.768.75 Recurrences and periodicities

.768.8 Auroral Lists. See also 538.744.8

.768.82 Notable displays

538.78 Magnetic Surveys Accomplished

538.781 World-wide Scope. Includes hemisphere charts. Alternate form 538.78 (100)

538.782 Widespread Programs of International Collaboration
.782.1 International Polar Year 1882-83
.782.2 Second International Polar Year 1932-33

538.783 Intensive Observations at Base Stations. Includes expeditions and temporary observatories, not occupied continuously for periods longer than 30 months. (See also 538.79)

538.784/9 Continental or Smaller Scope. Divide geographically like 940-999. Alternate form 538.78 ( ) with local number in curves.

Includes magnetic charts (isogonic, isoclinic, isodynamic, equipotential, etc.), magnetic declination (variation of the compass), distribution and secular change, annual change, descriptions of magnetic stations, etc. See also deviation of the compass at 538.716.4 and preparation of secular-change tables at 538.726.1.

538.79 Magnetic Observatory Results. Divided alphabetically by name of observatory. Fixed stations activated continuously for at least 30 months. Class the fundamental data here; special investigations of limited aspect (such as daily variation) go with the topic of the investigation. See also 538.783

538.791 Consolidated Results for Groups of Observatories. Alternate form 538.79 (100). Includes summaries of activity or "character of days". Suggested arrangement: Chronological by earliest year of characterization if before 1900, otherwise by year of issue.

Department of Terrestrial Magnetism H. D. Harradon, Chairman
Carnegie Institution of Washington
Washington, D.C., U.S.A., May 25, 1948

REPORT OF COMMITTEE TO PROMOTE INTERNATIONAL COMPARISONS OF MAGNETIC STANDARDS

By J. Keränen, Acting Chairman

In his report of this Committee at the Washington Meeting (Trans. Washington Assembly, 1939, pp. 283-286), Dr. D. la Cour explains that for the most part, QHM instruments retain their constancy even during long transports sufficiently well to permit their use as a means of obtaining comparisons between geomagnetic observatories. Since that report it has only to a small extent been possible to carry out international comparisons of magnetic standards. I will here give a short review on the results of such intercomparisons which I have received by correspondence.

Denmark--In the Rude Skov Magnetic Observatory intercomparisons have been made during the years 1939-1947 with the magnetic instruments from Finland, Greenland, Letland, Norway, Sweden, and the United States of America, but in most cases information is lacking as to what differences the magnetic standards show in observatories. An intercomparison, however, made between the standards for horizontal force between Cheltenham in the United States of America and Rude Skov during January to May 1948 has given a very clear picture of the fitness of the QHM's for such work. The difference between the standards of these observatories for the horizontal force was received with a mean accuracy of ± 0.4. This value confirms the capability of QHM's for intercomparisons also between very distant observatories.

Sweden--The magnetic department of the Hydrographic Service has made intercomparisons as follows:

Lovö and Rude Skov 1940-45, 1947
Lovö and Sodankylä 1942, 1946, 1947
Lovö and Tromsö 1947
Abisko and Rude Skov and Sodankylä 1946

The work comprises in most cases measurements of both components of the magnetic force, horizontal and vertical intensity, and in two cases, 1941 and 1943, also the dip.

By the suggestion of the Secretary of the Association, Dr. J. W. Joyce, an intercomparison is planned during the year 1948 between the following observatories: Rude Skov, Abinger, Agincourt, Cheltenham, Huancayo, Pilar, Vassouras, Christchurch, and Watheroo. For the intercomparison UNESCO has granted the Association the sum of $1,200.

On the initiative of Dr. L. Koenigsfeld, Director of the Magnetic Observatory of Manhay in Belgium, the Association will recommend at the Oslo Assembly that the program of geomagnetic observatory intercomparisons should be extended to include regular intercomparisons between representative magnetic observatories of the world. I suggest that such an intercomparison is necessary between all observatories in the near future.

REPORT OF COMMITTEE ON OBSERVATIONAL TECHNIQUE

By H. E. McComb, Chairman

1. Magnetic Materials: All parts of geomagnetic measuring instruments, except magnets, core materials, etc., should be fabricated from pre-tested, non-magnetic materials. Astatic galvanometers (moving magnet system) or quartz horizontal magnetometers are satisfactory for this purpose.

2. Standardizations and Comparisons: (a) New or repaired instruments should be standardized with foot screws in different orientations. If no "polarity" is apparent, the instruments should be standardized in the one position normally used in routine work.

(b) A standardization series should consist of not less than three sets of observations for any element; double that number for intercomparison of observatory instruments.

(c) Except for special studies, such as determination of distribution coefficients, observations for H with deflection magnetometers should be made only at those distances normally used in the field.

(d) Unless station differences have been previously established, the instruments should be interchanged in any series of direct comparisons.

(e) The quartz horizontal magnetometer (la Cour) has been found quite useful in the determination of station differences in horizontal intensity for stations immediately adjacent to each other and for actual intercomparisons at great distances. If temperature control is adequate such comparisons may be made with considerable speed and with sufficient accuracy for all practical purposes. In many places the quartz horizontal magnetometer is being used for routine H base-line determinations for long periods.

3. Instrumental Constants:

(a) Distribution Coefficients: Since it is impossible accurately to estimate distribution coefficients from dimensions of magnets, approximate values may be derived from dimensions, positions, etc., and then, if comparisons are made against an instrument of high precision, final adjustment of the index correction to zero may be accomplished by changing the value of log C.

(b) Induction Coefficients of magnets may be measured quickly and with sufficient accuracy by Nelson's method, and because of its simplicity, it is preferred to Lamont's method. (Terrestrial Magnetism and Atmospheric Electricity, June 1938).

(c) Unequal Deflections: Differences of several degrees for magnet east and west is an indication of unequal distances. These deflections should be equalized, if possible, by adjustment of the deflection bar.

(d) Temperature Coefficients of Magnets should be measured directly whenever possible. In certain cases it has been found necessary to use terms in t^2 to harmonize results. Researches on the development of magnets having great stability and low temperature coefficients are recommended.

(e) Temperature Coefficients of Variometers: It is important that the compensating elements be maintained at the same temperature as the recording magnet. Copper lined, wooden covers have been found useful in eliminating sudden changes within the instrument. Temperature coefficients, if appreciable, should be redetermined as may be necessary for proper reduction of observatory data. The operation of magnetographs at different standard temperatures, through adequate temperature controls, provides necessary data for checking the effectiveness of temperature compensation.

(f) Adjustment of Instrumental Corrections: In Resolution 4(b), Washington Meeting, 1939, the Association recommended that instruments for the determination of Declination and Inclination be adjusted so that their corrections do not exceed the standard error of a single observation. For observatories where such adjustments are made, comparisons may be limited to instruments for the determination of horizontal intensity.

4. Declination Recording Stations: Secondary Observatories: A paper tape recorder having a paper speed of only 2 mm per hour when used with an ordinary declination variometer may be used for recording, automatically, the variations in magnetic declination over long periods of time without attendance at the station. Such stations would be quite useful for coverage of those areas remote from existing magnetic observatories. These stations would furnish an accurate value of the daily mean and when supplemented with absolute observations once or twice per year would give a precise value of the secular change for that area. Distribution of such stations should be quite general and even though operated for only short periods, the results would be a great value in secular change studies. It has been shown that such stations are quite essential in high latitudes.

5. Field Observations (Repeat Stations): (a) It is important that the height of the instrument be the same in successive occupations of a station if the results are to be used for secular change studies. A slight anomaly in the area may be of sufficient magnitude to give a false idea of secular change if the instrument is not operated at the same elevation above the ground each time the station is occupied.

(b) Observations should be distributed over an interval of two or three days at a repeat station, the number of days depending upon the distance from a magnetic observatory. In general, observations made late in the afternoon are more useful (reliable) than those made earlier in the day.

(c) The earth-inductor does not give sufficiently accurate results in high magnetic latitudes. It is hoped that experiences with induction magnetometers of the saturable core type may solve this problem. The performance of an earth-inductor may be governed largely by the condition of the commutator and brushes. These should be cleaned frequently and thoroughly with pure grain alcohol and soft cotton cloth. The brushes should be constructed of hardened copper or other material which will not set up thermo-electric currents.

6. Magnetograms: (a) It is important that the standard time of the time marks be known and that the parallax between the recording spots and the time marks be eliminated.

(b) The labor and expense of scaling hourly values of magnetic elements and of subsequent reduction and publication of results should be reduced to minimum requirements for investigators in the field of geomagnetism.

(c) The use of punch-card systems for processing magnetic observatory results and for simplification of statistical analyses is highly recommended.

7. Quartz Fibers: (a) The method of attachment of quartz fibers to variometer "heads" and to the magnet-mirror frame is of the utmost importance, especially in the case of horizontal intensity variometers. All methods which have been suggested and used have some merit.

(b) La Cour's method of attachment of the fibers is probably the most economical, but at times, especially with inexperienced technicians, the method presents some difficulties in orientation problems.

(c) A modification of la Cour's method, in which the ends of the fiber terminate in 3 mm quartz cylinders which may be clamped quite readily, has been used with some success.

(d) Bending the ends of the fibers at right angles and mounting them in metal lugs with fused shellac has proven quite successful and permits the technician to select a fiber of suitable dimensions (torsion constant) before an excessive amount of work is done in preparing the fiber for the installation.

(e) Some researches in the annealing and stabilizing of fibers would be desirable.

8. Orientation of Variometer Magnets: In accordance with Resolution No. 4(a) of the Washington Assembly, it is recommended that the orientation of each variometer magnet should be tested (and adjusted if necessary) at the time of installation and at regular intervals of two to four years thereafter.

9. Insensitive Magnetographs: Insensitive magnetographs to supplement the records from the more sensitive instruments have been helpful during intervals of great disturbances and should be operated whenever possible.

10. Reserve Spots: (a) La Cour's method of using multiple prisms has found general favor because of its simplicity.

(b) Prismatic, front-surfaced mirrors for H- and D-variometers have been used with considerable success. The mirrors are precisely ground and polished with three facets at certain angles to each other, the center face being used for the regular spot and the adjacent faces for the upper and lower reserves. The intersections of the faces must be parallel so that the images lie in the same horizontal plane. They require no subsequent adjustment in azimuth or inclination relative to each other. The reserve distances must remain constant so long as the recording distance is unchanged.

11. Scale Values: In general the following listed variometer scale values would seem to meet most requirements:

Geomagnetic latitude	For observatories with sensitive and insensitive variometers						For observatories with only one set of variometers		
	Sensitive			Insensitive			Average sensitivity		
	D	H	Z	D	H	Z	D	H	Z
	′/mm	γ/mm	γ/mm	′/mm	γ/mm	γ/mm	′/mm	γ/mm	γ/mm
0°-30°	1	3	4	1	15	4	1	4	4
30 -50	1	3	4	4	25	15	1	5	6
50 -60	1	5	5	5	30	25	3	15	15
60 -90	1	7	7	9	45	45	5	25	25

12. Visible Recording: The use of the saturable core induction variometer should be developed further and the results of those now in use made available (if possible) to others for appraisal and study.

13. Magnetic Observatory Manual: The need of a magnetic observatory manual is increasingly apparent. Such a manual should cover every phase of magnetic observatory work from the construction of the observatory, through the techniques of installation and routine operation of the instruments, to the final results.

Washington, D.C., U.S.A.

REPORT OF THE COMMITTEE ON THREE-HOUR RANGE INDICES FOR MAGNETIC CHARACTERIZATION

By A. G. McNish, Acting Chairman

This Committee was established at the Washington meeting of the International Union of Geodesy and Geophysics with Dr. J. Bartels as Chairman. Its activities were seriously hampered by the war and its aftermath, making necessary the appointment of an acting chairman to serve for Dr. Bartels. The Committee succeeded in bringing about the publication of magnetic character figures C and the magnetic K-indices for the period 1940-1946 which appear in Bulletin 12 of the Association of Terrestrial Magnetism and Electricity of the Union. Data for 1947 were published in the Bulletin 12A.

The accomplishment of this was due to cooperation of officers and members of the Union and not through the actions of the members of the Committee. The means whereby this was accomplished are described in the preface of Bulletin 12, prepared by Dr. John A. Fleming, which is quoted herewith as a part of this report:

"The need of a quantitative measure of geomagnetic activity is important, particularly in investigations on correlations. The magnetic character-figure C, on the scale of 0, 1, and 2, has served well for general purposes, but, because of the rapidly growing requirements, especially in ionospheric correlations, has proved somewhat inadequate.

"At the Assembly of the International Association of Terrestrial Magnetism and Electricity held in Washington in 1939, the Association adopted a Resolution and urged cooperation on the part of all magnetic observatories to try out a more quantitative measure of activity to characterize the variation in the degree of irregular magnetic activity throughout each day, especially in order to meet the requests made by the International Union of Scientific Radiotelegraphy and other bodies for information concerning the magnetic activity more detailed than the daily magnetic character-figures. The new measure, based upon work done at the Potsdam Magnetic Observatory, is the so-called three-hour-range index K. The Resolution indicated that this trial-scheme should be made for the three years 1940 to 1942. A Committee on Three-Hour-Range Indices was duly appointed to organize the provision of this measure of activity with special regard to speedy publication. Dr. Bartels was designated as Chairman of the Committee, the other members being Messrs. van Dijk, Egedal, McNish, Stagg, and Sucksdorff. The death of Dr. van Dijk, who had charge of the publication of the character-figures C and of the K-indices, and the interruption occasioned by World War II have prohibited communication of data from many observatories as well as publication since 1940. Meanwhile, data for both measures have been received and there has been an increasing desire on the part of all observatories to compile the material. Since the end of the war, many data not heretofore available have been supplied. The general usefulness of the K-index was so universally recognized during the original trial-period of 1940 to 1942 that the cooperating observatories have continued to compile and supply the material since 1943.

"The Department of Terrestrial Magnetism of the Carnegie Institution of Washington voluntarily assumed the responsibility of compiling the values received from the various observatories beginning in 1940. This work was done under the enthusiastic direction of Mr. H. F. Johnston, who continued as member of the Department's staff until June 30, 1946, and since that time as a member of the staff of the United States Coast and Geodetic Survey. With the authority of the Chief of the Division of Geomagnetism and Seismology of that Survey, he has continued the necessary compilations. Mr. Walter E. Scott and Miss Ella Balsam of the Department of Terrestrial Magnetism have also taken active part since 1940.

"The Executive Committee of the Association early in 1948 considered what might be done to publish the data for the years from 1940 to 1946 and, if possible, through 1947. That Committee was unanimous in the opinion that study and discussions of measures of magnetic activity are of such vital importance to geomagnetic research that all the material should be prepared and presented as Bulletin No. 12 of the publications of the Association. To that end, a special allotment of $1,000 was authorized, in addition to any available balances from past allotments, to cover the cost of preparing tabulations and publication. It is to be recalled that the data have been assembled by many observatories and have involved an immense amount of labor and time. It would be quite unfair, therefore, to all of those who have taken part, both in the observatories and at organizations utilizing the material, not to have this long and valuable series published.

"The untiring support of Messrs. Johnston and Scott and Miss Balsam has made possible presentation of the material for the seven years from 1940 to 1946 in the following pages; in this laborious task they have had much assistance from Mr. W. C. Hendrix, Draftsman of the Department of Terrestrial Magnetism. All geomagneticians must be grateful for these services so generously contributed, and for the authority of the executive officers of the United States Coast and Geodetic Survey and the Department of Terrestrial Magnetism in furthering this task."

The tremendous burden of compiling such data on a regular basis imposes a serious limitation on the time available for creative research. The Acting Chairman of the Committee has discussed this problem with several authorities in the field and proposes the following recommendations for consideration at the meeting of the Union in Oslo:

(1) that C figures be discontinued after December 1948,

(2) that observatories, as far as they are able, continue to supply K indices, and

(3) that an international magnetic activity figure be determined by an average of K-indices from strategically located observatories (approximately 16).

Since there is now a sufficient overlap of magnetic character figures and K-indices to establish the relationship between the two measures, the homogeneity of the C-series, such as it is, will not thus be destroyed for future work. The K-index is superior to the C-figure, particularly because of the finer grained characteristics of magnetic activity which it presents. This is necessary in the study of certain problems, such as relations between magnetic activity and radio wave propagation.

World-wide magnetic activity is not described much more efficiently by a large number of observatories contributing K-indices than by a small number. If the small number of observatories is uniformly distributed about the earth, the world-wide aspects are better described by their average than by the average of a larger number of observatories not so distributed. Furthermore, a small number of observatories may be counted upon to supply data more promptly and regularly than a large number so that the results will be more immediately available.

The Acting Chairman of the Committee therefore urges the appointment of a permanent Committee of the Union to consult with interested agencies and to plan and put into effect a system for compiling the proposed world-wide mean K-index and disseminating it to interested agencies. He further urges that consultations be held at the meetings of the Union to determine what agencies might be willing to undertake this service.

Since world-wide data on magnetic activity are of international concern and benefit it is suggested that funds be provided by the Union for the maintenance of this service.

Washington, D.C., U.S.A.

PROGRESS-REPORT OF THE JOINT COMMITTEE OF THE COMMISSION OF TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY OF THE INTERNATIONAL METEOROLOGICAL ORGANIZATION AND THE ASSOCIATION ON METHODS AND CODES TO ADEQUATELY DESCRIBE MAGNETIC DISTURBANCES AND PERTURBATIONS

The Joint Committee of the Commission and of the Association was set up by resolution of the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization (IMO) at its Warsaw Meeting in September 1935 and later confirmed by the Association. J. A. Fleming, as a member of both bodies, was designated Chairman, with A. Nippoldt and E. Sucksdorff of the Commission, and S. Chapman and N. H. Heck of the Association, as the other members. The place left vacant by the death of our distinguished colleague Nippoldt during 1936 was filled by J. Bartels, also of Germany.

IMO has, since our last report, adopted the policy of discontinuing most of its Special Commissions; among these is the Commission of Terrestrial Magnetism and Atmospheric Electricity. Your Committee has, however, continued to consult and consider as full members Messrs. Bartels and Sucksdorff appointed on behalf of that Commission.

The first report of the Committee submitted at Edinburgh in 1936 appears on pp. 222-234 of Bulletin 10 of the Transactions of the Association. The second report submitted at Washington, appears on pp. 286-291 of Bulletin 11 of the Transactions of the Association. The Committee has no material modifications to suggest in the systematized schemes it has recommended for description of magnetic disturbances and perturbations except in one particular as follows: The important progress made during the last decade in ionospheric technique and methods of observation and correlation studies with geomagnetic phenomena. The great importance of geomagnetic-activity measures to determine quantitative relations of geomagnetic, ionospheric, and solar data have been well demonstrated during the war in the world net of over 50 ionospheric stations for collection of data from which to determine and forecast the effects of ionospheric movements and disturbances on radio communication. A significant contribution to these aspects has been the publication of Bulletins 12 and 12A of the Association, which provide complete data on magnetic activity estimates represented by the character-figures C and K for the eight-year period from 1940-47, so ably compiled by H. F. Johnston, W. E. Scott, and Ella Balsam, from the data supplied by cooperating observatories.

The Committee repeats its recommendation made at Edinburgh and Washington, namely: (a) That the magnetic character-figures C be on the same general scale as heretofore, namely, 0, 1, and 2, but that observatories be requested to estimate a somewhat finer gradation on the scale 0.0, 0.5, 1.0, 1.5, and 2.0; (b) That values of the three-hour-range indices K, which have been supplied since 1939 and found useful particularly in connection with ionospheric developments, be continued at least in a number of key observatories. It is recommended that the Assembly ask the various observatories to continue the compilation of these indices. It is to be hoped also that certain observatories newly established in the interim since the last Assembly be requested to supply K-indices. Further, it is probable that the International Union of Scientific Radio may propose a system of ionospheric character-numbers; if so, our Association should take steps to implement any such suggestion.

The Committee has submitted definite and suggested methods and symbols for systematized descriptions of magnetic disturbances and perturbances in its first report at Edinburgh. The recommendations there still await action of the Association. It is desirable that some such systematized methods be followed in order to make the descriptions of magnetic disturbances and perturbances from selected observatories more comparable than is the case for the present somewhat heterogeneous method of description submitted by various observatories and observers--character of description varying even at a single observatory with every change of the reporting observer.

The Committee asks that it be discharged and recommends that the further implementation of such of its suggestions and any addition or revision thereto, as may be adopted by the Association, be made a responsibility of the Committee on Three-Hour-Range Indices for Magnetic Characterization.

Jno. A. Fleming, Chairman
For the Joint Committee

Washington, D.C., U.S.A.
July 31, 1948

JOINT COMMITTEE OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY AND OF THE INTERNATIONAL SCIENTIFIC RADIO UNION ON THE IONOSPHERE

E. V. Appleton, Chairman

Report of this Committee, which has now been expanded and renamed "The Mixed Commission on Ionosphere" with members from the International Scientific Radio Union, International Union of Geodesy and Geophysics, International Astronomical Union, and International Union of Pure and Applied Physics, has been published under the title "Mixed Commission on Ionosphere, Proceedings of the First Meeting Held in Brussels from July 28-30, 1948". This report has been issued by the General Secretary of URSI, 42 Rue des Minimes, Brussels 42, Belgium, 155 pp., 1949.

REPORT ON INTERNATIONAL COLLABORATION TO ADVANCE THE STUDY OF THE MOON'S EFFECT UPON GEOPHYSICAL PHENOMENA

By S. Chapman

Earlier Reports in this series [See the Comptes Rendus of the Association for Stockholm 1927 (pp. 466 and 330-333) and Lisbon 1933 (pp. 136-143) and the Transactions for Edinburgh 1936 (pp. 214-215) and Washington 1939 (pp. 297-299.] described the work undertaken up to 1939 on the determination of lunar daily variations in geophysical phenomena, with the aid of grants from the Association. by the Computing Bureau of the Department of Mathematics of the Imperial College of Science and Technology, London. At the Lisbon and Edinburgh meetings of the Association grants of Ł300 each were made towards the costs of the Bureau, namely, Ł100 per year for six years from 1933. Some details of these costs were given in my 3rd Report; the major part, for salaries and materials and overhead expenses, was provided by the College. In addition, valuable aid was given by the British Tabulating Machine Company, Limited, in providing and maintaining, free of charge, a set of Hollerith computing machines (punching machines, a sorting machine and a tabulating and adding machine) with which in recent years all the lunar determinations were made.

In conjunction with Dr. J. C. P. Miller, while he was Research Assistant in charge of the Computing Bureau, a convenient method was developed for determining lunar effects in series of hourly or bihourly values of geophysical elements. The method is applicable with or without the aid of Hollerith machines, and is suitable for data of many kinds, meteorological, geomagnetic, ionospheric, and for earth currents and earth potentials. The paper [S. Chapman and J. C. P. Miller, Monthly Notices of the Royal Astronomical Society, Geophysical Supplement, 4, 649, 1940] describing the method was published in 1940. The probable error of any determination thus made can be calculated conveniently by a method given by Miller in 1934 [J. C. P. Miller, Monthly Notices R.A.S., 94, 860, 1934]. The methods described in these two papers were adopted as standard by the Bureau, and have been extensively applied.

These papers are not altogether easy to read, because they include the theory of the methods involved. The actual steps to be taken can be explained more simply if the account of this theory is omitted, and a further paper on the subject has therefore been prepared, to explain the practical application of the method. It is hoped that this will prove useful to observatories and research institutions and others, and will encourage the application of the method to the great stores of hourly data available, and also to new data in the future. It is not necessary, though convenient, to have Hollerith machines available for this work.

This "practical" paper has been prepared by my research pupil, Mr. K. K. Tschu, British Council Scholar at Oxford, of the Central Meteorological Institute, Nanking, China. The paper is expected to appear in the Australian Journal of Research. It includes a new application of the Chapman-Miller method to the determination of a lunisolar periodic component first predicted and investigated in ionospheric data by Dr. D. F. Martyn.

Soon after the outbreak of war in 1939 my Research Assistant (then Mr. J. Crank) was called to scientific war service, and shortly afterwards Miss V. Gwilliam, one of the two computers in the Bureau, also left, leaving Miss Godfrey as the sole worker. She continued the lunar analyses until (and for some little time after) my resignation from the headship of the Department of Mathematics at the Imperial College, in 1946. She was well versed in the extensive routine part of the computations, but was not trained to do the more skilled final stages of the analysis. Much work on meteorological and magnetic data was done during this period. Miss Godfrey's services were also put at the disposal of Prof. A. Duperier, for a determination, undertaken at my suggestion, of the lunar tidal variation in the cosmic ray measurements provided by his automatic recorder. Miss Godfrey has now left the Imperial College, and no other member of the mathematics staff there is sufficiently interested in lunar geophysical effects to carry on the work of the Computing Bureau.

At Oxford there are no facilities for such work, at present, and as I shall not have many years of service there before retirement, I decided not to attempt to re-start the work there.

Fortunately Dr. M. V. Wilkes, Director of the University Mathematical Laboratory, Cambridge, and his colleague Dr. K. Weekes (who with Sir Edward Appleton first determined the lunar atmospheric tide in the E layer of the ionosphere) were interested in the lunar tide and other oscillations of the atmosphere, and responded favorably to my proposal that they should include in their research program the lunar analysis of geophysical data. An approach was therefore made to the British Tabulating Machine Company, Limited, to seek from them the same valuable aid formerly accorded by them for this work at the Imperial College, and they have generously provided an up-to-date Hollerith installation to be used for this and other purposes. It may therefore be considered appropriate for the Association to make some grant, such as was formerly made for the work of the Imperial College Computing Bureau, to support the continuance of such work at Cambridge. Besides the new data accruing year by year from observatories all over the world, there remains a great store of past observatory data whose lunar analysis is desirable.

In 1945 cooperation was arranged between the Imperial College Computing Bureau and the Institut de Physique du Globe, Paris (Director, Professor J. Coulomb) for the determination of the lunar atmospheric tide at Paris, from over 60 years' barometric pressure data from Paris and Parc Saint Maur. Mr. D. Kastler and Mlle. Roquet on behalf of the Institut came from Paris and stayed in London for several weeks to take part in this joint work, in conjunction with Miss Godfrey, who continued it after their return to Paris. The University Mathematical Laboratory, Cambridge, also participated in the reduction of the data for the last two decades. The final stages of the analysis have been made by Mr. D. Kastler, under whose name the paper describing the results will, it is hoped, shortly appear. The value found for the tide at Paris is in reasonable agreement with that at Greenwich, and is determined with a satisfactorily small probable error.

In 1947 I was joined at Oxford by Mr. K. K. Tschu, who was already well read in the subject of lunar geophysical effects. With his valuable cooperation I am now engaged in preparing for publication the large body of results accumulated at the Imperial College during and before the war. After familiarizing himself thoroughly with the Chapman-Miller method, Mr. Tschu checked the final stages of the lunar analyses of meteorological data not yet published, particularly of those made during the period when the Computing Bureau was deprived of the supervision of a Research Assistant. Some errors in the calculated phases were found and corrected, including some affecting certain of the determinations of the lunar atmospheric tide (in barometric pressure) mentioned in my 1939 Presidential Address to the Association of Meteorology.

In this work our first attention has been given to the lunar effects in meteorological data, because for these both the reductions and the results are simpler than for the magnetic data. A joint paper by Mr. Tschu and myself is now in course of publication by the Royal Society, giving determination of the lunar atmospheric tide (in barometric pressure) for 27 stations widely distributed over the world.

Later a paper will be prepared giving the solar daily barometric variations for these stations; their determination is a by-product of the lunar computations, and it is of interest to compare the solar and lunar variations obtained from the same data at each station.

Another lunar meteorological reduction now completed and ready to be prepared for publication deals with the north-south and east-west components of wind velocity at Mauritius. This is the first determination of the lunar tidal wind yet made. The probable errors slightly exceed half the determined amplitudes, so that the lunar tidal wind is not yet adequately evaluated from the 15 years' data used; further data from the same station are available and should be analyzed in like manner.

In the forthcoming second year of his two-year stay in England, Mr. Tschu intends to cooperate with me in the preparation for publication of the large store of geomagnetic reductions made at the Imperial College. As indicated in detail in my 3rd Report, this material covers an aggregate of over 300 years' data, from the magnetic observatories of Batavia, Cheltenham, Greenwich, Helwan, Pavlovsk and Sitka.

I suggest that the Association should appoint a Committee to promote the continuance and extension of the study of lunar influences on geophysical phenomena, and that grants should be made to encourage one or more institutions to act as international centers for such work.

REPORT OF THE TEMPORARY COMMISSION ON THE LIQUIDATION OF THE INTERNATIONAL POLAR YEAR 1932-33

In view of the action taken by the International Meteorological Organization that there should be a Temporary Commission appointed on the Liquidation of the International Commission for the Polar Year 1932-33, John A. Fleming, J. Keränen, J. M. Stagg, and Andrew Thomson were designated by President Johnson of the International Meteorological Organization to be members of that Temporary Commission. Following correspondence with Dr. Stagg and personal contacts between the other three members of the Commission as originally appointed, a report with recommendations for the liquidation of the agenda was prepared and presented in October, 1947, before the meeting of the International Meteorological Organization in Washington. This report may be briefly summarized as follows:

The realization of the Second Polar Year in 1932-33, as a truly international project, is a monument to the enthusiasm and indefatigability of the late Dr. D. la Cour and to the support generously provided by the Danish Meteorological Institute. From it have already resulted many valuable contributions to knowledge of polar geophysics in numerous publications and in completed or partially completed manuscripts. There remains much material not yet fully compiled or discussed. It would be peculiarly unfortunate if the potentialities for increased understanding of polar geophysics resulting from this great project, in which so many nations and men took selfless part at great cost, were not fully analyzed and published. The past ten years have demonstrated that progress and future human welfare depend upon better knowledge of natural phenomena in the Arctic and Antarctic.

The recommendations included were briefly as follows:

(1) Terminal date to be set at December 31, 1950.

(2) Continuance of Temporary Commission until December 31, 1950, with the addition to its personnel of Dr. Helge Petersen, Director of Det Danske Meteorologiske Institut, Copenhagen, Denmark, and Dr. Harald U. Sverdrup, Director of the Institute for Polar Research for Norway, Oslo, Norway, with the understanding that the total membership be limited to six, and that any replacements necessary because of resignation or death be made by the Temporary Commission with the approval of the President of the International Meteorological Committee.

(3) Authority to co-opt services of scientific men as deemed desirable, authority to receive funds available, and authority to set up a Central Bureau and to appoint a part-time or full-time Executive Officer with duties and responsibilities to be set by the Temporary Commission.

(4) Authority to disburse funds now available or becoming available for the liquidation of the agenda, and to request re-allotment of the balance of $12,000 grant by the Rockefeller Foundation which had been reverted, as well as to solicit further financial aid as may be appropriate from other organizations.

(5) Preparation of a complete inventory of instruments and their present distribution with authority to dispose of instruments as deemed desirable.

(6) The establishment of a complete bibliography of microfilms and publications.

(7) Preparation of an authoritative historical summary of the Polar Year 1932-33.

(8) Liquidation of the agenda through the allocation of items under four sections, namely, (a) meteorology and allied results, (b) geomagnetism, earth currents, atmospheric electricity, and allied results, (c) auroral results, and (d) aerological results. The Temporary Commission to determine what, if any, of the observations made may not now be worthwhile compiling for publication in view of data obtained, and development of methods improved since the Polar Year.

The Commission's report drew attention to the fact that the accomplishments of the program of the Second International Polar Year were heroic and that it would be a calamity and injustice to those who gave so generously in effort and time not to see its work completed in respect to thorough compilation, analysis, discussion, and publication as a whole enterprise. This report and its recommendations was submitted to the Directors' Conference of the International Meteorological Organization in Washington on October 8, 1947, and it and its recommendations were adopted.

The Commission is glad to report that the Rockefeller Foundation, at the meeting of its Board of Trustees, December 2-3, 1947, made a final grant of $12,000 to the Temporary Commission for the purpose of realizing the liquidation of the agenda within the terminal time set. The balance of funds on deposit in Copenhagen, amounting to something more than $7,600, are also available. It is gratifying to note that the Danish Minister responsible for the Meteorological Institute has authorized that Institute to participate in the work as proposed in the report of the Temporary Commission. Dr. Helge Petersen, Director of the Danish Meteorological Institute, has assigned Mr. V. Laursen as Executive Officer, and Mr. Laursen will have assistance from Messrs. J. Olsen and J. Egedal of Dr. Petersen's staff in carrying out the work.

The Central Bureau at Copenhagen has already taken steps to organize the work. Dr. Petersen will submit a progress report.

It is hoped that all persons interested in the completion and publication of the Polar Year data, or who may have material and discussions for reports, will communicate promptly with Dr. Petersen (address, Det Danske Meteorologiske Institut, Kõbenhavn K, Denmark).

Jno. A. Fleming, President

Washington 5, D. C.,
July 31, 1948

REPORT ON THE ESTABLISHMENT IN COPENHAGEN OF A CENTRAL BUREAU FOR THE LIQUIDATION OF THE POLAR YEAR 1932-33

By Helge Petersen

In the report which Dr. J. A. Fleming, in his capacity as President of the Temporary Commission on the Liquidation of the Polar Year, presented to the Conference of Directors of the International Meteorological Organization, held in Washington in September-October 1947, it was recommended to set up a Central Bureau and repository of all records, materials, and publications of the Polar Year 1932-33, and in the remarks to this recommendation the Commission expressed the hope that the Danish Meteorological Institute might be willing to provide facilities for this Central Bureau. This action, of course, was taken with a view to the predominant role which the late Dr. la Cour, while Director of the Institute, played in the realization of the Polar Year program, and to the considerable amount of Polar Year material already accumulated in Copenhagen.

The Conference of Directors approved the recommendations of the Commission, and the Danish Institute was officially invited to participate in the liquidation, not only by providing facilities for the planned Bureau, but also by letting scientists from the Institute staff take part in the work. In spite of the fact that the Institute is actually suffering from a lack of scientific personnel, we felt that we ought to support in every way possible the accomplishment of this outstanding international enterprise to which Dr. la Cour devoted so much of his energy and eminent skill, and with the consent of the responsible Danish authorities the Central Bureau has now been established.

The address of the Central Bureau will be the Meteorological Institute, Copenhagen, where Messrs. J. Egedal, J. Olsen, and V. Laursen will assist in the carrying out of the work, with the last-mentioned acting as Executive Officer. The Bureau requests that all persons, institutes, and organizations which have taken part in the carrying out, reduction, and discussion of Polar Year observations, or which are otherwise interested in the accomplishment of the work, will assist in the realization of the program set forth by the Liquidation Commission. It is hoped that the Central Bureau will soon communicate with all institutions which have in some way or other been engaged in Polar Year work, but many changes have taken place during and after the war, and some of the channels through which Dr. la Cour has previously got so valuable information may now be closed, so that the cooperation and best advice of everybody interested is highly needed if a reasonable completeness of the final result is to be obtained.

One of the tasks of the Central Bureau will be to prepare an inventory of all instruments belonging to the discharged Polar Year Commission. This inventory will comprise a rather great number of geomagnetic variometers and recorders which, if they were available today, would meet to some extent the existing general demand for observatory equipment. The instruments were lent to observatories taking part in the Polar Year observations, and at the Copenhagen meeting of the Polar Year Commission, 1933, it was decided that such observatories which expressed their wish to continue the use of the instruments also after the Polar Year should be allowed to do so until further notice. It seems that most of the observatories have preferred to keep the instruments, but a formal transfer of the instruments has never taken place, and before a final decision can be made as to their future use a new application to the observatories in question will be necessary. This application, which is now under preparation at the Central Bureau, will reveal if some of the instruments are actually available for use at other observatories where a completing of the recording equipment is needed. The Central Bureau has already arranged that the two quick-run magnetographs used in Iceland in 1937 for the preliminary giant-pulsation investigations be returned to Copenhagen. A thorough overhauling of these instruments will be necessary before they can be used again.

A good deal of formalities had to be overcome before the funds of the International Polar Year Commission which were deposited on a blocked account in the Danish National Bank could be transferred to the Liquidation Commission. Among the first expenditures on the account of the Liquidation Commission can be mentioned a grant which will make possible the prompt publication by Prof. Mario Bossolasco of the observations from the Polar Year station Mogadiscio.

Danish Meteorological Institute
Copenhagen, Denmark
August 16, 1948

PART V

COMMUNICATIONS

Due to limitation of funds it has not been possible to publish complete texts of the many excellent communications submitted for the Oslo Assembly. In some cases abstracts of the papers are given; in other cases where the communication has already been published, a statement is made referencing the periodical in which the complete text may be found; and finally some communications which have not yet been published are presented by title only.

A. Discussion on Physical Aspects of the Influence of Solar Activity on Terrestrial Magnetism

INTRODUCTORY REMARKS TO THE DISCUSSION

By L. Vegard, Discussion Leader

This session should be devoted to an interchange of ideas and suggestions relating to the nature and source of the solar processes which are responsible for variations in the earth's magnetic field, for the production of aurorae, and for the physical properties of the upper atmosphere.

Having the honor to be called upon to act as discussion leader, I think it would be a good procedure to give a short summary of some of the essential facts and relationships, which have been derived from the observations, their statistical treatment and the correlation between observed phenomena.

Variations in the Earth's Magnetic Field

Both the correlation between the statistical results of magnetic variations and those from solar activity as well as examination of individual cases of variations has shown that the variability of the earth's magnetic field is connected with solar activity as it manifests itself through sunspots, solar flares, floculae faculae and prominences. Still we do not always know which part each of these solar processes may play in the various types of magnetic variations.

With regard to the regular diurnal variation corresponding to undisturbed conditions, I think we now have a fairly correct conception regarding its physical explanation. This variation has been explained in a satisfactory way as due to induced currents in the ionospheric layers and these layers are under normal conditions produced by some sort of photon radiation from the sun. But when we go further and ask for the nature of the solar processes responsible for the various ionospheric layers and their properties, we are still on uncertain ground. These are most important problems which I think should be open for our discussion. But apart from these details we may say that we have a fairly satisfactory theory of the quite regular diurnal variation of the earth's magnetic field. As regards magnetic variations I think we should concentrate our discussion on the magnetic disturbances.

I think that the classification of magnetic perturbations which were introduced in the Birkeland work: "The Norwegian Aurora Polaris Expedition 1902-03" will be well adapted as a basis for the discussion of the physical explanation of magnetic storms.

The perturbations are divided into the following groups:

I. The equatorial perturbations.
II. The polar storms.
Each of these groups are divided into positive and negative according as the horizontal component is increased or diminished by the perturbing force.
III. Cyclo-median storms.
As a fourth group may be added the giant pulsations, although they may appear to be closely related to the polar storms.

The cyclo-median disturbances appear as a bay in the magnetic curves and are found to be identical with those which accompany solar flares and the "fade-out" phenomena occurring in radio transmission. The perturbing field is found to be of essentially the same type as the field producing the regular diurnal variation and may be regarded as an intensification of this field due to an increase of conductivity of ionospheric layers, particularly the D-layer. This type and its interpretation is of the greatest importance because it gives us the perturbing field which results from a solar radiation which passes in straight orbits and strikes the dayside of the earth. We must therefore find some other explanation for the other types of perturbations which have essentially different perturbation fields.

The perturbing force of a typical equatorial storm is mainly restricted to the horizontal component and has nearly the same magnitude at the equator all around the earth, but decreases towards greater latitudes. In the case of the positive storm the perturbing force has the same direction as the horizontal component. In the case of the negative disturbances the direction is opposite. The positive perturbations are the more frequent and are characterized by a sudden commencement occurring simultaneously all around the equator.

Fields of this type must be produced by current systems approximately symmetrically distributed with respect to the magnetic equatorial plane.

In order to explain that the intensity of the field is approximately the same at all points at the equator, the current system must either form a ring around the earth with its central line in the plane of the magnetic equator, or, have a distance which is very great compared with the diameter of the earth.

As a further step I think we may safely assume that the primary current systems are to be found outside the earth, and must be due to the motion of electrons and ions. Now it is easily seen that an electrically charged particle moving in the equatorial plane and producing a magnetic force in the same direction as the horizontal component H, will be subject to a deviating mechanical force directed away from the earth. Therefore, the positive equatorial perturbations cannot be produced by a ring current if the orbits are circles with the earth as center; but must be due either to a current sweeping past the earth at a distance which is large as compared with the diameter of the earth, or to a ring composed of quasiperiodic orbits.

The negative equatorial perturbations on the other hand may result from the formation of a ring current composed of circular orbits.

The equatorial perturbations usually develop into polar storms.

The characteristic features of a typical polar storm are:

It has a local field with a storm center usually near the auroral zone. The horizontal component of the perturbing force is usually directed nearly perpendicular to the auroral zone. According as the force is directed southwards or towards the north, the storm was called negative and positive, respectively. The intensity of the field falls off very rapidly away from the storm center. From the way in which the vertical component of the perturbing force varies, we can conclude that the primary current system producing the field must be situated above the ground, and at an altitude of the order of magnitude of say 200 km.

On account of its local character, a storm center at one part of the auroral zone will have a very small effect at some distance along the auroral zone and therefore these perturbations show a pronounced diurnal variation. This diurnal variation is for our present purpose best represented by the average diurnal magnetic storm. This average storm shows a most regular and typical feature especially for all localities near the auroral zone.

In the morning and forenoon there is a quiet period followed by a positive perturbation in the afternoon, which in the evening quite suddenly changes direction to turn into a much stronger negative storm, which has its maximum near magnetic midnight.

This quite regular variation consisting in a sudden change from a positive to a negative storm with maximum storminess near magnetic midnight calls for some simple explanation. Apart from details the regular distribution of the polar storm centers relative to the magnetic axis and the auroral zone shows that the current systems (consisting of electrons and ions) must be under the control of the earth's magnetic field from distances which are large compared with the dimensions of the earth.

The Birkeland-Störmer theory gives a possibility of understanding the essential features of the polar magnetic storms with regard to geographical distribution and time variations but many features want to be cleared up regarding the constitution of the magnetically effective electric ray bundles and the typical diurnal variation of polar storminess.

Probably some secondary effects operating near the earth may play an important part and it is a tempting theoretical problem to try to find out what will occur in the region of the ionosphere when the bundles of solar corpuscles penetrate into it.

Results from Auroral Observations

The geographical distribution and the variation with time of auroral frequency is subject to a geomagnetic control similar to that shown by the polar magnetic storms. The zone of maximum frequency has its center at the magnetic axis point and the diurnal variation shows a maximum about one hour before magnetic midnight.

The direction of arcs and bands has a tendency to show a nearly constant magnetic azimuth and the ray streamers follow the magnetic lines of force.

The lower limit of the aurorae may vary between say 65 and 200 km, but most of these stop at an altitude of 100-110 km. The upper limit may vary from say 130 to 1000 km.

To reach down to an altitude of 100 km electrons must have an energy of the order of 10,000 electron volts, protons an energy of 150,000 - 200,000 electron volts, and other positive ions still greater energy.

For a given lower limit the length of the streamers may vary within wide limits. This means that the distribution of luminescence along the streamers is not a function of the altitude of the lower limit. This may result from three causes:

1. Variation in the composition of the solar electric rays.
2. Variation in the density distribution in the upper atmosphere.
3. The influence of the magnetic field on the orbits of the electric rays.

The latter is probably the most common and prominent factor.

Spectral analyses have shown that the upper atmosphere is mainly composed of a mixture of nitrogen and oxygen partly in the state of molecules and partly dissociated into atoms in various states of ionization.

Hydrogen lines only appear occasionally, indicating that showers of hydrogen from the sun occasionally enter into the atmosphere. A closer inspection of the H_β-line shows that sometimes it coincides exactly with H_β in the comparison spectrum. In other cases a diffuse line displaced towards shorter waves appears and may most probably be interpreted as the H_β-line displaced through Doppler effect. The displacement corresponds to a velocity of about 300 km/sec towards the observer.

Also the yellow sodium-line appears in the auroral spectrum, and shows similar fluctuations indicating that sodium from the sun enters the atmosphere. A Doppler effect of the sodium line has not yet been observed.

Already in 1923 it was found that molecular nitrogen is a predominant component of the atmosphere to the very top of the highest auroral rays reaching altitudes up to 1000 km. This shows that the auroral region under the influence of some solar effects develops a coronal structure, where the density varies very slowly with increase of altitude.

As the effective molecular weight is of the same order as nitrogen atoms--and as the temperature measured from the energy distribution within the rotational bands is of the order of 40°C circa--the coronal structure cannot be explained by a high temperature.

The only possibility seems to be that the distribution of matter in the upper atmosphere is influenced by electrostatic forces produced by the photoelectric effect of a soft X-radiation from the sun. This radiation would give two ionization maxima, which I have identified with the layers E and F_2. The F_1-layer should be produced by ultraviolet light in the region 20-1000 Å units.

In order to produce a maximum of ionization at the altitude of the E-layer, the energy of the X-rays must be 1000 to 1500 electron volts, corresponding to a wavelength of 10 → 8 Å.

The interpretation of the coronal lines by Edlén has shown that a radiation of this energy must be emitted from the sun.

The explanation of the coronal structure of the auroral region explained the zodiacal lights and is directly applicable to the solar corona--and to the bundles of rays responsible for the production of the aurorae and most magnetic disturbances.

To explain the magnetic effect of the solar ray bundles it is assumed that they are magnetically active bundles mainly consisting of electrons, electrostatically neutralized by positive ions. Also positive ions, e.g. protons, may follow the bundles, but give a reduction of the magnetic effect. In this way we may also account for the hydrogen showers and the possible Doppler effect shown by hydrogen lines.

CONTRIBUTION A L'ÉTUDE DES EFFETS GÉOMAGNÉTIQUES DES DIFFÉRENTES MANIFESTATIONS DE L'ACTIVITÉ SOLAIRE

Par Antonio Romañá, S.J. et J. M. Princep

Résumé

Ce travail a deux parties. Dans la première nous avons étudié l'effet sur les courbes de l'Observatoire de l'Ebre des éruptions chromosphériques brillantes comprises dans les listes publiées par le Quarterly Bulletin on Solar Activity, de Zürich. Les résultats viennent d'être publiés dans le n.° 1 de la nouvelle série de Publications de l'Observatorire de l'Ebre intitulée Miscellanea. Dans la seconde nous cherchons une classification systématique, des baies magnétiques enregistrées à l'Observatoire de l'Ebre, dans le but de donner une base plus solide à l'étude des phénomènes solaires capables de les produire. Les résultats seront publiés sous peu dans la collection des Mémoires de l'Observatoire de l'Ebre sous le n.° 10. Nous donnons ici un résumé de ces deux travaux.

1.° Eruptions chromosphériques et crochets.--Les éruptions chromosphériques comprises dans les listes de Zürich de 1935 à 1946 sont en nombre de 5.268. Or les enregistrements magnétiques de l'Observatoire de l'Ebre ayant été hors de service régulier depuis le mois d'Avril 1938 jusqu'au mois de Décembre 1941, il faut supprimer des éruptions chromosphériques à étudier toutes les observées pendant cette période: il en reste 2.808. Parmi celles-ci, 1.546 ont été observées en conditions favorables à la production d'un crochet à Tortosa, dont 1.137 de caractère 1, 348 de caractère 2 et 61 de caractère 3. Or on n'a enregistré en rapport avec elles que 86 crochets, dont 35 tout à fait nets et 51 plus ou moins masqués. Le pourcentage des éruptions chromosphériques de caractère 1 avec crochet associé étant presque nul et trés petit celui des éruptions de caractère 2, on est porté à croire que seules les éruptions de caractère 3 sont vraiment aptes à donner lieu à ce phénomène, d'autant plus que les éruptions de caractère 1 ou 2 qui l'ont produit ont pu être aussi facilement de caractère 3, car dans la plupart des cas leur commencement a echappé à l'observation. Cela nous a porté à étudier dans les listes de fulgurations de classe 3 publiées par Newton au Monthly Notices celles ayant été en situation favorable à la production d'un crochet à Tortosa; nous y avons ajouté quelques éruptions plus récentes de grande intensité. Le pourcentage d'association monte pour celles-ci au 63 %. Un examen des possibles causes favorisant ou empêchant l'enregistrement d'un crochet nous a porté aux conclusions suivantes:

a) Le rapport entre le nombre de crochets et le nombre d'heures que le Soleil reste à une hauteur déterminée sur l'horizon, augmente avec celle-ci. Il ne croît pas pourtant toujours; mais il passe par un maximum pour la hauteur comprise entre 40° et 50°, avec des maximums sécondaires pour 60° - 70° et 10° - 20°.

b) La comparaison de ces résultats avec les heures les plus fréquentes d'enregistrement de crochets à Tortosa confirment que ceux-ci suivent la variation diurne et que par conséquent les heures d'inflexion des courbes ne sont pas aptes à leur inscription. Par contre les heures les meilleures sont celles des élongations maximum et par conséquent les courbes les plus à propos pour leur étude celles qui présentent une onde diurne plus marquée. Il s'ensuit que c'est une erreur de limiter souvent leur étude à la composante horizontale, mais qu'il faut choisir dans chaque Observatoire la courbe la plus à propos.

c) Quant il s'agit des grandes éruptions (toutes les autres circonstances restant les mêmes) la probabilité de la production d'un crochet associé est maximum quand l'éruption se produit dans la zone centrale du disque solaire. En effet l'étude comparative des éruptions de ce genre, capables de produire un crochet à Tortosa ou à Greenwich, apparues au centre du disque ou à sa périphérie, nous a montré que le crochet s'est produit dans le 78 % des cas pour les premières, tandis que pour les autres il n'a été observé que dans le 17 % des cas.

2.° Essai de classification des baies géomagnétiques.--Les études sur ce type de perturbation géomagnétique ont porté généralement à des résultats un peu imprécis parce qu'on s'est appuyé souvent sur un nombre trop petit d'observations et plus encore parce qu'on s'est restreint à la considération de la composante horizontale. L'étude des courbes de Tortosa pour les trois composantes H, D, Z de 1913 à 1933 et de 1942 à 1946 nous a permis de confirmer ou élargir les résultats trouvés par d'autres investigateurs et surtout nous a fait voir la nécessité de faire attention aussi aux autres courbes pour aboutir à des résultats cohérents.

Pour les baies positives de H on a trouvé de nouveau le maximum diurne entre 22^h et 23^h, avec un maximum secondaire en été entre 18^h et 19^h; les maximums annuels se présentent aussi aux équinoxes, avec les minimums aux solstices. Quant à sa fréquence séculaire elle ne suit pas la courbe de l'activité solaire, mais plutôt celle de l'activité magnétique. Pour D et Z leurs maximums ne sont pas en correspondance avec ceux de H.

En nous limitant à l'étude de H et D, car les baies en Z sont à Tortosa peu importantes, nous avons réussi à classer les baies en ces 8 types, dont les maximums se succèdent régulièrement pour les 5 premiers pendant les heures de la nuit, et pendant celles du jour pour le 7ème, --le 6ème et le 8ème étant plutôt rares--,

1	D		$\Delta D>0$ (→ E)	5	D′		$\Delta D<0$
2	HD	$\Delta H>0$	$\Delta D>0$	6	H′D′	$\Delta H<0$	$\Delta D<0$
3	H	$\Delta H>0$		7	H′	$\Delta H<0$	
4	HD′	$\Delta H>0$	$\Delta D<0$ (→ W)	8	H′D	$\Delta H<0$	$\Delta D>0$ (→ E)

Dans l'hypothèse que les baies soient une perturbation magnétique produite par des systèmes des courants ionosphériques, on a réussi à donner une représentation de la position moyenne du vecteur représentatif d'un tel système des courants pour Tortosa (en le supposant horizontal) pour chaque type de baies. En partant d'une position donnée du vecteur et en considérant une rotation complète du même le long du jour en sens contraire aux aiguilles d'une montre, on trouve les différents types de baies dans le même ordre dans lequel elles font leur apparition. On trouve en particulier expliquées de la sorte les baies qui en H ou en D prennent la forme d'une onde double et que Lahaye appelle complexes.

Observatoire de l'Ebre
Juillet 1948

DISCUSSION:

J. Coulomb: "Prof. Maurain and I made a statistical study of bays registered in Parc St. Maur based on some 60 years of recording, with similar results [Maurain et Coulomb, Comptes Rendus Ac. Sc. Paris, 216, 1943, p. 273 and p. 327]. We tried, like Wiechert, to apply the Störmer theory, but contrary to these authors (Romañá and Princep), the comparison gave poor results."

SOLAR FLARES AND THEIR TERRESTRIAL EFFECTS

By Wilfred C. Parkinson

Abstract

Considering the 140 crochets on the Huancayo magnetograms, it is found that, of the 64 which were coincident with reported flares, 13 of these flares were of intensity 3 (very intense flares), 28 of intensity 2, and 23 of intensity 1. The remaining 76 crochets were identified by the simultaneous commencement of an ionospheric fade-out. A study of the intensities of the 64 flares producing crochets and also the characteristics of the crochets is being made.

Taking 117 storms of 1936 to 1946 which were preceded by flares of intensity 2 or greater, the statistical mean of the intervals between flare and storm was 42.5 hours. Of the 117, 85 were associated with flares occurring in sunspot groups not more than 45° from the central meridian and 32 were in the outer zone. The statistical mean of the 85 in the inner zone was 42.4 hours and that of the 32 in the outer zone was 42.7 hours. However, when tabulated on a percentage basis in 12-hourly-interval groupings, the curves show a maximum frequency between 24 hours and 36 hours, both for inner and outer zones.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D.C., U.S.A.

LE PROBLÈME DES RÉGIONS IONOSPHÉRIQUES

Par M. Nicolet

The complete text is published in the Journal of Geophysical Research, vol. 54, pp. 373-381 (1949).

ON THE VARIATIONS OF ELECTRON AND ION DENSITIES IN THE F_2 LAYER AT THE TIME OF THE SOLAR ECLIPSE ON FEBRUARY 5, 1943

By T. Yonezawa

The observational data, obtained at Kushiro, Hokkaido, of the maximum electron density in the F_2 layer at the time of the solar eclipse on February 5, 1943, are shown in Figure 1 by dots, and the mean variation of the maximum electron density, averaged over several days before and after the day of the eclipse, are shown by a full line in the same figure. The corresponding true heights were about 260-270 km.

We assume that the variations of electron and ion densities on usual days and at the time of the eclipse are governed by the following equations:

$$dn'/dt = I - \alpha n'^2 - \beta n' + \gamma n'_-, \quad dn'_-/dt = \beta n' - \gamma n'_-; \tag{1}$$

$$dn/dt = k_1 I - \alpha n^2 - \beta n + k_2 \gamma n_-, \quad dn_-/dt = \beta n - k_2 \gamma n_-; \tag{2}$$

where n and n_- are the electron and negative ion densities at the time of the eclipse and n' and n'_- are those on usual days; t is time; I is the number of ionizations which occurred per cc per second on usual days by the ultraviolet radiation of the sun; α is the recombination coefficient of an electron and a positive ion; β is the attachment coefficient of an electron to neutral molecules and atoms, multiplied by their number density; γ is the detachment coefficient of an electron from a negative ion by the action of solar radiation; k_1 is the ratio of the solar radiation energy, which is effective in causing photo-ionization, at the time of the eclipse to that on usual days, and k_2 is the corresponding ratio of the energy which is effective in causing detachment.

For the value of γ we have adopted the one which was worked out theoretically by Yamanouchi in the case of negative oxygen ions [1]: $\gamma = 2.90 \times 10^{-3}\ \text{sec}^{-1}$. The values of k_1 and k_2 can be calculated, if we properly assume the distribution of radiation energy over the sun's disk. Thus we can solve for n'_- and n'_- the two equations on the right hand side in Eqs. (1) and (2), obtaining, if we neglect transient terms,

$$n'_- = \beta \int_{t'_0}^{t} n'(t_1) e^{-\int_{t_1}^{t} \gamma dt_2} dt_1 \equiv \beta n^{*\prime}_-, \tag{3}$$

$$n_- = \beta \int_{t'_0}^{t} n(t_1) e^{-\int_{t_1}^{t} k_2(t_2)\gamma dt_2} dt_1 \equiv \beta n^{*}_-; \tag{4}$$

here t_0 is a time sufficiently previous to the beginning of the eclipse and t'_0 is a corresponding time on a usual day. We can calculate $n^{*\prime}_-$ and n^{*}_- from the observational data. Substituting for n'_- and n_- from Eqs. (3) and (4) in the equations on the left hand side in Eqs. (1) and (2) and eliminating I from the resulting two equations, we obtain

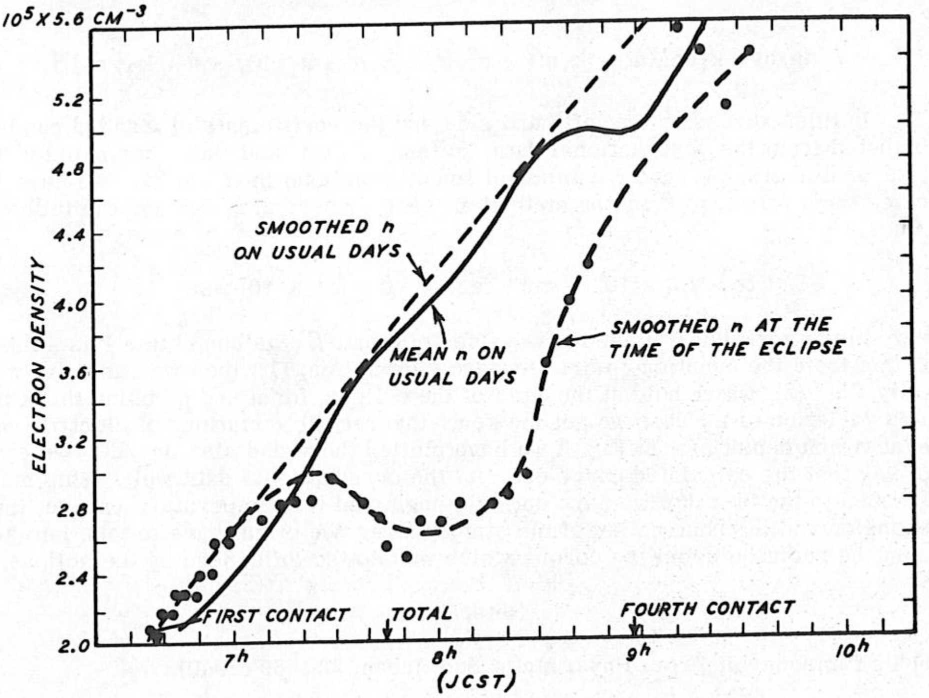


Figure 1

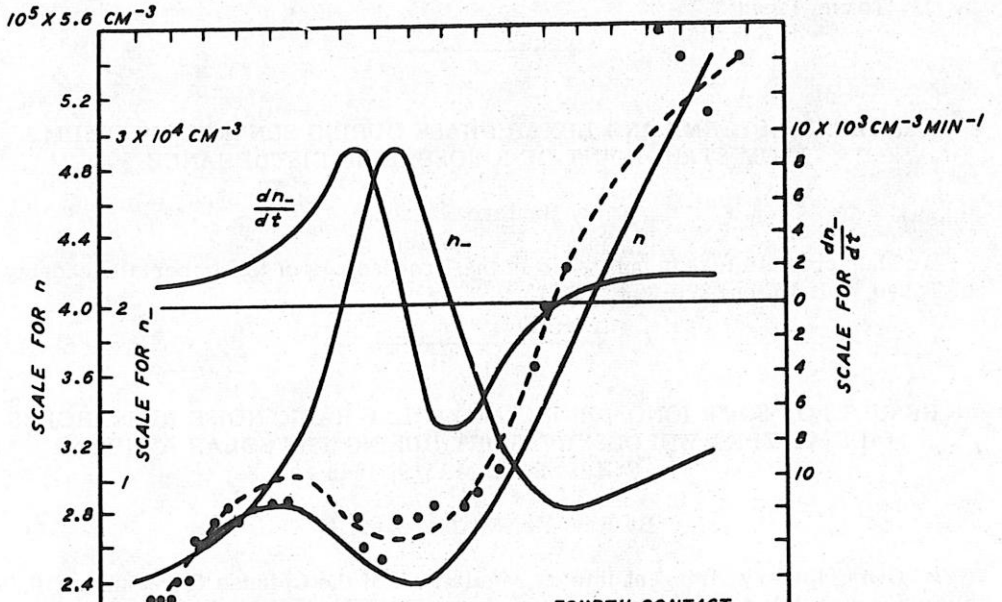


Figure 2

$$dn/dt - k_1 dn'/dt = (k_1 n'^2 - n^2)\alpha + (k_1 n' - k_1 \gamma n_-^{*\prime} - n + k_2 \gamma n_-^*)\beta.$$

In this expression the left hand side and the coefficients of α and β can be computed from the observational data, so that, if we insert these computed values at several hours, we have a number of linear equations in α and β. We have solved them for α and β by the method of least squares and obtained the following values:

$$\alpha = 2.8 \times 10^{-10}\ \mathrm{cm}^3\ \mathrm{sec}^{-1}, \quad \beta = 5.9 \times 10^{-5}\ \mathrm{sec}^{-1}.$$

In the next place, using these values of α and β, we can obtain I as a function of time from the equation on the left hand side in Eqs. (1); then we can solve numerically Eqs. (2), which hold at the time of the eclipse, for n and n_- using this calculated variation of I. Thus we get the semi-theoretical variations of electron and negative ion densities. In Fig. 2 we have plotted these and also dn_-/dt. We can not say that the calculated curve of n fits the observational data well. This may be ascribed to the fact that we have entirely neglected the temperature change, the expansion and the contraction of the atmosphere. We might have to take into account the radiation from the corona which was not so influenced by the eclipse.

Reference

[1] T. Yamanouchi, Proc. Phys. Math. Soc. Japan, 22, 569 (1940).

Physical Institute for Radio Waves
Ministry of Education
Tokyo, Japan

MAGNETIC STORMS AND LUNAR PHASE DURING SUNSPOT MAXIMUM FROM STANDPOINT OF IONOSPHERIC DISTURBANCE

By Hantaro Nagaoka

The complete text is published in the Proceedings of the Imperial Academy of Tokyo, vol. 16, pp. 290-293 (1940).

RESULTS OF SOME IONOSPHERIC AND SOLAR RADIO NOISE RESEARCHES MADE AT ZI-KA-WEI OBSERVATORY DURING THE SOLAR ANNULAR ECLIPSE OF MAY 9, 1948

By Rev. Fr. E. Gherzi, S. J.

Owing to very stringent import regulations of the Chinese Government, it is almost impossible to get into China any scientific instrument. This explains why the results obtained during the annular solar eclipse were only relative measurements.

Ionosphere Research

Pulses were sent on a frequency of 5.8 megacycles by means of a "self-pulsed" oscillator. The peak power was about 60 watts and pulse duration about 100 microseconds. A half-wave aerial was used at about one-half wave length above the ground. The following results were obtained:

7h (120° E.G.)	Single and moderate reflection from the F layer. Virtual height about 200 km.
8h 33m	Eclipse began.
8h 45m	Still a single F reflection. It remained showing alone until 9h 51m. At 9h 53m, time of the maximum of the eclipse (0.985 of the sun's disc), a rather strong reflection from the F2 layer appeared suddenly from about 350 km virtual height. F was still noticeable but had decreased. The F2 reflection remained with slight "pumping" until 9h 55m, when it disappeared and F became stronger.
10h 05m	While the eclipse was decreasing we had suddenly a series of echoes--F (200 km); F2 (350 km) double and unsteady; F3 single and steady. Another echo from about 700 km appeared and between F and F2 we had for a short time two smaller echoes which quickly disappeared.
10h 10m	One F echo of normal intensity and from time to time again an echo from about 700 km.
11h 00m	Only one F reflection (200 km).
11h 23m	Eclipse ended. No reflections from the E layer were noticed on our frequency during the eclipse.
17h	The usual series of F, and three multiples all of a good intensity.

The oscillograph used was an Allen DuMont instrument kindly donated many years ago by the president of the firm. The receiver was a Hallicrafter SX 42, to which we had made some modifications of our own to reduce its time constant. Mr. John Johnston of the National Geographic Society of the United States had generously presented this fine instrument. To them all our sincere thanks.

Radio Solar Noise Research

A horizontal beam with one director and one reflector was installed in our garden for a frequency of about 61.3 megacycles. The beam and its two parasitic elements were checked the day before the eclipse. The radiator stood about one-half wave length above the ground. The beam was connected to an RCA receiver, type TSB-6, with a frequency range from 60 to 80 megacycles. This receiver should have been matched with a feeder of 70 ohms impedance. We used a feeder of 100 ohms impedance and that meant a slight mismatching. As the receiver had a tendency to get into self-oscillation when perfectly tuned, we kept the sensitivity below the maximum value. This receiver was kindly loaned by Sir Denis Boyd, Commander in Chief of the British Pacific Fleet, and we want to express here our sincere gratitude for his generous aid to scientific work.

The output, in decibles, is given by a meter. As we do not know the sensitivity value we had been using we cannot calculate the exact value of the solar noise. When adjusted for full sensitivity, the receiver is listed as responsive to a 5-microvolt input signal. The industrial activity all around Zi-Ka-Wei Observatory was checked on the oscillograph and found to have remained constant during the eclipse. So much so that it interfered in a similar way during the time of the experiments. Besides a meter keeping constant the power supply input to the receiver, we inserted a telephone into the receiver for checking the kind of noise and to notice if any transmission was entering into the receiver. The observed values of radio solar noise during the eclipse are:

7h (120° E.G.)	-10 db. (the receiver's noise without aerial had been reduced to -16 db.)
8h 00m	-8 db.
8h 33m	Eclipse began.
9h 00m	-12 db.
9h 30m	-16 db.
9h 45m	-16 db.
9h 53m	-16 db. (Maximum of the eclipse)
10h 30m	-12 db.
11h 00m	-5 db.
11h 23m	Eclipse ended.
14h 30m	-7 db. (We forgot to point the beam towards the sun.)

These figures show a real decrease of the solar radio noise while the beam was continuously kept towards the sun, in azimuth and declination, according to calculated values for our position. Owing to the overcast skies the sun itself could not be seen.

The decrease of the solar radio noise was rather rapid at the beginning of the eclipse, but its recovery was rather slow.

LONGITUDINAL INEQUALITY OF SOLAR DIURNAL VARIATION IN GEOMAGNETIC FIELD

By T. Nagata

In the analysis of the solar diurnal variation in geomagnetic field on quiet days, the assumption that it varies with the local time ($t = T + \lambda$, where T denotes the universal time), and does not otherwise depend on longitude, has been usually adopted as the first approximation. Strictly speaking, however, S_q-variation does differ appreciably for stations in different longitudes. Therefore, for the given solar activity and the season, the S_q-field must be assumed to be a function of latitude ϕ, local time t as well as longitude λ, namely $S = S(\phi,\lambda,t)$. Since $t = T + \lambda$, we can write

$$S = S(\phi,\lambda,T) \qquad \text{as} \qquad S = S(\phi,t,\lambda).$$

On the other hand, a detailed picture of distribution of S_q-field over the earth at various Greenwich Times has recently been obtained by M. Hasegawa [1] from the data of the Second Polar Year observations. According to his results, in which S_q-field on the earth is expressed in the geomagnetic coordinates, S_q-field changes fairly regularly with the universal time. The most conceivable cause of the longitudinal inequality of S_q-field mentioned above seems to be the effect of disagreement of the geomagnetic and geographic poles on the dynamo-action in ionosphere. Here, the data which were examined by Hasegawa are rearranged in the geographic coordinates, the mean solstitial distribution of S_q-field at every two hours in GMT being calculated.

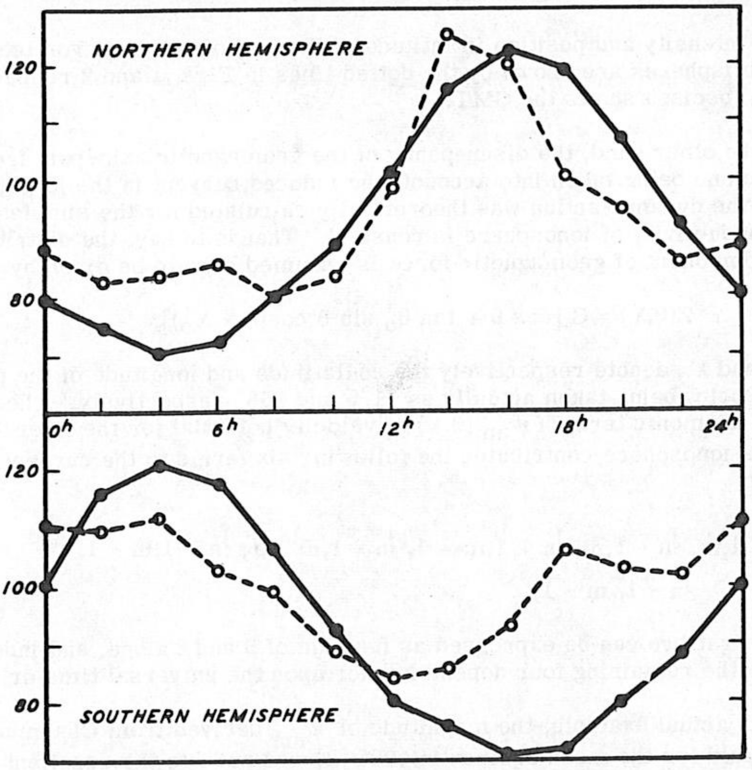


Fig. 1. Change in the intensity of foci of equivalent current vortices in S_q with UT.

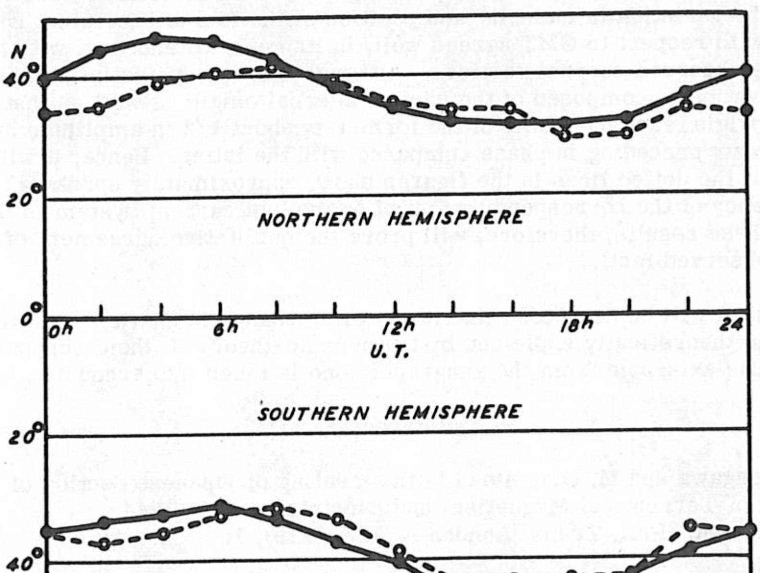


Fig. 2. Change in the position of foci of equivalent current vortices in S_q with UT.

The intensity and position in latitude of the foci of potential vortices of S_q in both hemispheres are shown by the dotted lines in Figs. 1 and 2 respectively, where the abscissa shows the GMT.

On the other hand, the discrepancy of the geomagnetic axis-pole from the geographic one being taken into account, the induced current in the ionosphere caused by the dynamo-action was theoretically calculated for the simplest case that the conductivity of ionosphere is constant. That is to say, the distribution of vertical component of geomagnetic force is assumed here to be given by

$$Z(\theta,\lambda) = G\,[\cos\theta + \tan\theta_0 \sin\theta \cos(\lambda - \lambda_0)],$$

where θ_0 and λ_0 denote respectively the co-latitude and longitude of the geomagnetic axis-pole, being taken actually as 11°.5 and -68° respectively. Then, any particular harmonic term of $\psi_{nm}(\theta,\lambda)$ of velocity potential for the lateral movement of the ionosphere contributes the following six terms to the current function J; they are

$$J_{n+1,m},\ J_{n-1,m},\ J_{n+1,m+1},\ J_{n-1,m+1},\ J_{n+1,m-1},\ \text{and}\ J_{n-1,m-1},$$

where the first two can be expressed as function of θ and t alone, and independent of λ, while the remaining four depend further upon the universal time or longitude.

As an actual example, the magnitude of ψ_{nm} derived from Chapman's analysis of S_q-field for the mean equinox in 1905 [2] was put into the equations, the distribution of $J(\theta,\lambda)$ at every two hours in GMT is computed. The intensity and position in latitude of the foci of equivalent current vortices in both hemispheres thus calculated are shown by the full lines in Figs. 1 and 2. As will be seen in these figures, the variation in intensity and position of the foci of equivalent current vortices with respect to GMT agrees well, in its general tendency, with that of the foci of the observed current vortices. Although $S(\theta,\lambda,T)$-potential obtained from the observation is composed of the part of internal origin as well as that of the external origin, each harmonic of the former is about 1/2 in amplitude and less than one hour preceding in phase compared with the latter. Hence, it will be assumed that the dotted lines in the figures show, approximately speaking, the general tendency of the corresponding foci of equivalent current system in the ionosphere. These results, therefore, will prove the qualitative agreement of the theory with the observed fact.

Thus it will be concluded that the regular change in S_q-field with the universal time is theoretically explained by the dynamo-theory if the discrepancy of the geomagnetic axis-pole from the geographic one is taken into account.

References

[1] M. Hasegawa and M. Ota. Read at the meeting of Japanese Section of Association of Terrestrial Magnetism and Electricity, Feb. 1944.
[2] S. Chapman. Phil. Trans. London A. 218 (1919), 1.

Geophysical Institute
Tokyo University, Japan

MAGNETIC DISTURBANCE DURING SUDDEN FADEOUTS OF RADIO TRANSMISSION

By Hantaro Nagaoka

The complete text is published in the Proceedings of the Imperial Academy of Tokyo, vol. 16, pp. 201-207 (1940).

RADIO FADEOUT AND EARTH MAGNETIC VARIATION

By S. Imamiti

[By title only]

SUR DES DIFFÉRENCES ESSENTIELLES AUTRE LES ORAGES MAGNÉTIQUES À DÉBUT BRUSQUE ET À DÉBUT PROGRESSIF

Par E. Thellier and Mme. O. Thellier

The complete text is contained in the following two articles:

"Sur une différence essentielle entre les orages magnétiques à début brusque et à début progressif, en ce qui concerne la récurrence de 27 jours", Comptes Rendus des Séances de l'Académie des Sciences, vol. 227, pp. 1044-1046 (1948).

"Sur la variation, au cours du cycle solaire, de la période et de l'ampleur de la récurrence des orages magnétiques", Comptes Rendus des Séances de l'Académie des Sciences, vol. 228, pp. 715-721 (1949).

GENERAL DISCUSSION:

J. Olsen presented an abstract of his paper entitled "Persistent solar rotation-period of 26-7/8 days and solar-diurnal variation in terrestrial magnetism". The complete text is published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, vol. 53, pp. 123-134 (June 1948).

DISCUSSION OF OLSEN'S PAPER:

S. Chapman: "This paper brings forward what appears to be good evidence for a continuing periodicity of 27 days over a period of many years, without change of phase; this is quite different from the recurrence tendency with diminishing probability and frequent change of epoch that is so familiar in the records of disturbance at most stations. It is most desirable to continue studies along the lines followed by Mr. Olsen for other stations within the auroral zone as soon as the material becomes available."

SUGGESTED LINES FOR FURTHER INVESTIGATIONS AND STUDIES

By L. Vegard

Being asked to suggest lines for further research it will be natural for me mainly to deal with problems within my own region of research and experience. Further I want to emphasize the importance of gathering reliable experimental data, which may give the necessary background for theoretical deductions and theories. And to all those who are taking up theoretical problems and suggesting theories, I would like to recommend that they, from the very start, make themselves acquainted with the actual facts and empirical relationships which have been obtained through observations and experiments. Much useless work would be spared if this line is followed.

1. A more exact determination of the geographical distribution of auroral frequency and the position of the auroral zone and its possible variation with solar activity.

2. A more accurate determination of the diurnal distribution of auroral frequency particularly in polar regions.

3. Magnetic and auroral observations in the antarctic in order to coordinate the conditions in the northern and southern hemisphere.

4. The determination of magnetic azimuth of the average direction of auroral arcs, bands, and draperies particularly near the auroral zone.

5. Determination of the diurnal variation of the perturbing force particularly for a number of stations near the auroral zones. From these data the perturbing fields should be constructed for the polar regions, in order to see how the perturbing fields on an average move along the auroral zones in the course of 24 hours.

6. The geomagnetic control and the diurnal variation of the perturbing fields of polar storms should form an important and necessary basis for any attempt to explain theoretically the current systems producing these disturbances and the relation of these systems to solar processes.

7. Observational data relating to aurorae appearing at low latitudes are of great interest. These observations should give height of lower and upper limit of the auroral streamers and if possible also spectrograms of the luminescence corresponding to the lower and upper part of the streamers. The plates should be provided with an intensity scale to enable intensity measurements by means of photographic photometry to be made. Auroral observations from the western hemisphere (United States and Canada) will therefore be of great value.

8. Determination of the distribution of intensity along the auroral streamers for various auroral forms should be continued, and should be seen in relation to the height of the lower limit.

9. The study of the possible connection between aurorae and magnetic disturbances, and also the correlation between the latitude of an aurora and the intensity of the magnetic disturbance should be continued.

10. For the study of the composition and state of the ionosphere it is very important that the large number of weak lines and bands, which are known to be present in the auroral spectrum, should be accurately measured and identified. For this purpose it is essential to have spectrographs which have at the same time a much greater lightpower and dispersion than those used up to the present.

11. The great variability of the intensity distribution within the auroral spectrum are indications of variations of the composition and state within the ionosphere and probably also in the properties of the solar radiations producing the aurorae and causing the ionospheric changes, and the variability effects should be correlated with solar processes. For such investigations it is essential to obtain distinct spectrograms with the smallest possible time of exposure, and it is essential to use spectrographs of extremely high lightpower, of moderate dispersion, but which give very sharp lines.

12. Particular interest is attached to the appearance of the hydrogen lines and the yellow sodium line from aurorae and night sky, and the variations and possible Doppler effect which may be shown by these lines.

13. Spectrographs of this type should also be used for the spectral analysis of the night sky luminescence and the zodiacal light. The variability of intensity distribution within the spectra of these luminescence phenomena should be studied and seen in correlation to solar activity.

14. The time variation of the intensity of certain auroral and night sky lines should be followed at various localities and correlated with solar processes. Intensity registrations by means of photocells and amplifiers may possibly appear to be useful.

15. The screening height and the upper limit for the intensification of the sodium D-line should be determined as accurately as possible by using spectrographs of high lightpower provided with means for an accurate determination of height and azimuth of the collimator axis, and means for an exact determination of the intensity of the D-line as a function of time.

16. The intensity of the D-line in twilight and in the night sky luminescence should be measured (registered) each clear evening for longer periods for the study of possible regular periodic variations and the irregular fluctuations of intensity. The fluctuations should be correlated with solar processes.

17. Spectrograms of aurorae, night sky and twilight provided with means for intensity measurements should be taken simultaneously at different magnetic latitudes with spectrographs and plates which are as equal as possible.

18. For the explanation of the conductive layers of the ionosphere the experimental determination of the absorption coefficient of the photon radiation in the wavelength interval between say 20-1000 Å for the different atmospheric gases, is highly important.

19. Measurements of the temperature of the upper atmosphere as defined by the rotational energy of nitrogen molecules should be measured from auroral spectrograms corresponding to auroral streamers of great altitude and from sunlit aurorae.

20. The determination of the width of the green line (5577) and the strongest component (6300) of the red doublet by interferometers giving very sharp maxima should be continued.

21. In view of the theory of the ionosphere and the zodiacal lights resulting from auroral investigations correlations may be expected to exist between the properties of the zodiacal light on the one side and those of the F_2-layer and the phenomena connected with solar activity on the other. Observational data suitable for the study of these relationships will be most valuable.

22. In order to explain the great fluctuations and variability shown by the luminescence phenomena taking place in the upper atmosphere more laboratory experiments made with the object of studying the physical conditions underlaying the emission of lines and bands appearing in the spectra of these light phenomena, are highly wanted. The experimental data must be supplemented by theoretical investigations regarding the elementary excitation processes.

23. From Edlèn's interpretation of the coronal lines it follows that a photon radiation of energy corresponding to 1000 - 1500 electron volts is emitted from the sun. It is highly important to find out the part which this radiation plays in the establishment of the ionospheric layers. For the solution of these problems it would be extremely important to measure the relative intensity of the radiation from the sun in the region between say 1000 to -8 Å units, by bringing instruments to altitudes above the E-layer.

B. The Ionosphere

RAPID CHANGES IN THE IONOSPHERE

By H. W. Wells

Significant changes in characteristics of the ionosphere are found to occur within a few seconds during periods of disturbance. Rapidly moving "clouds" were observed repeatedly during the ionospheric storm, March 25-27, 1946. The "clouds" were first detected at maximum ranges of 800-900 km. They were tracked inward at apparent velocities of 1 to 2 km per second to F-layer levels (300-400 km)

The principal effects of influx of the clouds are: (1) sudden increases in F-layer ionization; (2) rapid changes in F-layer height indicating turbulence which is often progressive from high to low heights and from high to low frequencies; (3) rapid fluctuations of echo-intensity at the lower frequencies with occasional temporary disappearance indicating high absorption. The observations are interpreted as establishing that corpuscular radiation contributes to the net ionization of the F-region.

During the day, when the F-region is stratified into separate F1 and F2 layers, rapid fluctuations of apparent ionization and echo-heights have likewise been observed. This is of especial interest in view of the ultraviolet nature of F1 layer ionization which has been established by eclipse observations.

Two separate occurrences of sporadic E ionization have been recorded. On both occasions a small but noticeable disturbance in the F-region was apparent immediately prior to the first development of sporadic E. This relationship may contribute to a solution of the baffling question--what is sporadic E?

These observations have been made possible by the development of a fast-sweep ionospheric recorder which scans the frequency-range from 1 to 20 Mc/s in a few seconds. Successive records are photographed on single frames of motion picture film. Subsequent projection of the series of records as a motion picture provides a compression of the time scale which makes possible quick scanning of an enormous wealth of data, selections of portions for critical study, and visualization of dynamic events of short duration.

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

DISCUSSION:

D. F. Martyn: How is it known that these "clouds" of electrons come from above the earth? Is it not possible that they are moving horizontally in the ionosphere? Ratcliffe (Cambridge), Munro (Australia), and Piggott and Beynon (England) all find evidence of clouds or disturbances of the ionosphere moving horizontally with large velocities. It is possible that these effects are consequences of the movement through the ionosphere of the wandering current vortices recently accounted for theoretically by A. T. Price as a consequence of a changing magnetic field in a non-uniformly conducting atmosphere.

Mme. A. Vassy: En relation avec les nuages dont parle le Dr. Martyn, les mesures de la brillance du ciel nocturne effectuées dans un angle très faible avec l'aide de multiplicateurs d'electrons, nous ont montré l'apparition de plages plus claires que le fond du ciel, que nous appelons nuages parce qu'elles se déplacent plus rapidement. Elles de présentent particulierement vers 24 heures. Nous n'avons pas assez d'observations pour dégager une corrélation avec les phénomènes magnétiques.

C. Størmer: Regarding the motion of ionospheric clouds towards or from the receiving station, it might be important to fix the direction from which the echoes come, vertically down or more horizontally. In fact, in the case of the aurora it often happens that an aurora arc, for instance, is moving horizontally very rapidly towards south and later receding towards north due to the action of the magnetic field, and this might also happen with ionospheric clouds of charged particles. In that case it is not a motion of the same particles, but new particles are steadily coming in replacing the older ones which disappear and thus the ionospheric cloud seems to move as a whole.

HIGH-SPEED IONOSPHERIC RECORDING TECHNIQUE

By H. W. Wells

Multifrequency ionospheric recordings are now being made in a few seconds. This greatly increased speed of observation is the result of a new technique which permits operation over a wide frequency range (1-20 Mc) with only one moving shaft. Through elimination of the mechanical complications of cams, push rods, band switches, etc., which were necessary in earlier multifrequency recorders, a great improvement in speed of recording and mechanical simplicity has been achieved.

Use is made of the well-known principle of frequency interlocking by having one variable oscillator common to both receiver and transmitter. In this case, however, the variable oscillator operates over a frequency range of 31 to 50 Mc. This energy is mixed with a 30 Mc pulsed oscillator, producing sideband energy which varies from 1 to 20 Mc. The mixer stage is followed by a wide band amplifier which builds up the transmitter power from low levels to pulse powers of several kilowatts.

The development of a video type wide band amplifier without any tuned circuits has been a major contribution to the high-speed recording technique. Standard practices, as used in television and other video amplifiers, have been applied and extended in order to achieve the desired band width and power output. The output, or final amplifier stage, is designed to couple directly into a transmitting antenna. Satisfactory performance has been obtained with a single Delta type antenna supported from a central mast and terminated with a non-inductive impedance.

The receiver uses a similar antenna in the present model although provision could be made for a single antenna for both transmitter and receiver. Input to the receiver is through a just detector stage which mixes the incoming signals with energy from the 31-50 Mc variable oscillator to produce a fixed frequency output at 30 Mc. The subsequent steps of amplification, detection and application to the cathode ray indicator are conventional.

For the recording of ionospheric data the echo pattern of each sweep is photographed on a single frame of motion picture film. The technique has been perfected to the extent that successive records can be projected as motion pictures which provide a sense of continuity through compression of the time scale.

Preliminary application of the high-speed recording technique during periods of magnetic disturbance has resulted in the discovery of hitherto unsuspected rapid fluctuations of both ion density and echo heights for the several ionospheric layers. It is expected that continued use of this powerful new tool for study of special ionospheric features will contribute significantly to basic understanding of many ionospheric phenomena.

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

DISCUSSION:

O. E. H. Rydbeck: A high power fast sweep ionospheric panoramic recorder is now in regular operation at the new Swedish geophysical observatory at Kiruna (north of the polar circle).

CONTINUOUS RECORDING OF DOMINANT IONOSPHERIC CHARACTERISTICS

By L. V. Berkner

The automatic multifrequency techniques for ionospheric measurement have proven a powerful tool in the exploration of the earth's outer atmosphere. While such methods give essentially a panoramic view of the variation of ionization of the ionosphere, certain defects are implicit to these methods when applied to analysis of particular ionospheric characteristics. For example, the multifrequency records must be scaled and the results tabulated or graphed to provide for their subsequent analysis. This proves a laborious task involving great effort when thousands of multifrequency records must be scanned. As a consequence, the Department of Terrestrial Magnetism has initiated investigations into the possibility of simplifying the methods of recording and analyzing any particular dominant ionospheric characteristic.

The basic idea now under study has stemmed from the common interest of the Mount Wilson Observatory and the Department of Terrestrial Magnetism in the study of bright chromospheric eruptions. Since the discovery by Forbush in 1946 of coincidence of cosmic-ray bursts with certain chromospheric eruptions, it has become especially desirable to know more of the special characteristics of such eruptions. It is now well known that unusual absorption in the ionosphere (radio fadeout) is a sensitive measure of solar chromospheric activity. It was proposed in 1937 that if a continuous index of absorption of critical regions of the ionosphere could be maintained, it could provide some advance warning of chromospheric activity, a warning that would permit more adequate preparation for visual observation of the transient solar effects. This has led to the concept of the duplex-channel differential recorder to provide such a warning. As the development of this device has proceeded, it has become evident that it will be capable of recording in a simple and direct way not only the absorption index of the ionosphere but also many other selected dominant characteristics.

The fundamental objective of such a recorder is to provide the equivalent of a simple pen-and-ink record of the fluctuation of any dominant ionospheric characteristic such as critical frequency, functions of virtual height, or absorption functions of given layers. The basic idea involves essentially simultaneous transmission of radio waves on two channels separated by a small increment of wave frequency. The differences in characteristics of echoes on these two frequencies (in either amplitude or time delay, or both) provides to the equipment the information needed to contain the desired characteristic within the selected increment of wave frequency.

To utilize this information, certain independent decisions must be made by the equipment in comparing echoes on the two channels.

(1) Relative amplitude of echoes.
(2) Relative time delay of echoes.
(3) Selection of echoes of proper pulse shape and rejection of all other signals.
(4) Selection and integration of the appropriate number of successive echoes for the basis on which the comparison is to be made.

If warning of unusual events is to be included, there must also be supplied:

(5) A source of information of normal events to provide the basis for comparison and warning, and an appropriate means of comparison.

These decisions can be made by electronic circuits which in turn continually and automatically adjust the wave frequencies of the duplex channels to contain the selected characteristics. Likewise, other deciding elements of the circuit can be automatically adjusted. Thus the device "locks on and follows" the selected ionospheric characteristic. Actual recording can be done from a voltage which is proportional to the shaft rotation (and, therefore, the wave frequency) of the basic oscillator, or to the parameters of other deciding elements of the circuit. Similarly recording can be done on a magnetic tape which will permit direct harmonic analysis and interpretation of the results without further operation on the data.

Certain critical elements of this device are now in the advanced-design stage and the completed design will be tested in the near future.

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

CHARACTERISTICS OF SPORADIC E

By H. W. Wells

Sporadic E-region ionization is the term used to describe the occurrence of temporary but intense ionization in the E-region. It normally is recorded at heights somewhat above those of the normal E-layer. It presents a blanketing type of echo from the ionosphere which is often sufficiently dense to mask out the higher ionospheric layers. This abnormal condition may last from a few minutes to a few hours. In general, it is much more prevalent in the higher latitudes than in equatorial regions. At Huancayo, on the geomagnetic equator, this effect is rarely observed, and then with minor intensity. At other locations approaching the auroral zone sporadic-E becomes much more frequent in occurrence. At the auroral zone, however, sporadic-E is found to occur much more frequently at night time than in the daytime. Reports from ionospheric observatories at somewhat lower latitudes, for example at Canada, show much more sporadic-E in the daytime than at night. This apparent anomaly may be reconciled, however, if one assumes that the ionizing agency is more penetrating in the daytime along the auroral zone and results in low-level ionization which causes the high absorption characteristic of daytime observations in the polar regions. The same radiations at somewhat lower latitudes may be somewhat less penetrating and produce intense ionization in the E-region giving strong reflections.

There is a pronounced tendency for sporadic-E to occur much more frequently during local summer than in winter. The seasonal features of sporadic-E already well established for the Northern Hemisphere have been confirmed for the Southern Hemisphere as a result of analyses of the Watheroo data. Average diurnal curves at Watheroo show most frequent occurrence at night with maximum at midnight, local time, although there is a tendency for the most intense sporadic-E to occur during day hours. Annual trends show increasing values from 1938 to 1941 with decreasing values from 1941 through 1944. Detailed knowledge of characteristics of sporadic-E are of especial interest since radio-wave propagation on frequencies up to 80 Mc/sec or more may be made possible by this phenomena. No pronounced recurrence tendency of sporadic-E with the 27-day solar rotational period has been identified. Comparisons of sporadic-E and magnetic activity do not reveal any tendency of sporadic-E to be more prevalent during periods of magnetic disturbance.

Sporadic-E and aurora are closely related. Results of an investigation at College, Alaska, conclusively show the simultaneous occurrence of Es with aurora overhead. The converse does not hold, however, since Es may be recorded without aurora overhead.

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

CHARACTERISTICS OF E-REGION SPORADIC IONIZATION IN CANADA

By J. H. Meek

In addition to the regular ionospheric reflecting regions (E and F regions), vertical incidence ionospheric records frequently show unusual traces of greatly varying characteristics.

The pattern of occurrence of the regular E and F regions is fairly well known. Until recently, however, not much attention has been paid to detailed examination of the unusual and sporadic reflections which are observed. Tabulations are now made at most ionospheric stations of sporadic traces which occur at E region virtual heights (80-200 km) but there has not been much success in sorting out these traces in order to discover the reasons for their appearance. We have been content to define sporadic E (or Es) as any trace which appears in the E region and which does not follow the accepted pattern for daytime E traces attributed to ultraviolet radiation from the sun.

Study of ionospheric records from Canadian stations shows distinct types of sporadic E traces. For purposes of analysis these have been divided into six classes:

(S) short traces extending from either the f^oE or lower limit of the ionospheric equipment (1.7-2.0 Mc) to frequencies of 6.0 Mc or less. This is the most common type of sporadic E and is seen at all Canadian ionospheric stations.

(Sm) the same as the above type but having one or more multiple echo traces present.

(L) longer traces extending continuously from either f^oE or from the lower limit of the ionospheric equipment to more than 6.0 Mc. This type is frequently present at night at Churchill but not so often at other Canadian stations.

(Lm) the same as above but with one or more multiples present indicating low ionospheric absorption or high reflection coefficient. This type seems to have some correlation with severe ionospheric storminess, appearing before the reflections fail entirely in a blackout, and reappearing before the regular traces return to normal. (Ref. 1). The L type does not necessarily show the same correlation. Further analysis is being done on this type of Es.

All four types of Es show no definite critical or top reflection frequency. The echoes gradually lose intensity as the frequency of propagation increases until finally they cannot be distinguished through the background noise. There is good evidence that the top frequency returned is dependent on the radiated power of the ionospheric transmitter.

Virtual heights vary from 90 km to 180 km and traces showing a gradual rise in virtual height with increasing frequency are seen.

(P) this type of Es consists of short traces near 100 km virtual height occurring for bands of frequencies usually less than a megacycle in length on the ionospheric record. Records from photographic equipment show short continuous traces while manual equipments often show pips at only a few consecutive 1/10 Mc observations (due to the slower speed of operation). Such traces are seen at all Canadian stations but not often.

Not very much information can be obtained from existing tabulations of P type of Es due to the difficulty in deciding which traces should be classified under this heading. Fluctuations in equipment during observations and variations in sensitivity over the frequency range are responsible for a number of traces which actually should be classified as S or L rather than P. Some records of this type of Es have been correlated with meteor observations but others have no relation to meteors.

(R) continuous traces showing retardation near their top reflection frequencies but not recognized as a normal daytime E. This type of trace is seldom seen at stations other than Churchill and Clyde. Its characteristics are as follows:

(1) It appears as an extension of daytime E ionization and its critical frequency increases after sunset. The traces often become more spread and similar in appearance to night F region traces.

(2) Ordinary and extraordinary-ray traces are normally both present and distinguishable and of comparable intensity. At times the "o" trace shows one or more multiple echoes but no cases have been seen of multiple "x" traces. It may be due to greater absorption of the "x" trace in spite of the apparently strong first reflection.

(3) This type of trace usually turns into one without marked retardation or else it disappears by midnight.

(4) Traces frequently appear again in the early morning for a few hours or may carry on in to daytime decreasing in critical frequency to normal f^oE by about 10 a.m. local time.

(5) The virtual heights of this type of night E are often greater than daytime E. Other Es traces may show on the same record at lower virtual heights. In addition to retardation near the criticals, a gradual rise in virtual height with frequency is seen at times.

Table 1 indicates the relative occurrences of the various types of Es at Canadian stations for the year 1946 for which the data have been analyzed in detail.

Table 1

		Clyde	Churchill	Ottawa	Prince Rupert	Portage (1947)	St. John's
Total occurrence		561	3904	1748	4252	2638	3387
Per cent of total	S type	55.6	48.1	79.2	84.4	79.3	84.9
	Sm	4.6	5.8	7.4	10.5	12.6	9.6
	L	20.7	18.6	5.5	2.5	4.9	2.5
	Lm	7.5	10.8	3.9	2.6	3.2	3.0
	P	3.4	3.7	4.0	(Included in S, L)		
	R	8.2	13.0	0			

Notes

1. The proportion of L type Es is greater at Churchill and Clyde than at other stations, indicating a definite polar association.

2. The proportion of Sm type is less at Churchill and Clyde than at southern stations though the proportion of Lm is greater, again indicating polar preference.

3. R type is confined entirely to Clyde and Churchill records.

4. Except at Churchill (48 per cent), S type of Es accounts for well over half the Es seen at Canadian stations. Consequently any statistical analysis of total Es will show the characteristics of S type Es while the peculiarities of the other less common types are lost.

Plots of S type compared with Sm type, and L type with Lm types, have been made. Within the limitations of data available no major difference in occurrence characteristics were noticeable. As the data were more readily available, the total Es occurrence was divided into two groups. Group A fEs < 6 Mc. Group B fEs > 6 Mc.

Group A, in addition to types S and Sm, will include types P and R, but their effects are masked by the greater proportion of S and Sm. (Table I). Similarly, Group B, in addition to L and Lm, will include a few cases of P type which can be disregarded. The groups effectively separate S and L types of Es.

Notes on Group A plots

1. Peak occurrences of low frequency Es come in mid-winter at Churchill with small secondary peaks in the spring.

2. Clyde data also show winter maxima for 1943, 1944, 1945, but maxima in the fall for 1946, 1947.

3. The main peak occurrence at other stations comes in summer with a sizeable secondary peak in winter.

4. There is an unusual minimum in Prince Rupert data in the winter of 1945-46. No suitable explanation has been found.

The Washington data for total occurrence of Es (mostly below 6 Mc) shows the main peak in summer with only a small secondary peak in winter (Ref. 2). There is evidence of a definite change in occurrence characteristics of low frequency Es with latitude.

5. The changes in occurrence of low frequency Es from minimum to maximum of the sunspot cycle at Clyde, Churchill, and Ottawa follow the same trend as was observed at Washington (Ref. 2), with a general drop in occurrence. Prince Rupert, Portage, and St. John's stations show a definite increase of occurrence.

In connection with Group B plots (fEs > 6 Mc), it is interesting to note that the peak occurrence comes in summer at all the stations. At Churchill, the trend in occurrence of high frequency Es was opposite to that for low frequency Es. This was shown in more detail in a previous paper (Ref. 3).

A similar pattern shows at Clyde for 1944, 1945 data. In 1946 and 1947 the peaks, though somewhat indefinite, seem to follow the low frequency Es plots.

The diurnal characteristics of the two groups of Es are summarized in Table II. Totals for each year are used, as the monthly and three monthly plots do not show clear occurrence patterns due to the small number of values available. No significant seasonal changes were seen except in Churchill data (Ref. 3).

The table shows the significant diurnal maxima and minima for the years 1946 and 1947. Times of maxima and minima, local standard time, and the number of occurrences at these hours are listed.

The following results are of interest:

Table II

1946	fEs < 6 Mc				fEs > 6 Mc			
	Maxima		Minima		Maxima		Minima	
	LST	Occur.	LST	Occur.	LST	Occur.	LST	Occur.
Clyde	1900	79	0000	32	1000	12	0000	0
			1400	27	1800	20	1200	0
Churchill	02-03	200	13-15	12	0000	120	12-15	2
Ottawa	01-09	80	14-17	50	0000	10	0500	1
	2100	67	2200	52	1100	10	1600	0
					2000	10	2300	5
Prince Rupert	0400	202	0700	55	23-02	15	1600	1
	1000	192	2200	130				
St. John's	0700	175	1700	100	0200	14	06-17	4
	1900	130	2200	82	0900	15	1600	2
					1900	14	22-23	7
1947								
Clyde	16-21	18	Indefinite		0900	5	02-07	0
					1800	18	12-13	1
Churchill	01-02	215	1300	5	2300	30	09-16	0
Ottawa	2000	55	10-15	18	09-12	8	0600	2
					2000	18	1400	4
Prince Rupert	0600	247	2200	150	0700	23	1700	4
St. John's	0800	228	1300	200	0000	16	03-05	3
	18-19	210	2200	120	1200	14	1400	5
					1900	18	21-22	8
Portage	0300	208	12-13	20	0100	33	14-16	1

1. The most marked diurnal changes occur at Churchill and at Portage. For fEs <6 Mc the ratio of diurnal maximum hourly occurrence to minimum is greater than 10:1.

2. At all other stations the ratio of maximum to minimum occurrence is of the order of 2:1.

3. The proportionate drop in maximum to minimum at all stations is much greater for fEs >6 Mc.

4. In most instances the times of maxima and minima for fEs < 6 Mc as compared with fEs > 6 Mc agree as well as could be expected considering the small numbers of occurrences.

R type traces have been recognized only in records from Churchill and Clyde ionospheric stations. Many more occur at Churchill than at Clyde, however, considering the total amount of Es seen at each of these stations. The difference in percentage occurrence of R type at Churchill as compared with Clyde is not so marked (see Table I).

Much difficulty is found in separating the tabulations of R type Es from the normal daytime E-traces. However, an attempt to do this was made in analysis of Churchill and Clyde data. A high mid-winter peak of occurrence was found at both stations even when plots were adjusted to take account of the number of dark hours each month.

It is an accepted fact that night F2 exists although adequate explanations have not been made. On the same basis it seems logical to record the night E with the regular daytime E until further means of discrimination are found. This has been done at the Churchill ionospheric station for some time.

It has been noted that:

1. In the winters of 1945-46 and 1946-47 occurrence of E at night at Churchill was almost as frequent as in the day.

2. The rise and fall of daytime-E occurrence corresponds to ground level sunrise and sunset times.

3. The increased midday absorption is quite marked in the summer of 1947.

4. The absence of night-E in the winter of 1947 is probably connected with the general decrease in Es occurrence during 1947.

5. The winter peaks of night-E correspond with the regular night peaks of low frequency Es at Churchill (Ref. 3).

Plots of median critical frequencies of f^oE have shown that the winter night-E has noticeably higher ionization than the daytime-E.

<u>Summary</u>

Of all Canadian ionospheric stations, Clyde, the most northerly, shows least occurrence of Es, due to some extent to the greater average low level ionospheric absorption observed at this station. Relative occurrences of ionospheric blackouts at Clyde compared with other stations indicate that the drop of Es at Clyde cannot be explained entirely by absorption. The total Es at Clyde is of the same order as that at Washington while the occurrence is six times as great at latitudes between these two stations. This suggests a belt of high occurrence of Es extending parallel to the normal visual auroral zone and south of it. Whether it extends north of the visual auroral zone cannot be known until data are available from other places between the latitudes of Churchill and Clyde.

It is noted that the occurrence of Es at Clyde, Churchill, and Ottawa, all decrease as the maximum of the sunspot cycle is approached; however, the occurrence at the other stations, Prince Rupert, Portage, and St. John's increases. No explanation is offered at the present time for this phenomenon.

The most marked diurnal changes occur at Churchill and Portage, i.e., stations within the effective auroral zone. A daytime minimum is observed with occurrence of Es dropping to one-tenth that at diurnal maximum.

The low frequency type of Es has its peak occurrence in winter at Clyde and Churchill; peaks in both summer and winter at other Canadian stations; and a summer peak at Washington. There is therefore a complete change of occurrence characteristics of this type of Es with latitude, in crossing the southern half of the auroral zone.

The high frequency type of Es does not change in the same manner but has summer peaks at all stations.

The proportion of high frequency Es is definitely greater at the most northerly stations (Churchill and Clyde) than at other Canadian stations and seems to be definitely a polar type of Es. Occurrence drops off at more southerly latitudes, although it is seen on occasions at equatorial stations.

The retardation type of Es is peculiar to Churchill and Clyde stations. It has the appearance of normal daytime-E but occurs at night and it is most easily distinguished in the winter when the nights are longer. At Churchill, winter diurnal plots, disregarding the daytime-E, correspond to those found for low frequency Es. It is possible that most of the low frequency Es at Churchill should be classified as night-E peculiar to polar regions.

References

1. Wells, H. W. Polar radio disturbances during magnetic bays. Terr. Mag., vol. 52, No. 3, 315-320, Sept. 1947.
2. Phillips, M. L. Variations in sporadic E ionization observed at Washington, D.C. Trans. Amer. Geophys. Union, vol. 29, No. 1, 71-78, Feb. 1947.
3. Meek, J. H. Sporadic E ionization at Churchill, August 1943-July 1946. Can. Radio Wave Propagation Committee I/P No. 14.

Radio Propagation Laboratory
Defence Research Board
Ottawa
April, 1948

DISCUSSION:

D. F. Martyn: The present practice of ionospheric observatories is not uniform in describing sporadic E occurrences. This leads to grave difficulties in any statistical approach. A main difficulty is that we have not yet a clear picture of what Es is, whether it is in the form of scattering clouds, and what size and movement these clouds have.

It is not likely that sporadic E can be explained completely as due to ionization of the atmosphere by meteoric impact. The diurnal and seasonal variations of Es are markedly dependent on latitude, a result which would be difficult to explain on any theory of meteoric ionization.

F. L. Whipple: Continuous records at 3.5 megacycles per second by J. A. Pierce of Harvard show reflections of "meteoric" type and "sporadic E" type. The former, identified by their appearance, are correlated in frequency of occurrence with visually observed meteors far better than are the latter. An ionizing source other than meteors appears necessary to account for the "sporadic E" records.

CHANGE IN THE E-REGION IN THE MORNING AND IN THE EVENING

By H. Uyeda

[By title only]

IONOSPHERIC OBSERVATORIES ESTABLISHED BY THE DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON

By H. W. Wells

Following the development of automatic multifrequency ionospheric equipment in 1935 and 1936 by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, three identical units were installed at the Huancayo Magnetic Observatory (1937), the Watheroo Magnetic Observatory (1938), and the College Observatory, University of Alaska (1941).

The availability of four British multifrequency recorders (B.A.D. type 249) led to the establishment of additional observatories at Clyde, Baffin Island (1943), Maui, Territory of Hawaii (1944), Trinidad, British West Indies (1944), and Reykjavik, Iceland (1944).

A station was established at Christmas Island, South Pacific, in late 1944. The manually-operated apparatus originally installed was replaced in early 1945 by an automatic recorder designed and constructed by the Radiophysics Laboratory, University of Sydney, Sydney, Australia.

Small operating groups associated with the armed services were trained and equipped with manually-operated ionospheric recorders for the establishment of stations at Leyte, Philippine Islands (1945), Guam (1945), Okinawa (1945), and Loshan, China (1946).

Although a discussion of results is beyond the scope of this report, it is interesting to note that the Huancayo and Watheroo observatories are now completing a sunspot cycle of recordings. The long series of continuous data makes possible fundamental analyses leading to a precise determination of properties of the ionosphere. The simultaneous operation of a large number of ionospheric stations in all parts of the world and the free interchange of results is producing fruitful contributions to knowledge of the earth's outer atmosphere. Application of these data is resulting in greatly improved high-frequency radio communications.

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

IONOSPHERIC ANOMALIES AND FUTURE RESEARCH OBJECTIVES

By H. W. Wells

[By title only]

ELEKTRONENVERNICHTUNG IN DER F2-SCHICHT

Von Dr. Otto Burkard

Summary. If the influence of variable activity of the sun is eliminated from the nightly diminution of the F2-ionization, there results a linear law in the form of $dn/dt = \beta n$. The value of β is found to be about 1.10^{-4} sec^{-1}. The seasonal variation of β is investigated for the stations Huancayo, Kochel (near Munich), and Watheroo. If this variation is due to a temperature-effect, the summer temperature must be about three times larger than the winter temperature at middle latitudes.

Es wurde schon mehrfach versucht, eine Ionisierungsbilanz für die F2-Schicht aufzustellen, ohne jedoch bisher zu einem befriedigenden Ergebnis gelangt zu sein. Da durch die derzeitigen Echolot-Messungen nur eine einzige Grösse, nämlich die Elektronendichte zugänglich ist, während man bezüglich Temperatur, Druck und Zusammensetzung der Luft nur Vermutungen hegen kann, ist dieses Problem an sich schon recht schwierig. Es wird anscheinend völlig unlösbar durch die stets veränderliche Sonnentätigkeit, die in noch kaum erforschtem, wechselnden Ausmasse die Ionisierung der F2-Schicht beeinflusst. Aus dieser Erkenntnis heraus wurde daher ein völlig neuer Weg beschritten, indem zuerst aus dem Beobachtungsmaterial dieser wechselnde Einfluss der stets sich ändernden Sonnentätigkeit eliminiert wurde und erst das auf diese Weise vorbereitete Material wurde zu weiteren Untersuchungen herangezogen.

Ueber die ersten Ergebnisse, die auf diesem Weg gewonnen werden konnten und die weitere Untersuchungen in der begonnenen Richtung als durchaus aussichtsreich erscheinen lassen, wird im folgenden kurz berichtet.

Wie schon von W. M. Goodall (Proc. Inst. Radio Eng., vol. 27, 1939, 701-703) und zuletzt auch wieder von mir (Acta Phys. Austr., vol. 1, 1947, 98-102) gezeigt worden ist, besteht ein sehr enger Zusammenhang zwischen der an einem beliebigen Ort zu einem beliebigen Zeitpunkt gemessenen kritischen Frequenz fo und der zur gleichen Zeit geschätzten Grösse bzw. Häufigkeit der Ca-Flocculi auf der Sonnenscheibe (Z). In Abänderung der bisherigen Veröffentlichungen kann man den Ansatz machen:

$$(\overline{fo})^2 = A \cdot (\overline{Z})^2 + B \qquad (1)$$

worin fo den Monatsmittelwert der kritischen Frequenz (F2-Schicht), gemessen zu einer beliebigen Tageszeit in MHz, bedeutet und Z den Monatsmittelwert der Ca-Flocculi-Kennzahlen darstellt, wahrend A und B Konstante sind, die nur mehr vom Ort und von der gewählten Tageszeit abhängen, nicht aber in verschiedenen Jahren verschieden gross sind. Fasst man also korrespondierende Werte ($\overline{fo}$, $\overline{Z}$) gleicher Monate und gleicher Tageszeit aus verschiedenen Jahren zusammen (benutzt wurde vorläufig einheitlich der Zeitraum 1940-1944), so lässt sich trotz der unvermeidlichen Streuung von $\overline{fo}$ und vor allem vom bloss geschätzten $\overline{Z}$-sowohl A als auch B nach Gleichung (1) bestimmen. Man erhält so für alle zwölf Monate je einen 24-stündigen Tagesverlauf von A und B und diese können nun umgekehrt wieder dazu benützt werden, ein auf gleiche, d.h.konstante Sonnentätigkeit bezogenes, "normiertes" Monatsmittel $\overline{fo}$ zu berechnen. Für ganz geringe Sonnentätigkeit, etwa dadurch ausgedrückt, dass Z = Null ist, gibt allein schon der Wert B die auf Z = 0 normierte kritische Frequenz. Für eine mittelstarke Sonnentätigkeit hingegen wird man etwa Z = 3 wählen (Z variiert zwischen 0 und 5) und erhält aus $\sqrt{9A + B}$ den tages- und jahreszeitlichen Verlauf der auf Z = 3 normierten kritischen Frequenz. Bei diesen so errechneten, auf eine bestimmte gleichbleibende Sonnentätigkeit bezogenen Werten für fo sind also die Schwankungen der Sonnentätigkeit, wie sie in den ursprünglichen Messergebnissen so störend auftreten, nicht mehr vorhanden. Ein unmittelbarer Vergleich untereinander wird jetzt dadurch für diese normierten Werte erst sinnvoll und möglich.

Verhältnismässig am einfachsten gestaltet sich die Aufstellung einer Ionisierungsbilanz für die Nachtstunden, dα zu diesen Zeiten die hauptsächlich wirksame UV-Strahlung der Sonne fehlt, so dass man es zum Grossteil nur mit Elektronen- bzw. Ionen vernichtenden Prozessen, also mit einem Schichtabbau, zutun hat. Es mag an dieser Stelle viel leicht angebracht sein, kurz auf die Vorgänge der Elektronenbildung bzw.-vernichtung in der F2-Schicht einzugehen, ausführlich hat hierüber zuletzt K. O. Kiepenheuer (Ann. Astroph., vol. 8, 1945, 210-242) berichtet und nach seinen Ergebnissen handelt es sich in der F2-Schicht im wesentlichen um folgende Prozesse:

I)	$0_2 + h\gamma \longrightarrow 0 + 0$	Dissoziation der Moleküle in Atome
II)	$0 + h\gamma \longrightarrow 0^+ + e$	Elektronenbildung
III)	$0^+ + e \longrightarrow 0 + h\gamma$	unmittelbare Wiedervereinigung
IV)	$0 + e \longrightarrow 0^- + h\gamma$	mittelbare Wiedervereinigung (Anlagerung)
V)	$0^+ + 0^- \longrightarrow 0^2 + h\gamma$	Ionen-Wiedervereinigung

Bezeichnet man nun noch mit n_e, n_+, n_- und n der Reihe nach die Zahl der Elektronen, der positiven und negativen Ionen und der ungeladenen Atome, die im Kubikzentimeter enthalten sind, so lassen sich folgende Gleichungen aufstellen:

$$n_+ + n_- + n = k = \text{Gesammtzahl der Atome/cm}^3 \quad (2)$$

$$n_+ = n_- + n_e \text{ (aus elektrostatischen Gründen)} \quad (3)$$

$$dn_e/dt = q - \alpha_1 n_+ n_e - \alpha_2 n n_e \text{ (worin q die Elektronenbil-} \quad (4)$$

$$dn_+/dt = q - \alpha_1 n_+ n_e - \alpha_3 n_+ n_- \text{ dung nach II angibt und } \alpha_1, \quad (5)$$

$$dn_-/dt = \alpha_2 n n_e - \alpha_3 n_+ n_- \quad \alpha_2, \alpha_3 \text{ die Wiedervereinigungskoeffizienten bedeuten.)} \quad (6)$$

Für die Nachtstunden kann zunächst q = 0 gesetzt werden, so dass sich die Gleichungen vereinfachen:

$$dn_e/dt = -\alpha_1 n_+ n_e - \alpha_2 nne \text{ oder unter Verwendung von (2) und (3):}$$

$$dn_e/dt = -(\alpha_1 - \alpha_2)n_e^2 - [\alpha_2 k + (\alpha_1 - 2\alpha_2)n_-]\cdot n_e \quad (7)$$

Setzt man hierin noch $(\alpha_1 - \alpha_2) = \alpha$ und $[\alpha_2 k + (\alpha_1 - 2\alpha_2)n_-] = \beta$, so erhält man schliesslich

$$dn_e/dt = -\alpha \cdot n_e^2 - \beta \cdot n_e \quad (8)$$

Als Grenzfälle kommen hier also entweder eine quadratische ($\beta = 0$) oder eine lineare ($\alpha = 0$) Wiedervereinigung in Frage, je nachdem, ob die zeitliche

Abnahme der Elektronendichte der zweiten oder ersten Potenz der Elektronendichte n_e proportional ist.

Zur Ueberprüfung der letztgenannten Gleichung (8) wurde als erstes das auf gleiche Sonnentätigkeit normierte Beobachtungsmaterial der bekannten Station Huancayo herangezogen. Da nach der Dispersionstheorie $n_e = 1.24 \cdot 10^4 f_o^2$ (n_e = Elektronen/cm^3 und fo = Frequenz in MHz) gilt, so ist für geringe Sonnentätigkeit (Z = 0) einfach $n_e = 1.24 \cdot 10^4 \cdot B$. Diese Zahlen in Abhängigkeit von der Zeit in einem Diagramm eingetragen ergeben ganz klar eine Abnahme der Elektronendichte nach einem e-Potenz-Gesetz. Noch deutlicher tritt dies in Erscheinung, wenn man log (B) in Abhängigkeit von der Zeit aufträgt, denn dann ordnen sich die Punkte für die Nachtstunden recht genau einer geraden Linie bestimmter Neigung ein. Aber auch für grössere Sonnentätigkeit, entsprechend Z = 1, 2 oder 3 wurde für die Nachtzeit eine eindeutig lineare Beziehung zwischen $\log(AZ^2 + B)$ und der Zeit t gefunden. Man muss also daraus schliessen, dass in der Nacht für Huancayo das lineare Wiedervereinigungsgesetz

$$dn_e/dt = -\beta n_e \tag{9}$$

gültig ist. Dieses Ergebnis steht in ausgesprochenem Gegensatz zu den meisten früheren Arbeiten, in denen eine quadratische Wiedervereinigung angenommen worden war, ohne dass allerdings eine Ueberprüfung dieser Behauptung an Hand entsprechenden Beobachtungsmaterials stattgefunden hätte. Erst F. L. Mohler (Phys. Rev., vol. 57, 1940, 1071) dürfte als einer der ersten darauf aufmerksam gemacht haben, dass auch eine "Anlagerung" der Elektronen an ungeladene Atome in beachtlichem Ausmasse stattfindet.

Die aus theoretischen Ueberlegungen abgeleitete Gleichung (8) kann also nur dann mit den beobachteten Werten in Einklang gebracht werden, wenn entweder α exakt gleich Null zu setzen ist, was bedeuten würde, dass $\alpha_1 = \alpha_2$ oder aber, wenn zumindest $\alpha \cdot n_e \ll \beta$ ist, so dass man, um Uebereinstimmung zwischen Theorie und Beobachtung zu erhalten, schreiben kann:

$$dn_e/dt \doteq [\alpha_2 k + (\alpha_1 - 2\alpha_2)n_-] \cdot n_e = \beta n_e \tag{10}$$

Die β-Werte, die sich so aus den Beobachtungen an der Station Huancayo errechnen, liegen grössenordnungsmässig bei 10^{-4} sec^{-1}, was für die Elektronen in der F2-Schicht eine mittlere Lebensdauer von rund 10^4 sec (in Uebereinstimmung mit Kiepenheuer loc. cit.) ergibt. Des weiteren findet man für die einzelnen Monate und für verschiedene Sonnentätigkeit etwa:

$$0.55 \cdot 10^{-4} \leqslant \beta \leqslant 1.35 \cdot 10^{-4}$$

wobei irgendein ausgesprochener Zusammenhang mit dem jeweiligen Sonnenstand nicht zu Tage tritt, wohl aber eine deutliche Abnahme des β-Wertes mit zunehmender Sonnentätigkeit beobachtet werden kann. Die aus den Monatsmitteln errechnten Jahresmittel für β sind:

Sonnentätigkeit Z	0	1	2	3
$10^4\beta$:	0.97	0.89	0.76	0.67
Schwankung:	±0.08	±0.06	±0.04	±0.03

Einige Schwierigkeit bereitet die Auswertung der fo-Beobachtungen an anderen Stationen und zwar deshalb, weil dort häufig in der Nacht die normale Abnahme der Elektronendichte durch das Auftreten der sporadischen F-Schicht (vgl. Burkard, Terr. Mag., vol. 53, 1948) gestört wird. Trotzdem wurde aber die Untersuchung auf zwei weitere Stationen, nämlich Kochel in der Nähe von München, und Watheroo in Australien ausgedehnt, wobei zunächst ebenfalls aus dem 5-jährigen Beobachtungsmaterial 1940-1944 die Konstanten A und B ermittelt werden mussten. Dann wurde wieder der Logarithmus des auf gleiche Sonnentätigkeit (Z = 0, 1, 2 und 3) normierten Frequenzquadrats $\bar{f}_0^2$ in Abhängigkeit von der Zeit t in einem Diagramm aufgetragen. Auf diese Art ersieht man in den meisten Fallen sehr leicht, für welchen Zeitraum der Nacht die Elektronenabnahme ungestört verläuft und auch hier wieder ergibt sich Linearität zwischen $\log(n_e)$ und t.

Die Jahresmittel bei verschiedener Sonnentatigkeit ergaben ($10^4 \beta$):

Z	0	1	2	3
Kochel	0.87 ± 0.03	0.85 ± 0.03	0.81 ± 0.06	0.79 ± 0.09
Watheroo	1.12 ± 0.15	1.05 ± 0.13	0.98 ± 0.13	0.90 ± 0.18

Wieder also ergibt sich auch für diese beiden Stationen eine mittlere Elektronen-Lebensdauer von rund 10^4 sec, die mit zunehmender Sonnentätigkeit deutlich zunimmt. Eine unbedingt sichere Erklärung für diese Zunahme zu geben, ist nicht leicht, wissen wir doch noch allzu wenig, ob und wieweit zum Beispiel α_1, α_2 und n_- im Lauf der Nacht ihren Wert ändern. Am einfachsten freilich durfte es sein, auch hier Temperaturschwankungen in Betracht zu ziehen. Denn es ist durchaus wahrscheinlich, dass mit einer Zunahme der Sonnentätigkeit auch die mittlere Temperatur der Schicht ansteigt, ihre Volumsvergrösserung hätte dann eine entsprechende Abnahme der Atombzw. Ionendichte (k, n_-) zur Folge, so dass also auch β bei stärkerer Sonnentätigkeit kleiner werden muss.

Eine solche Erklärung dürfte noch eine weitere Stütze in dem Ergebnis erfahren, dass sowohl für Kochel als auch für Watheroo die einzelnen Monatsmittel für β einen deutlichen Gang mit der jeweiligen Sonneneinstrahlung zeigen, und zwar in dem gleichen Sinn, dass steilerem Einfall der Strahlung beziehungsweise langer Sonnenscheindauer kleinere β -Werte entsprechen. Es würde dies in Uebereinstimmung mit der obigen Annahme von Temperaturschwankungen stehen.

Die beiden folgenden Tabellen enthalten eine Gegenüberstellung der β -Werte, gemittelt jeweils über die drei Monate Mai, Juni, Juli und andrerseits November, Dezember, Januar.

Nördliche Halbkugel, Kochel, $\Phi = 47° 11'$ N

Z	0	1	2	3	J(Std.)
Winter: $10^4 \beta$	0.92	0.97	1.06	1.19	2.11
Sommer:	0.76	0.73	0.52	0.41	8.43
Sommer/Winter:	0.83	0.75	0.49	0.34	4.00

Südliche Halbkugel, Watheroo, $\Phi = 30° 19'$ S

Z	0	1	2	3	J(Std.)
Winter: $10^4 \beta$	1.75	1.62	1.62	1.64	4.13
Sommer:	0.55	0.57	0.58	0.59	8.43
Sommer/Winter:	0.31	0.35	0.36	0.36	2.04

Zum beichteren Vergleich wurde in der letzten Spalte die Sonneneinstrahlung J eingetragen, errechnet aus

$$J = \int_A^U \cos_\lambda \cdot dt \tag{11}$$

worin λ den Zenitwinkel der Sonne bedeutet und das Integral von Sonnenaufbis Sonnenuntergang erstreckt wurde. Da

$$\cos_\lambda = \sin \Phi \sin \delta - \cos \Phi \cos \delta \cos \frac{2\pi t}{24} \tag{12}$$

ist, so wird

$$\int_A^U \cos_\lambda dt = 2 \sin \Phi \sin \delta \cdot [12 - \frac{24}{2\pi} \text{arc} \cos(\text{tg} \Phi \text{ tg} \delta)] + \frac{24}{\pi} \sqrt{\cos(\Phi + \delta) \cdot \cos(\Phi - \delta)} \tag{13}$$

mit Φ = geogr. Breite des Beobachtungsortes und δ = Sonnendeklination.

Aus den beiden Tabellen ist zu entnehmen, dass in Watheroo in allen Fällen, in Kochel jedoch nur im Falle stärkerer Sonnenaktivität die Sommerwerte für β rund ein Drittel der Winterwerte betragen, was also bedeuten würde, dass die Temperatur in diesen Fällen im Sommer rund dreimal so gross ist als im Winter, falls man überhaupt diese Erklärung als richtig annimmt. Dass dagegen für Huancayo nicht auch solche Schwankungen der β-Werte mit der Sonneneinstrahlung gefunden werden können, mag wohl daran liegen, dass für diese Station die Unterschiede der Sonneneinstrahlung im Lauf des Jahres nur recht gering sind, sodass andere Einflusse oder vielleicht auch nur die natürliche Streuung der β-Werte diesen Zusammenhang verdecken.

Der hier gegebene kurze Bericht soll zweierlei aufzeigen. Einmal, dass mit der Methode der Ausschaltung der veränderlichen Sonnentätigkeit, wie sie hier erstmalig zur Anwendung kam, sicherere Schlüsse auf die Vorgänge in der F2-Schicht gezogen werden können, als dies bisher möglich war und dass zweitens die Untersuchungen auch noch auf möglichst viele andere Stationen zu erstrecken wären, um eine Klärung der noch offenen Fragen zu ermöglichen.

Für die Ueberlassung des Beobachtungsmaterials der drei Stationen, das hier Verwendung fand, schulde ich Herrn Direktor Dr. M. A. Tuve (Carnegie Institution) und Herrn Geh. Rat Prof. J. Zenneck ergebensten Dank.

Graz, Austria
November 18, 1948

WORLDWIDE DISTRIBUTION OF THE ORDINARY COMPONENT CRITICAL FREQUENCIES OF F2-LAYER

By H. Uyeda

It is well known that the ordinary component critical frequency of F2-layer foF2 varies with the solar activity. If we determine its minimum value corresponding to s (relative sunspot number) = 0 by extrapolation and we plot the value against geomagnetic latitude Φ, we get a very smooth distribution curve. Figure 1 represents the distribution curve of (foF2) s = 0 thus obtained, where foF2 means its running 12-month average of the daily mean values and s means its running 12-month average. The following characteristics of the curve are noteworthy.

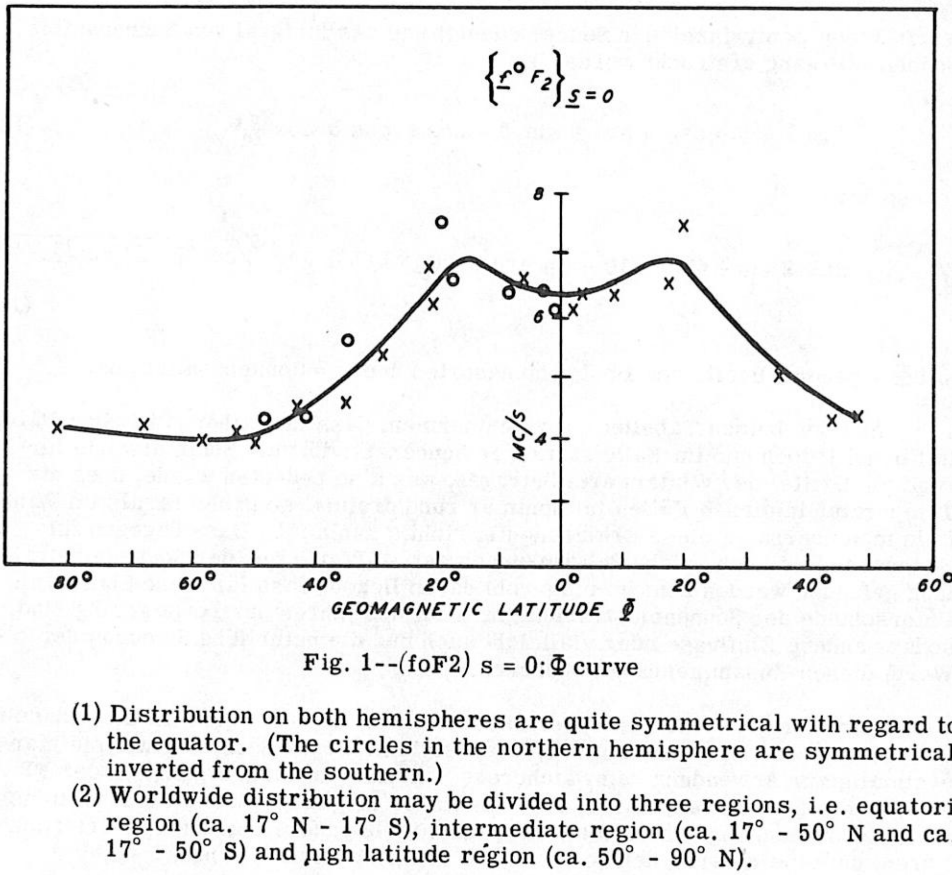


Fig. 1--(foF2) s = 0:Φ curve

(1) Distribution on both hemispheres are quite symmetrical with regard to the equator. (The circles in the northern hemisphere are symmetrically inverted from the southern.)
(2) Worldwide distribution may be divided into three regions, i.e. equatorial region (ca. 17° N - 17° S), intermediate region (ca. 17° - 50° N and ca. 17° - 50° S) and high latitude region (ca. 50° - 90° N).

Although (foF2) s = 0 is distributed according to Φ as stated in the above, foF2 seems to be distributed also regularly with respect to the geomagnetic coordinates. Figure 2 represents the mean annual distribution in the northern hemisphere of the daily mean values of foF2 during 1945 to 46 plotted on the geomagnetic coordinates where the annual mean is the conventional one of the representative four months of the four seasons, i.e. June, September, December in 1945 and March in 1946. The distinctive characteristics are as follows:

(1) Distribution is regular with respect to the geomagnetic coordinates.
(2) Distribution on American side is rather lower than on the other.
(3) Distribution may be divided into three regions; i.e. equatorial region (20° N and southwards), intermediate region (20° - 50° N), high latitude region (50° - 90° N).
(4) The mode of distribution in the high latitude region is rather different from in the other, and its center of symmetry is near the true magnetic north pole.

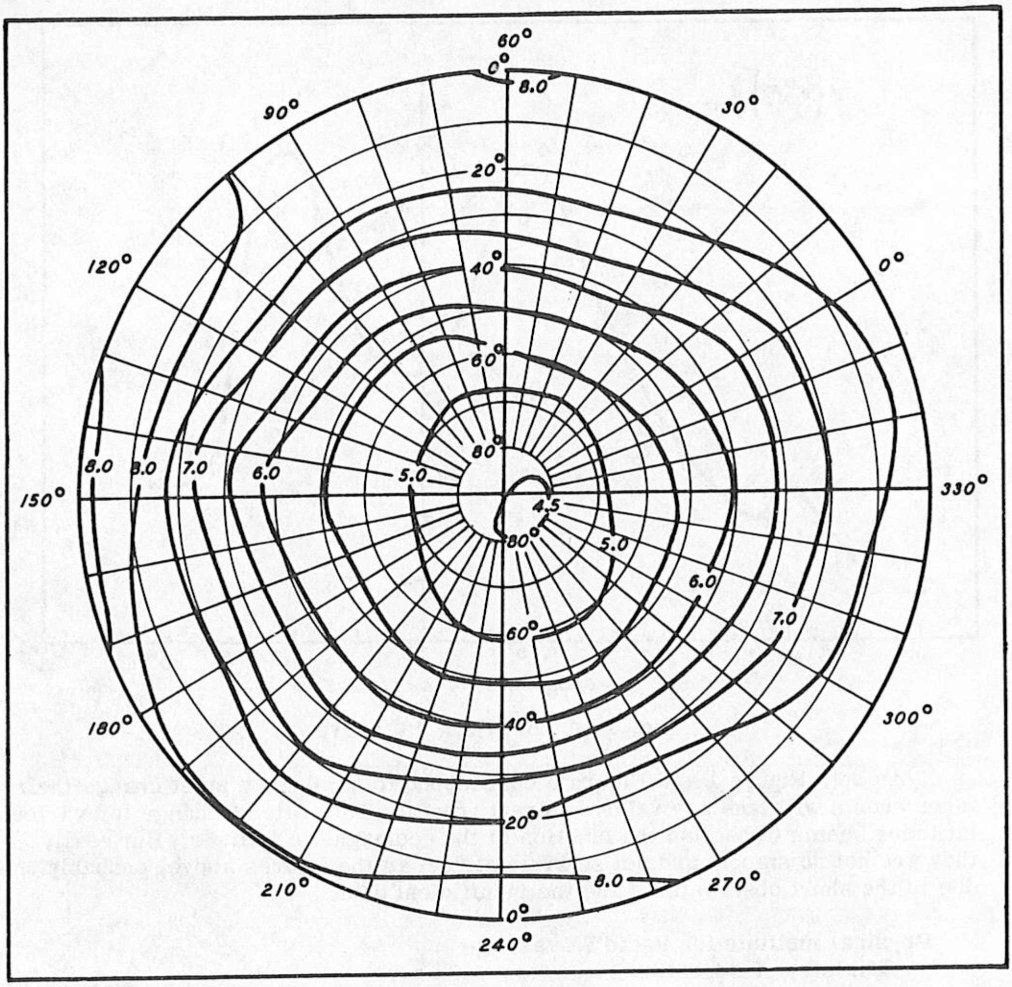


Fig. 2--The geomagnetic distribution map of the annual mean values of foF2 on the northern hemisphere

Like foF2, the amplitude of the daily variation A (foF2) is also regularly arranged on the geomagnetic coordinates. Figure 3 represents the distribution curve of A (foF2) s = 0, where A (foF2) means its running 12-month average of the amplitude of the daily variation. The distinctive characteristics are as follows:

(1) Distribution is nearly symmetrical on both hemispheres with regard to the equator. (The circles in the northern hemisphere are the symmetrically inverted points of the southern.)
(2) Worldwide distribution may be divided into three regions; i.e. equatorial region (20° N - 20° S), intermediate (20° - 50° N and 20° - 50° S) and high latitude region (50° - 90° N).
(3) Amplitude in the auroral region is a little larger than that in the conjunctive regions.

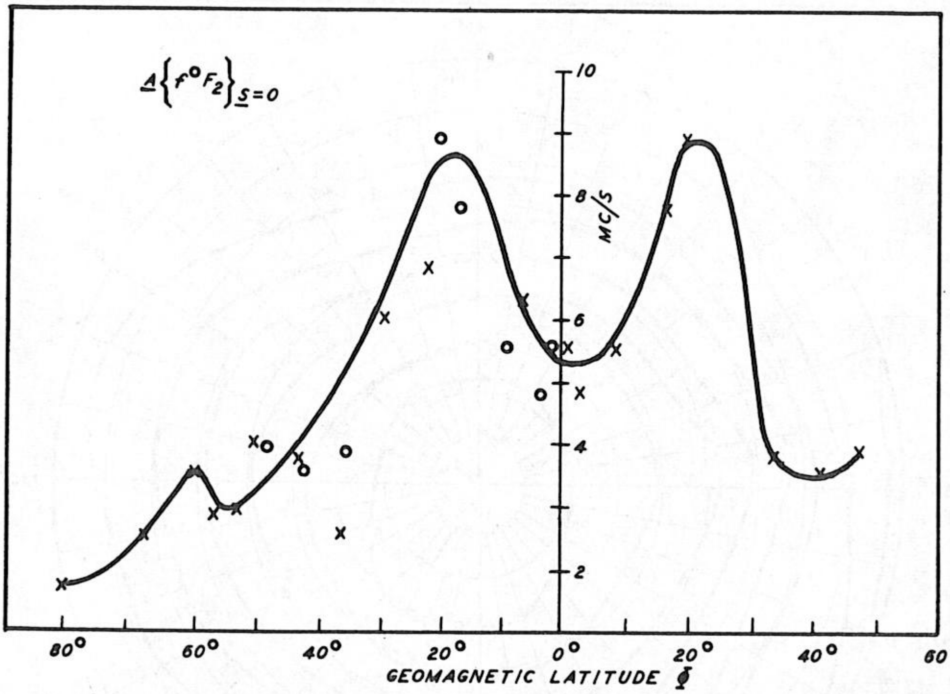


Fig. 3--A (foF2) s = 0:Φ curve

As both Figure 1 and Figure 3 correspond to s = 0, they must change their form when s will take any value different from 0. This rate of change for various latitudes seems to be also the function of the geomagnetic latitude. But really they are not so smooth and not so symmetrical as the figures above, probably due to the short observations and the insufficient data.

Physical Institute for Radio Waves
Ministry of Education
Tokyo, Japan

ON THE VARIATION OF MINIMUM FREQUENCY IN h′-f CURVE OF IONOSPHERIC OBSERVATION

By Y. Aono

Abstract

Using the h′-f curves which were observed every half an hour with the equipments of manual type at Shibata Station (139° 18′.5 E, 37° 57′.0 N), Kokubunji Station (near Tokyo, 139° 29′.3 E, 35° 42′.4 N) and Yamakawa Station (130° 37′.7 E, 31° 12′.5 N) from March 10 through April 10, 1947, the diurnal variations of the deviation of f_{min} (minimum frequency in h′-f curve) from its median value during the period was investigated on the phase relation of time for three stations above stated.

The results of this investigation show a possibility of propagation of the absorbing region of the ionosphere, which causes the variation of f_{min}, with a speed of a few hundred kilometers per hour and of existence of specialty of the place of eruption, which can exert influences upon the ionosphere of the earth.

In order to make sure these problems, it is desirable to observe the ionosphere at several stations each a few hundred kilometers apart and to establish a system of international cooperation to get the complete informations about the solar eruption.

Physical Institute for Radio Waves
Ministry of Education
Tokyo, Japan

FORMATION OF F12-LAYER

By Y. Nakata

Abstract

This paper attempts to explain qualitatively several phenomena of the F2-region by the introduction of a new layer termed the F12-layer.

Physical Institute for Radio Waves
Ministry of Education
Tokyo, Japan

DIURNAL VARIATION IN THE PRODUCTION OF IONS IN THE IONOSPHERE

By Hantaro Nagaoka, M.I.A.

The complete text is published in the Proceedings of the Imperial Academy, Tokyo, vol. 18, pp. 144-150.

THE FORMATION OF F1- AND F2-LAYERS OF THE IONOSPHERE

By Hantaro Nagaoka, M.I.A.

The complete text is published in the Proceedings of the Imperial Academy, Tokyo, vol. 18, pp. 382-389.

SIX MONTH PERIOD OF TERRESTRIAL MAGNETIC ACTIVITY AND ITS RELATION TO F2-LAYER OF THE IONOSPHERE

By Hantaro Nagaoka, M.I.A.

The complete text is published in the Proceedings of the Imperial Academy, Tokyo, vol. 16, pp. 26-32.

IONOSPHERIC BAYS ACCOMPANYING GEOMAGNETIC BAYS

By T. Nagata and N. Fukushima

By comparing geomagnetic and ionospheric data, which were obtained at Kakioka (36°.2 N, 140°.2 E) and at Kokubunji (35°.7 N, 139°.5E) respectively, it was found that a geomagnetic bay is accompanied by a variation in the critical frequency of F2 layer, which is also of a bay-type. This particular variation in ionosphere is named "ionospheric bay"

Observations in the following four selected months were used as data in this study, namely December 10, 1946 to January 10, 1947, March 10 to April 10, 1947, June 10 to July 10, 1947, and September 10 to October 10, 1947, these being the periods of joint observations conducted by the Ionospheric Research Special Committee, National Research Council of Japan. For the purpose of examining the particular ionospheric variation, which is presumably caused by geomagnetic bay, only those bays which occurred during magnetically quiet days were picked up. During the above-mentioned four periods, 7, 21, 9 and 15 bays were used, respectively. It was noticed from the ionospheric data that f^oF2 deviates a little from its normal diurnal variation approximately at the same time when geomagnetic bay occurs.

The average modes of variation in H and D in geomagnetic bays which occurred in successive three hours of a day are shown in the first and second columns in Figure 1, while the corresponding horizontal vector diagrams are given in the third column. In the last column of the figure the corresponding Δf^oF2, the deviations from the normal diurnal variation in f^oF2 curve, are shown. As will be seen in this figure, the mode of variation in Δf^oF2 is similar to that in ΔH with respect to the local time. In Figure 2, Δf^oF2_{max}, the maximum deviations of Δf^oF2, are plotted against the local time. According to the result of actual calculations, these are approximately expressed by

$$\Delta f^oF2_{max} = 0.79 \cos(t - 1.2^h) \pm 0.36 \text{ Mc/sec}$$

From the variation in the critical frequency of F2 layer, the maximum variation, ΔN_{max}, in the maximum electron density N in that layer, and the ratio $\Delta N_{max}/N$ are calculated, with the results as follows:

$$\Delta N_{max} = (19.8 \cos(t - 1.1^h) \pm 11.3) \times 10^4/\text{cc}$$

$$\Delta N_{max} = 21.6 \cos(t - 1.0^h) \pm 16.8 \text{ per cent,}$$

where t means local time and the values after ± are the mean deviations of individual observation from the empirical formulae. It is found that the above-

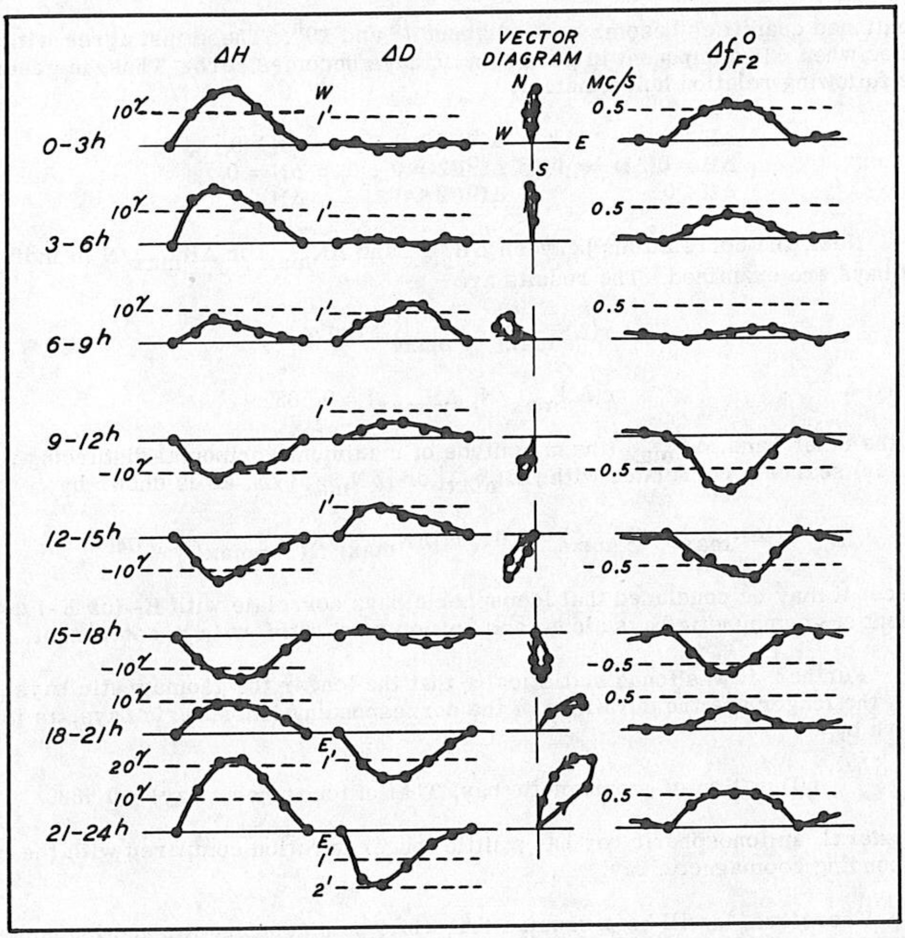


Figure 1

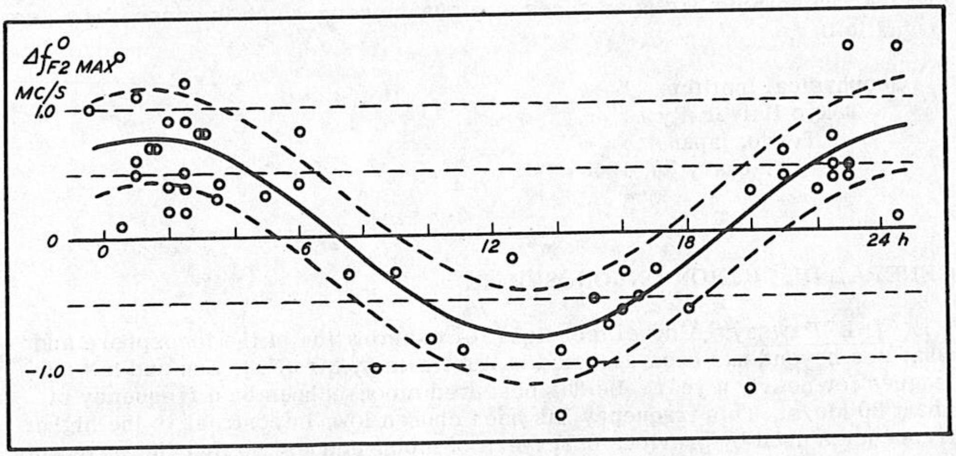


Figure 2

mentioned quantities become zero at about 7^h and 19^h. These just agree with the times when ΔH-component in geomagnetic bays becomes zero. Thus, in general, the following relation holds, namely

$$\Delta H > 0 \quad \Delta f^oF2 > 0 \quad \Delta N > 0,$$
$$\Delta H = 0 (\Delta D \neq 0) \quad \Delta f^oF2 = 0 \quad \Delta N = 0,$$
$$\Delta H < 0 \quad \Delta f^oF2 < 0 \quad \Delta N < 0.$$

Next, the correlations between ΔH_{max} and ΔN_{max} or $\Delta N_{max}/N$ in individual bays are examined. The results are

$$r(\Delta N_{max}, \Delta H_{max}) = 0.774,$$

$$r(\Delta N_{max}/N, \Delta H_{max}) = 0.565.$$

On the other hand, ΔF_{max} (the magnitude of maximum horizontal disturbing force vector) scarcely correlates with $|\Delta N_{max}|$ or $|\Delta N_{max}|/N$, as is shown by

$$r(|\Delta N_{max}|, \Delta F_{max}) = 0.07, \; r(|\Delta N_{max}|/N, \Delta F_{max}) = 0.04.$$

Hence, it may be concluded that ionospheric bays correlate with H- (or X-) component of geomagnetic bays alone, and not, or very little, with Y-component.

Further, it was found statistically that the longer the geomagnetic bays last, the longer are the durations of the corresponding ionospheric bays, as is shown by

r(Duration of geomagnetic bay, That of ionospheric bay) = 0.688.

In general, an ionospheric bay has a little longer duration compared with the corresponding geomagnetic bay.

Therefore, it will be presumed that while both geomagnetic and ionospheric bays begin nearly at the same time, the former reaches its maximum and comes to its end a little earlier than the latter. It will be rather logical conclusion then that the ionospheric bay is an accessory phenomenon which is caused by a geomagnetic bay.

Geophysical Institute
Tokyo University
Tokyo, Japan
January 30, 1948

GENERAL DISCUSSION ON IONOSPHERE:

J. L. Pawsey: A novel technique for examination of the ionosphere and what lies beyond has been operated in Australia by Mr. F. J. Ken and his colleagues for nearly a year. He has observed moon-echoes on a frequency of about 20 Mc/s. This frequency has been chosen low, in contrast to the higher frequencies used by previous observers of moon-echoes, so that the wave may be modified by the ionosphere.

A standard broadcast transmitter, of about 100-kw power, with the standard directional aerial directed towards the east, is used. At certain times the moon rises through the beam of the aerial and at these times echoes are received using a similar aerial directed to receive signals from the east and a standard communications receiver with a bandwidth of about 100 c/s. The transmitter is keyed and the echoes received aurally and also displayed on a long persistence cathode ray oscillograph.

Of the first seven trials, echoes were observed on six occasions. The maximum strength was that corresponding to zero attenuation and reflection from a smooth metal sphere. However, the echoes were usually much weaker, of the order of 10 db less, and were very variable with both long and short periods.

At low angles of elevation the echoes are not received, but they appear above a critical angle. This angle appears to be a little higher than the critical angle for reflection.

O. E. H. Rydbeck: In connection with Dr. Pawsey's report of 20 Mc/s, 100 kw moon-echoes at low elevation, were the daily echoes (received over a period of one week) of the same character every day or did they vary in shape and amplitude and, if so, was there any correlation with general ionospheric characteristics?

J. F. Pawsey: They varied a lot. It is not known if there was any correlation with ionospheric data at that time.

C. Terrestrial Magnetism

DECLINATION RESULTS AT CANADIAN STATIONS NORTH OF LATITUDE 60°N, 1938-47

By R. G. Madill

The complete text is contained in Dominion Observatory Publication, vol. XI, No. 9, Ottawa, 1949.

A NEW MAGNETIC SURVEY OF THE NETHERLANDS

By J. Veldkamp

The complete text is published in Terrestrial Magnetism and Atmospheric Electricity, vol. 53, No. 4, pp. 387-397 (1948).

CORRELATION OF MAGNETIC FIELD DATA

By F. Bahnemann

Since the inception of magnetometric measurements for prospecting purposes the problem of the magnetization of rocks and minerals has occupied the minds of all who were interested in the practical application of the magnetic method.

Textbooks and handbooks have usually simplified matters to a large degree by stating that the magnetization of rocks is generally due to induction by the earth's field and that all other cases must be regarded as exceptions to a well established rule. The introduction of the Schmidt Field-Balance and the ever increasing number of observations during the last two decades carried out over pertinent geological objects the world over has definitely shown that magnetization solely by induction of the earth's field is, if at all, responsible only for a small number of occurrences. To exclude ambiguities it may be stated that the term: "induction through the earth's field" is employed here in the usual sense, meaning that a magnetic body of susceptibility K is magnetized according to the intensity H of the magnetic field, due consideration being given to the relative position of field and body, form of body, demagnetizing factor, etc., i.e., $J = KH$.

It might be of interest to state, that with the possible exception of the Lower Witwatersrand shales the author has not encountered one instance where the magnetization of a geological body had, beyond doubt, to be attributed, solely, to induction. Even with respect to the magnetic shales of the Lower Witwatersrand, the surprisingly constant magnetite content of which has been the decisive factor in the successful prospecting for the western extension of the Witwatersrand

System, the author is prepared to go only so far, as to say that the fieldstrength anomalies detected on the surface could be produced by rocks magnetized by induction. In this case the values of the susceptibility to be assumed have been in accordance with reasonable assumptions and surface measurements on weathered samples, which, however, cannot be taken as being truly representative for the fresh rock.

One factor comes out beyond any doubt. The magnetic rocks show a surprising variety in magnetic effects, although the magnetic material is the same in all of them: magnetite.

There have been many attempts, notably those of Koenigsberger to arrive at some general idea regarding the magnetization of rocks and minerals. There seem to be two ways of attacking this problem. The one is: To study the magnetic behavior of the main ferromagnetic mineral, magnetite, in the laboratory. The second is: To make use of the numerous magnetic measurements in the field. To avail ourselves of this opportunity it would be necessary to collect not only the magnetic data, but to supplement these with a topographical and geological description of the occurrence, so that this description would contain: Geographical and magnetic coordinates, if possible the magnetic elements of the region in question, dip and strike of occurrence, a geological, petrographical and mineralogical description of the occurrence as accurate as possible--the geological age being of special interest.

The required descriptions of magnetic bodies have to a certain extent to replace the experimental conditions arbitrarily to be selected in the laboratory. On the other hand the study of such geological bodies might often reveal physical conditions which could be produced only with great difficulties in the laboratory.

A careful study and review of the geological conditions of certain occurrences of magnetic rocks forced many observers to the conclusion that other influences must come into play in order to arrive at the measured magnetic disturbances.

The most striking observations in this respect made by every worker in the field are the following two:

1. Stronger magnetization than could be expected from the magnetite content under the assumption of induction through the earth's field.

2. Anomalous direction of the magnetization; often inverse to that to be expected from induction through the earth's field.

There are examples, for instance the Pilansberg Dyke System in Transvaal, where every geological or tectonical explanation has failed. The instance of the inverse magnetization of the Pilansberg Dyke System has led the author to reconsider the applicability of some old experiments carried out already by Ewing some 60 years ago and showing that one can get a variation of the magnetization of a nickel wire by torsion. The type of curve produced is similar to the well-known hysteresis curve, where the change of magnetization is, however, produced by the changing field. The similarity is extending even to the change of direction of the magnetization with the change of direction of the applied torsion.

The modern theory of the magnetization curve of ferromagnetics as developed especially by R. Becker-Göttingen and his pupils allows to interpret the old experiments to a large degree. To avoid misunderstandings the point should be stressed, that by suitably applied mechanical forces, as for instance shearing stresses in the case of Ewing's experiments, a change of magnetization is produced and not magnetization as such as having been shown earlier by the author using Becker's concepts. It follows that there is a certain important difference between magnetically hard and soft materials. Hard materials showing remanent magnetization may change their magnetization by being subjected to mechanical stresses without any external magnetic field being present, whereas soft materials need this field in order to exhibit a similar behavior.

It is here not the place to go into too many details, however, so much should be stated that the elastic properties and the internal stresses of the material concerned play a vital role in determining their magnetic behavior. Although well known to physicists and engineers these modern results are curiously often overlooked by geophysicists.

The same applies to another old experiment carried out by J. Hopkinson on iron in weak magnetic fields. He was measuring the permeability of low carbon steel in fields of e.g. 0.3 Örsted as a function of the temperature and found a sharp increase of permeability not far below the Curie-point.

One is inclined to assume that this increase might be due to the disappearance of internal stresses in the material. Whatever the real cause of this effect, it deserves certainly to be investigated especially regarding its reality in other material, as for instance, magnetite. Should magnetite exhibit a similar effect--and there seems little doubt about that--the importance of this effect for the interpretation of geophysical phenomena appears to be obvious. Special attention would have to be attached to experiments showing the effects of cooling time, in order to find out, whether a strong remanent magnetization might be kept by the material when the temperature has changed down to some normal surface value. The depth in the earth's crust down to the temperature of the permeability increase, the form and extension of this surface and the thickness of the layer showing this effect would be of special interest with regard to the problem of secular variation. The presence of deep seated basic igneous rocks may be detected by magnetic surface measurements and their interpretation based on better knowledge of the magnetic behavior of magnetite subjected to varying temperatures and mechanical stresses in small magnetic fields. The author feels that in pursuing such studies we might even arrive at results of technological importance, since everything points to the existence of a sort of magnetic bond, which in suitable materials is superimposed upon the specific chemical and metallic bond, although it might become effective only between some sort of metallic macromolecules.

The solution of all these problems may be assisted by careful observations in the field, as was mentioned before. The observations should, however, be made with these ideas as a guide--as well in carrying them out as in interpreting them. The next step would be to coordinate these observations with one another and with the progress in the laboratory. After that fresh experiments should be devised and further observations in suitable localities be carried out. It seems that pooling and coordination of the results of measurements in the field are urgent necessities in order to assure further progress of our knowledge of the earth's field, the magnetization of magnetic matter and the interpreting of magnetic measurements in our search for untapped occurrences of raw materials.

TERRESTRIAL MAGNETIC RESEARCH IN SIKKIM AND SOUTHERN TIBET IN 1938 AND 1939

By K. Wienert

A complete account of this work is published in Terrestrial Magnetism and Atmospheric Electricity, vol. 52, No. 4, pp. 505-521 (1947).

A MAGNETIC SURVEY OF NORWAY

By B. Trumpy

The complete text is published in Jordmagnetiske Publikasjoner Nr. 1 of Magnetisk Byrå and Norges Sjøkartverk, 1945 (Bergen and Oslo).

MAGNETIC RESURVEY OF NEW ZEALAND

By H. F. Baird

Introduction

In May 1941 a magnetic resurvey of New Zealand was begun with Earth-Inductor Magnetometer C.I.W. No. 27, which was kindly loaned to the New Zealand government for such purpose by the Carnegie Institution of Washington.

Use of the term resurvey aims to connote both reoccupation of many of Farr's [1] original magnetic stations as well as extensions to its network of stations. Some new areas have become accessible by road since that original survey, many of its sites by 1941 were no longer available or suitable for reoccupation, while wartime and economic needs demanded information from new areas. The extensions or replacements aimed to fill all possible of those needs. Some new stations were put in magnetically anomalous regions usually because of geological, economic, or statistical considerations.

Farr's stations were nearly always described as being so many paces of now unknown length from objects which had long since disappeared. However, many were on homogeneous geological formations and were still capable of approximate relocation even though on the mainland few if any pegs were left by him. Approximate reoccupations after a lapse of about 40 years could in such places hardly appreciably affect the deduced average rate of secular variation over that interval.

Descriptive

Except at Thorpe where agricultural farming prevented it, a peg or concrete block carrying a copper nail or tack marked each resurvey station. In every case possible, and that was nearly everywhere, each peg was tied by traverse and true bearing to the most durable land survey marks in the vicinity. Thus practically all resurvey magnetic stations are geodetically coordinated, and fixed precisely in perpetuity, as the pegs to which they are tied are shown on registered plans kept in fireproof buildings. The only exception was for a time where plans in Hawkes Bay were destroyed by a fire which gutted the Survey Office after it had collapsed in the 1931 earthquake. On level terrain the instrument was used at sensibly the same height at each place, but on uneven terrain, encountered very infrequently, the aim was first to get working room in the small Japara cloth tent irrespective of instrument height.

Field observations usually included a morning and afternoon sunshot for azimuth, and sometimes a sunshot for latitude which more often was geodetically computed. Bearings sometimes were thrown from meridional circuits and corrected for convergence. Magnetic observations were two sets of dip each with circle, east and west, declination, oscillation erect, deflection with deflecting magnet erect, deflection with deflecting magnet inverted, oscillation inverted, and declination. In later years, when time and travelling conditions were not so pressing the magnetic program was often doubled. Deflections were at 20, 25, and 28 cms, which last with a half minute graduated circle called for extra care where H values were higher up north.

Intercomparisons of C.I.W. 27 against the Eschenhagen base-station traces were made before and after each program of field work. Until 1943 it was usual for deduced values of H at Amberley to be slightly higher than given by C.I.W. 27 observations. Since then the tendency has been for C.I.W. 27 values to be the higher. I have not yet found out when the H variometer was last reorientated at Amberley. If by 1941 the orientation was poor, a secular change of over half a degree in inclination since then may, because of increasing gradient of cosines of larger angles, be in widely differing ordinates of curve significance. QHM's standardize the H curves weekly so primarily there is need for restandardization of our QHM's and C.I.W. 27 at Cheltenham. Apart from this a statistical investigation of the collected records and observations will be made as soon as adequate staff remains available. When magnetometer observations have been made in gusty wind conditions, a doubt has often arisen as to their relative accuracy as against results derived in calm weather. As far as staff shortage permitted, work was done in seasons of the year when winds were expected to be less frequent or violent. However, availability of staff during the University long vacation weighed most in recent years as to when work was done.

Variability between Amberley and magnetometer declinations was slight. Intercomparisons in dip, which involve dependence on QHM results for H were reasonably concordant, except after the return of the instrument from Apia in 1945. Some further statistical investigation is needed, but the wide disparity after return from Apia is attributed to verdigris or other dirt, which was not easy to remove. At any rate performance improved after a thorough clean in late 1946, because specks of verdigris due to the tropical air kept appearing in odd places for some time. Up to June 1942, and including intercomparisons at Apia in 1945, the observations were made by Mr. J. W. Beagley, who in 1945 transferred to Apia Observatory as Director. Baird made all other observations from June 1942.

Timing was by Molyneux Chronometer which was used by Farr too on the original survey. Time signals were obtained fairly frequently by radio, and the rates were satisfactory. Since the Snares trip a portable radio has been carried. The taking of signals at different times on the same day shows that the rate varied a little during a 24-hour period, but its range was of no really appreciable significance.

These remarks are being drafted while much attention has to be given to arrangements needed for a trip by ketch to the Campbell Islands and for a land trip to some other South Island reoccupations. Some attention is also necessary to a program needed by the Harbor Board at Bluff where navigational aids are sought. Stations such as Port Jackson and Omapere were put in at the request of the Marine Department for whom we now keep New Zealand's Nautical Almanac up to date in the interest of safe compass navigation around our coasts. To meet the needs of aviation navigators a trip to Chatham Islands for reoccupations is also under consideration.

It is likely that by the end of 1948 the observations covered in this resurvey will be sufficiently analyzed and collated for final publication. An intercomparison before then at Cheltenham is regarded as essential. [Editor's note: Three Association of Terrestrial Magnetism and Electricity QHM's Nos. 33, 51, and 52 were sent by air to New Zealand for H comparisons during 1949. Mean difference of the average of the three QHM's minus Amberley was -2γ. This value is based on original QHM constants determined at Rude Skov. At the time of this note the QHM's have not yet been returned to Rude Skov for final calibration.]

A map of New Zealand showing the isogonals and isopors at epoch 1943.5 was prepared from deductions made by J. W. Beagley [2]. Instructions were to throw the epoch ahead of the time for which we had adequate smoothed data of current secular change rate. Actually in 1944 the secular change rate in declination proved higher than shown on the maps. The isogonals delineated by Farr and Beagley showed a tendency for departures from statistical normal to be mostly negative on the west of the central parts of New Zealand. In recent years, therefore, Baird put several new stations along the west coast from Paringa up to Waioneke, and east of Puponga towards a deep-seated geological formation in Nelson and Marlborough where earlier results may have unduly affected the trends of isogonals. Many new stations too were consistently negative in their departure from previous statistical normal, while others to the east were very disturbed indeed. A reconnaissance by airborne instruments appears the best way of eliminating suspected anomalous effects produced in this and other highly magnetically disturbed geological formations in New Zealand.

The latitude and longitude of Amberley base station are: Latitude 43° 10′S, longitude 172° 44′E, and of Christchurch original base station: Latitude 43° 32′, longitude 172° 37′. As the rate of secular variation, particularly in declination is different at these places the geographical coordinates are given so that Farr's Christchurch based values can be collated with these values based on Amberley.

References

[1] C. C. Farr, "A magnetic survey of the Dominion of New Zealand and some of the outlying islands, 1903.5", Lands and Survey File No. 37984.

[2] H. F. Baird, "Magnetic declination in New Zealand for epoch 1943.5", N.Z.J. S.T., vol. 25, No. 4 (Sec.B), pp. 175-178 (1944).

Magnetic Observatory
Christchurch, New Zealand

[Editor's note:
The original manuscript contains a listing of preliminary values of station differences with Amberley. Since final values will eventually be published, they are omitted from these Transactions.]

COMPLETION OF MAGNETIC AND ELECTRIC SURVEY OF THE EARTH

By E. H. Vestine

Since the founding of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, in 1904, a major share of effort in world magnetic and electric surveys was undertaken by the Department. After 1926 active participation diminished, though much work on land surveys was, and even today continues to be, done with instruments and equipment loaned by the Department. Since 1929, however, the oceans have been neglected by all. The Carnegie Institution of Washington has been unable to replace its non-magnetic survey ship Carnegie, destroyed by fire in 1929, and hence an area covering four-fifths of the globe has had no adequate coverage since that time.

During the years of World War II it was found possible to summarize the main results not only of the surveys of the Department but of nearly all other organizations as well. This turned out to be a major project in its own right, and its completion was made possible by the generous financial assistance of the United States Naval Ordnance Laboratory. The findings, mainly in mapped form, are summarized briefly in volume form [1], and most of the maps have been issued by the United States Hydrographic Office.

Main-field charts for epoch 1945.0 were prepared in seven magnetic elements, and these, together with new and corresponding isoporic charts (each decade since 1912.5) render a fair description of the Earth's main field throughout the period 1905-45. Computed values of the main field and its secular change were estimated at various heights up to 5000 km above the Earth for 1945.0 [2].

Spherical harmonic analyses of the secular change for epochs 1912.5, 1922.5, 1932.5, and 1942.5, and of the main field for epoch 1945.0, were carried out.

The north geomagnetic pole for 1945 was estimated to have a position of latitude 78°.6 north and longitude 289°.9 east, in good agreement with the accepted value for 1922 of latitude 78°.5 north and longitude 291°.0 east.

The main (dipole) terms of the analyses gave an estimated possible component of field of origin external to the Earth of less than one per cent.

Model current-systems confined to thin concentric spherical shells, which could reproduce the surface secular change and main fields, were calculated for various depths within the Earth. The current-functions found for depth 3000 km showed a high degree of complexity. Accordingly, it has been concluded, on grounds of simplicity, that the sources of the non-dipole terms of the main field and its secular change can only be located in the depth-range including a thin upper stratum of the central fluid core of the Earth and upwards to the Earth's surface. If the Earth's field is due to electric currents, these are likely to flow at depths greater than about 1000 km, if we adopt the estimates of electric conductivity of the Earth's interior given by Chapman, Price, Lahiri, and Colter. It is also necessary to conclude, on the basis of these estimates of conductivity, that an important source of the main field and its secular change is to be found at modest depths within the mantle of the Earth, or within the crust because there have been observed nearly "periodic" changes in the Earth's field of period less than about 100 years, as, for example, at Sitka, Alaska, during the years since 1900. This suggests the hope that we may find by more sensitive surface measurements than those heretofore employed, other geophysical quantities--such as stress or crustal movement--associated closely in time with the manifestation of secular change.

References

[1] E. H. Vestine, Lucile Laporte, Isabelle Lange, Caroline Cooper and W. C. Hendrix. Description of the Earth's main magnetic field and its secular change, 1905-45. Carnegie Inst. Washington, Pub. 578 (1947).
[2] E. H. Vestine, Isabelle Lange, Lucile Laporte, and W. E. Scott. The geomagnetic field, its description and analysis. Carnegie Inst. Washington, Pub. 580 (1947).

Department of Terrestrial Magnetism
Carnegie Institution of Washington
Washington, D. C., U.S.A.

DISCUSSION:

N. Ambolt commented on the discrepancy between the determination of the dip-poles in Vestine's paper and that given by Madill (see page 394).

The Astronomer Royal said that the observations made on polar flights of the *Aries* indicated that the position of the dip-pole was between the Amundsen position and the position derived from spherical harmonic analysis. The mean of the readings obtained gave pretty consistent result and indicated a latitude of the dip-pole of 74°.

Dr. J. Olsen recalled Amundsen's determination of the dip-pole and raised the question of the possible multiplicity of dip-poles or even their non-existence.

S. Chapman pointed out that theory required the existence of at least one dip-pole. He also drew attention to its diurnal variation, amounting to some 10 kilometers.

Dr. C. S. Beals (who read Madill's paper), in reply, said he did not think it necessary to consider whether Amundsen's pole was a local one. He also said that surveys were not yet sufficiently detailed to give accurate coordinates of the dip-poles. He agreed with Professor Chapman that the dip-pole might move by as much as 10 to 20 kilometers in a day.

ESSAI D'INTERPRÉTATION GÉOLOGIQUE DES ANOMALIES MAGNÉTIQUES DÉCELÉES DANS L'EST DE LA BELGIQUE

Par Edmond Hoge

Au cours des années 1937 et 1938, nous avons entrepris, à l'aide d'une balance magnétique de Copenhague, un levé de la composante verticale Z dans la partie orientale de la Belgique. Des déterminations ont été effectuées en des points situés à une distance moyenne de 5 kms. Un réseau uniforme de quelque 550 stations couvre ainsi toute la région située à l'Est du méridien de Namur et s'étendant jusqu'aux frontières des pays limitrophes (Pays-Bas, Allemagne, Grand-Duché de Luxembourg, France).

Le but de ce levé était d'étudier d'une façon systématique toute la zone d'influence du pôle d'attraction de Spa et celle du centre répulsif de Hasselt mis en évidence par la carte générale des anomalies établie d'abord par M. Dehalu et Melle Merken puis par nous-mêmes. En outre, notre levé, environ dix fois plus dense que celui de M. Hermant, pourrait nous permettre de mettre éventuellement en évidence des anomalies moins étendues qui n'apparaissaient pas sur les cartes antérieures.

Lors du Congrès de l'Association Française pour l'Avancement des Sciences, qui s'est tenu à Liège en juillet 1939, nous avons présenté la carte des valeurs observées de Z, réduites au ler janvier 1938. Celle-ci mettait en évidence les faits suivants:

1° Confirmation d'une zone d'attraction dans les environs de Spa et d'une région de répulsion au Nord de Hasselt.

2° Existence d'une crête d'anomalies positives, de direction NE - SW à travers l'Ardenne.

3° Présence d'une anomalie positive assez importante à l'W de Maestricht.

4° Présence de fortes anomalies positives et négatives dans la région Paliseul - Libramont - Bastogne.

5° Existence d'anomalies locales en différents points (Au Nord de Namur, en Hesbaye, dans les environs Muno, etc.).

Nous nous proposions dès 1939 de dresser la carte des anomalies proprement dites et d'essayer ensuite d'en tirer une interprétation géologique. Malheureusement la mobilisation d'août 1939, suivie de la guerre en 1940, puis de cinq années de captivité en Allemagne, nous empêchèrent de poursuivre nos recherches. Cellesci ont été reprises en 1945 et sont actuellement en cours. Nous ne pouvons à présent que donner quelques indications d'ordre général sur certaines relations qui existent entre les anomalies magnétiques signalées ci-dessus et la structure géologique du sous-sol belge.

Ainsi que l'avait déjà montré la carte générale des anomalies, il semble y avoir une liaison assez étroite entre la tectonique et la distribution des anomalies magnétiques. En général, les axes des anticlinaux sont le siège d'anomalies positives et les axes des synclinaux sont marqués par des anomalies négatives.

L'Ardenne notamment, où affleurent les terrains primaires du Dévonien et où émergent les massifs cambriens de Stavelot et de Serpont, est le siège d'anomalies positives. La ligne de crête magnétique suit très sensiblement l'axe de l'ellipse constituant le dôme de l'Ardenne. Le bassin de la Campine, par contre, constitué de terrains récents, est marqué par des anomalies négatives. De même, le synclinal de Namur est jalonné par des valeurs de Z peu élevées. Par contre, il semble bien que l'anomalie positive décelée à l'W de Maestricht et qui se prolonge en territoire hollandais, comme l'indique la carte de Ph. Hartmann, correspond à la terminaison orientale de l'anticlinal du Brabant.

Il y a lieu de signaler également la coincidence entre zones fortement perturbées, telle la région Paliseul - Libramont - Bastogne, et la présence de roches métamorphiques.

Enfin, certaines anomalies locales paraissent être en relation étroite avec certaines particularités géologiques. Ainsi, par ex., l'anomalie positive qui apparaît dans la region de Muno - Sainte Cécile, semble devoir être mise en liaison avec la présence du Cambrien qui affleure dans cette région (massif de Givonne) ou avec l'existence d'un pointement de roche éruptive (Kersantite).

Ces quelques considérations préliminaires montrent une fois de plus l'intérêt de mettre en parallèle les cartes géologiques et magnétiques se rapportant à une même région. La Belgique est un pays qui se prête particulièrement bien à cette étude. La carte géologique y a été dressée avec beaucoup de précision et de détails par les géologues belges et c'est pourquoi l'établissement de levés magnétiques détaillés peut permettre une étude féconde des relations qui existent entre anomalies magnétiques et phénomènes géologiques. Le nouveau levé magnétique qui sera entrepris prochainement par le service du Magnétisme terrestre de l'Institut Royal Météorologique de Belgique permettra de poursuivre d'une manière fructueuse l'étude de ces intéressants problèmes.

Uccle, Belgium
le 10 août 1948

LAS VARIACIONES DE LA COMPONENTE VERTICAL DEL CAMPO MAGNETICO TERRESTRE APLICADAS A LA PROSPECCION DE MINERALES

Por José G. Siñeriz

Generalidades

En varias ocasiones hemos tenido la oportunidad de resolver problemas de prospección geofísica recurrien do a los métodos magnéticos. El usado con mas frecuencia, fué el basado en las variaciones de la componente vertical, sobre la que ejerce gran influencia la acción perturbadora de algunas masas minerales.

Las últimas investigaciones que hemos efectuado, por medio de la observación de las variaciones de la componente vertical del campo magnético terrestre, fueron las de: La Capelada (Coruña), Alcaracejos (Córdoba), La Enebrosilla (Avila), cercanías de Bilbao (Vizcaya) y Cazalla de la Sierra (Sevilla).

La mas importante de todas ellas es la de Cazalla de la Sierra, de la que exponemos una referencia sucinta en los párrafos siguientes.

La Investigacion Magnetica en Cazalla de la Sierra (Sevilla)

Por el método magnético de prospección, se pretende estudiar la continuidad o discontinuidad del yacimiento de magnetita de Cazalla de la Sierra, descubierto hace varios años por sus afloramientos. Todas las manifestaciones encontradas pueden ser ramas o brazos, que llegan al exterior, de una sóla formación.

I. Reseña Geográfica y Geológica

La región donde se hallan enclavados los cotos ferríferos de magnetita, objeto de nuestro estudio, corresponde a la parte occidental del término de Cazalla de la Sierra, en la provincia de Sevilla, teniendo como límites, por el N. la Sierra del Timón; por el Sur, las lomas de los Asperonales y de las Calderetas; por el Este, los altos de Las Marianas y por el Oeste, el valle del Viar (Vease la lámina I).

La zona investigada está comprendida en un rectángulo de 5 Km. de lado mayor y poco mas de uno de anchura (Vease la Lam. I).

Desde el punto de vista geológico, la mayor parte de su superficie corresponde al estrato cristalino que está rodeado por un batolito granítico, excepto en una pequeña zona en que aparece en contacto con la formación cambriana.

Posteriormente a la gran inyección granítica sobrevinieron otras menos considerables de pórfidos y mas tarde surgieron las rocas básicas diabases, dioritas y piroxenitas que nó sólo atravesaron el granito sino también las formaciones sedimentarias.

Criaderos de magnetita--Dejando a un lado las pequeñas muestras de mineralización de la zona poniente de la Sierra, que se reducen a sustituciones de la caliza por hematites roja y carbonato de hierro manganesífero sin importancia alguna, ya que las cortas labores de investigación abiertas en ellas han demostrado su absoluta falta de extensión en superficie y profundidad, vamos a tratar del posible criadero de buenos minerales magnéticos que parece dibujarse en toda la ladera N. de la Grana.

A estas mineralizaciones, tanto por las leyes que ponen en evidencia, como por le extensión considerable en que se presentan (aunque sin conexión o enlaces mútuos comprobados) y sobre todo por su indudable relación genética con los grandes asomos eruptivos propios de esta parte de la provincia de Sevilla, es a los que hemos concedido la máxima importancia. La razón es bien sencilla: siendo varias y bastante distintas las muestras de mineralización en magnetita de buena ley y acusando todas ellas una íntima relación con diques o erupciones de rocas diabásicas y piroxénicas que repetidamente han atravesado con mayor o menor potencia y desarrollo, el gran macizo granítico que constituye el subsuelo de toda la Sierra de la Grana y se extiende por las provincias de Sevilla, Badajos y Córdoba hasta los límites amplísimos, es natural que exista la probabilidad de que todas las masas localizadas hoy en la superficie del terreno, tengan ensanchamientos y uniones subterráneas, con lo que llegarian a formar un sólo criadero de cubicación importante.

Si por el contrario, estás masas de mineral dependiesen exclusivamente de diques estrechos, o de verdaderas apófisis de la roca básica, sin uniones mútuas entre ellos y sin una mediana profundización en sus metalizaciones, desaparecerian todas las probabilidades de existencia de un verdadero yacimiento, quedando reducido el problema de las magnetitas de Nueva Luz a la presentación esporádica y sin regulación de masas aisladas de buen mineral, pero sin cubicación posible para plantear una explotación económica.

II. La Investigación Magnética de los Criaderos

Para la investigación magnética se hizo una red de estaciones, lo mas completa posible, observadas con los variómetros que miden la componente vertical, para poder trazar despues el plano magnético con curvas de igual anomalia de esta componente, que deben delimitar las zonas de mayor o menor interés. Se emplearon dos variómetros de componente vertical de la casa Askania compensados térmicamente, con lo cual se evita hacer la corrección de temperatura. De los dos variómetros, uno, se instaló en una base auxiliar, relacionada magnéticamente, con otra fundamental situada fuera de la zona sometida a la influencia de las perturbaciones magnéticas producidas por el criadero, para poder referir las medidas a un punto de anomalia cero, que es la que hemos considerado para la base fundamental. En la base auxiliar se tuvo continuamente el variómetro Num. 97120 con el fin de poder seguir las perturbaciones extrañas.

Con el segundo variómetro Num. 97118 se hicieron estaciones en la base auxiliar cuatro veces al dia, con el fin de poder comprobar si habia ocurrido alguna anormalidad en este variómetro, con el que se observaron las 182 estaciones de la red.

Todas las lecturas se refirierón a las 7 h. del 27 de junio, que fué la correspondiente a la primera estación observada en la base auxiliar.

Para establecer la red de estaciones se partió de un perfil principal de 26 estaciones con dirección aproximada E.O., y situados a una distancia mútua de 100 metros por lo que la longitud del mismo fué de 2,500 m. (Vease la Lam. II). El órden de numeración de las estaciones es el indicado para el perfil, o sea de E. a O. La primera o número uno, está al O. del cortijo del Rubiano y la 26 al Sur del cortijo del Higueron; normal a este perfil principal se hicieron 16 perfiles con estaciones de 50 en 50 ms. numerados de N. a S. con una longitud media de 500 metros. El número de cada perfil es el de la estación correspondiente del principal.

La componente vertical del campo magnético terrestre, tiene una variación normal de un extremo a otro de cada uno de estos perfiles, que no pasa de 5 gammas y que no tiene importancia en una zona de tan grandes anomalias magnéticas por lo que no se hizo la corrección de esta variación. Para completar una zona que quedó poco cubierta entre la parte Sur de los perfiles I y III, se hicieron ocho estaciones que figuran en el mapa magnético. Con el fin de seguir para todos los perfiles la misma norma en la numeración se denominó en cada uno de los perfiles transversales estación num. 3 a la que coincide con el perfil principal.

Con los valores obtenidos para las anomalias, se construyeron las curvas isanómalas, representadas en el plano correspondiente de 500 en 500 gammas. Para poder seguir su trazado con fadilidad, se han rayado, de distinta manera, las zonas que delimitan las anomalias de 1000 en 1000 gammas, hasta las que exceden de 7,000. Las de 2,000 a 3,000 gammas, que cubren la mayor parte de la zona, se han dejado en blanco para mayor claridad.

Observando los valores numéricos de las anomalias comprobamos que no hay ninguna inferior a 1,000 gammas, y que son muy escasas las inferiores a 2,000. Estas últimas estan comprendidas, principalmente, en la zona estudiada por los perfiles XXI, XXII y XXIII.

Las anomalías comprendidas entre 2,000 y 3,000 gammas, ocupan una zona muy amplia, que es la que, según ya hemos indicado, ha quedado sin rayar.

Al Este de la zona investigada, entre los perfiles III y XI, las anomalias crecen rápidamente desde 3,000 gammas, en adelante. En la estación 7 de los perfiles V y III, son mayores de 7,000 y en la 11, del perfil III, exceden de 4,600.

Al Sur del perfil III, se ha observado el XXVII, que determina otra zona de anomalias superiores a 3,000 gammas. Igualmente sucede en la parte occidental, entre los perfiles XXIV y XXVI, donde se presentan abundantes afloramientos de rocas, integradas principalmente, por cuarzo y magnetita. En una muestra de esta roca, finamente molida, sólo un 15% de su peso no era atraido por el imán.

El perfil XIII ha indicado tambien una zona de grandes anomalias, que son superiores a 7,000 gammas, en la estación 3.

Los resultados obtenidos confirman la hipótesis que hemos sentado sobre la génesis del yacimiento de magnetita. La erupción general de diabasa o piroxenita porfiroide, atravesó el granito y las capas de calizas arcaicas, llegando hasta aflorar, en algunos lugares. Uno de los minerales constitutivos de aquella erupción era la magnetita que se segregó del magma en las zonas de contacto con el granito o con la caliza, formando un manto que constituye el yacimiento estudiado.

Yá hemos dicho, que el efecto magnético producido por el yacimiento, depende tanto de la cantidad de mineral, como de la profundidad a que se encuentre. Como en este caso, hemos comprobado, que las anomalias máximas se encuentran en los afloramientos--el socavón Velaz--quez se encuentra cerca de la estación 11, del perfil 3; el pozo Covadonga, al Sur y cerca de la estación 7 del perfil V, y el socavón No. 2, cerca de la estación 3, del perfil XIII, parece deducirse de ello, que el factor profundidad, es el que ha tebidó mayor influencia; en cuyo caso, las líneas isanómalas trazadas, pueden ser consideradas como curvas de nivel del yacimiento, cuya potencia desconocemos. También nos es desconocida la profundidad, pudiendo sólo apreciar que esta varia lenta o rápidamente por la numeración de las curvas.

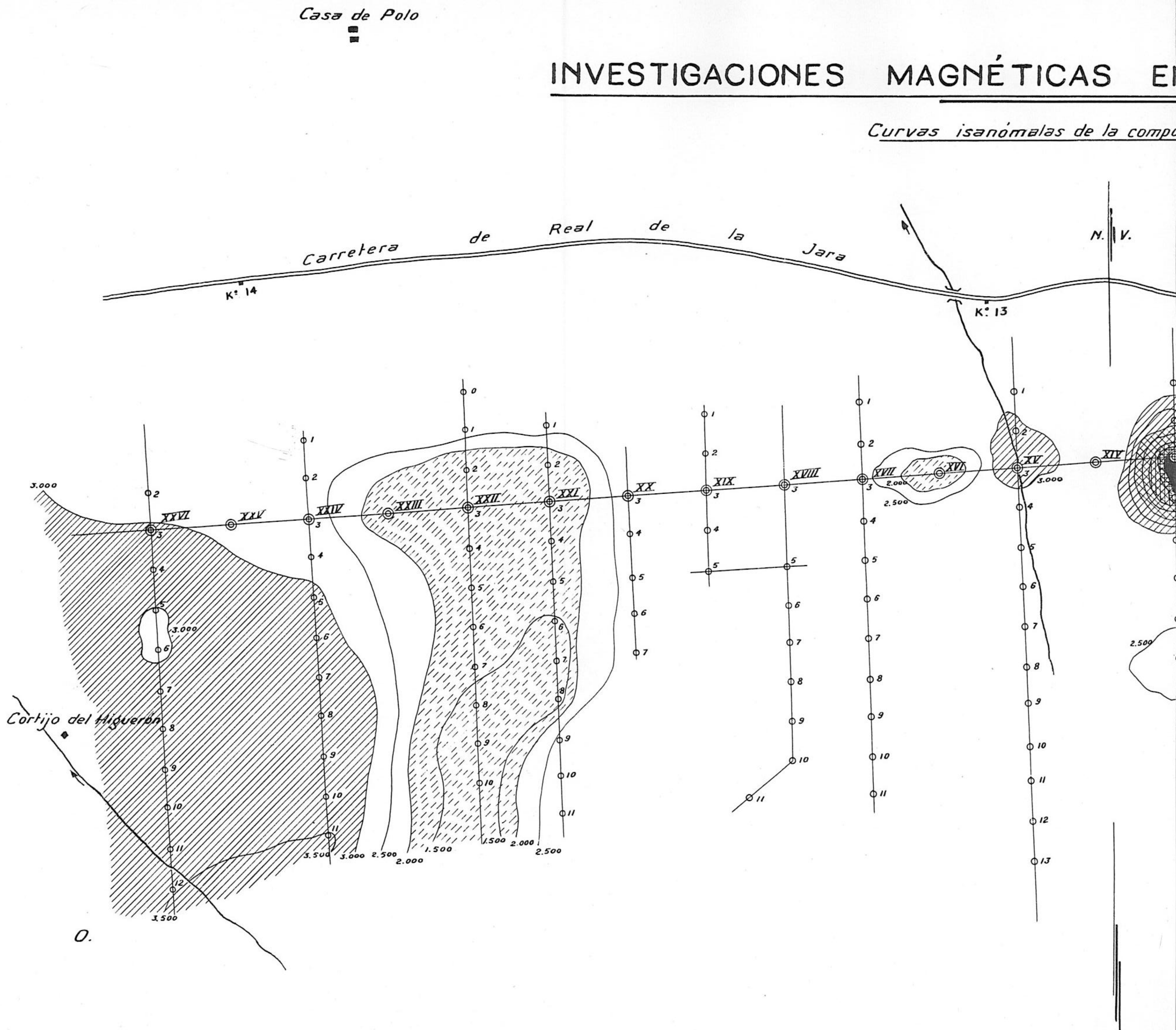
La zona mas importante, por la cantidad de magnetita que puede contener, es la comprendida entre los perfiles III y IX. Después, continua la del perfil XIII y por último, la determinada por los perfiles XXIV y XXVI. En la estación 11, del perfil III, se encuentra sólamente el afloramiento de un brazo o chimenea del yacimiento principal.

III. Conclusiones

Los resultados obtenidos en la investigación magnética, demuestran que en la mitad oriental de la concesión "Nueva Luz", próximamente entre los perfiles III y XV, existe un manto de magnetita, casi contínuo, que aflo ra en tres puntos (3 del perfil XIII; 7 del V y 11 del III) y que en los demás alcanza profundidades variables.

INVESTIGACIONES MAGNÉTICAS EN

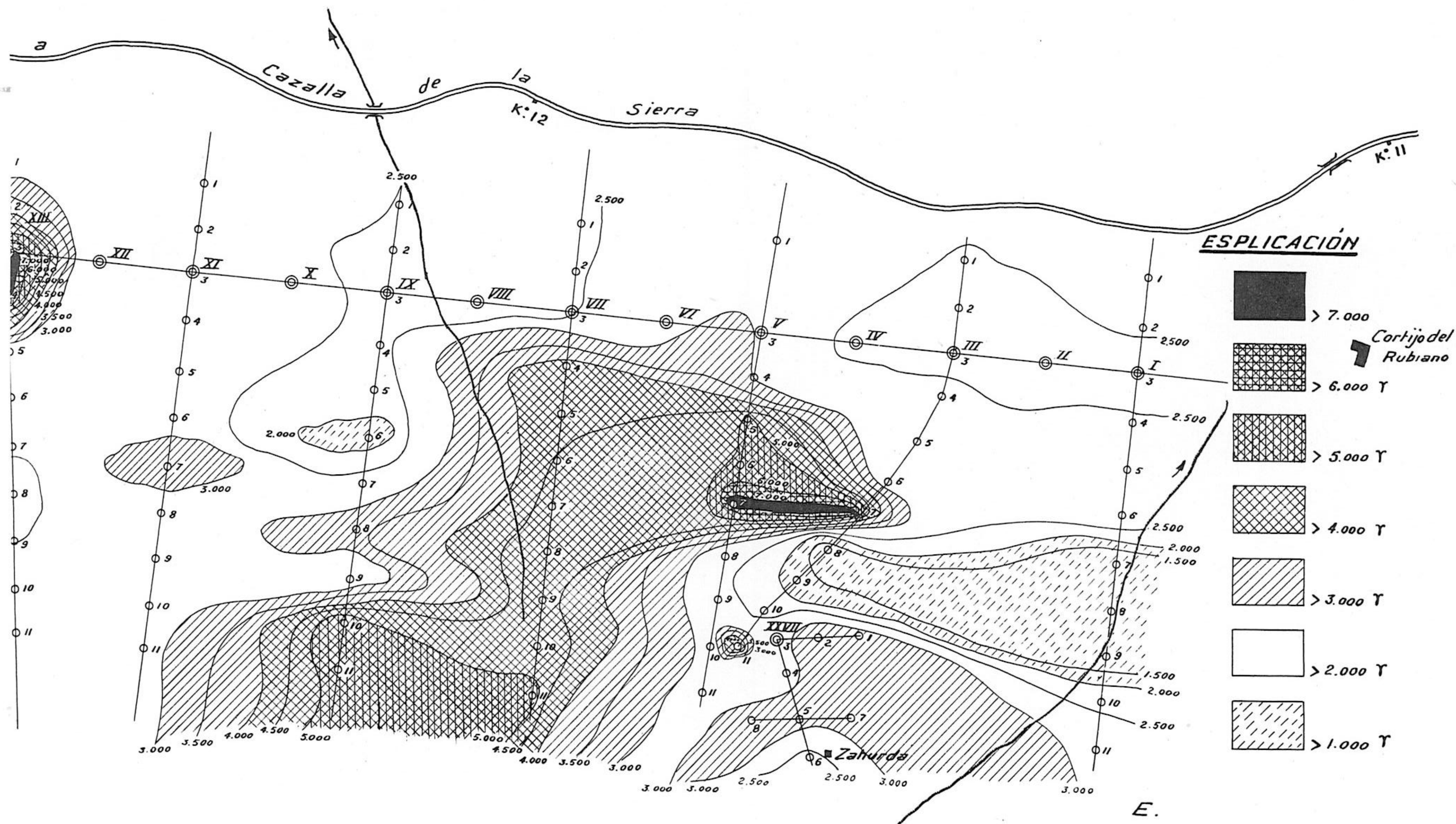
Curvas isanómalas de la compo

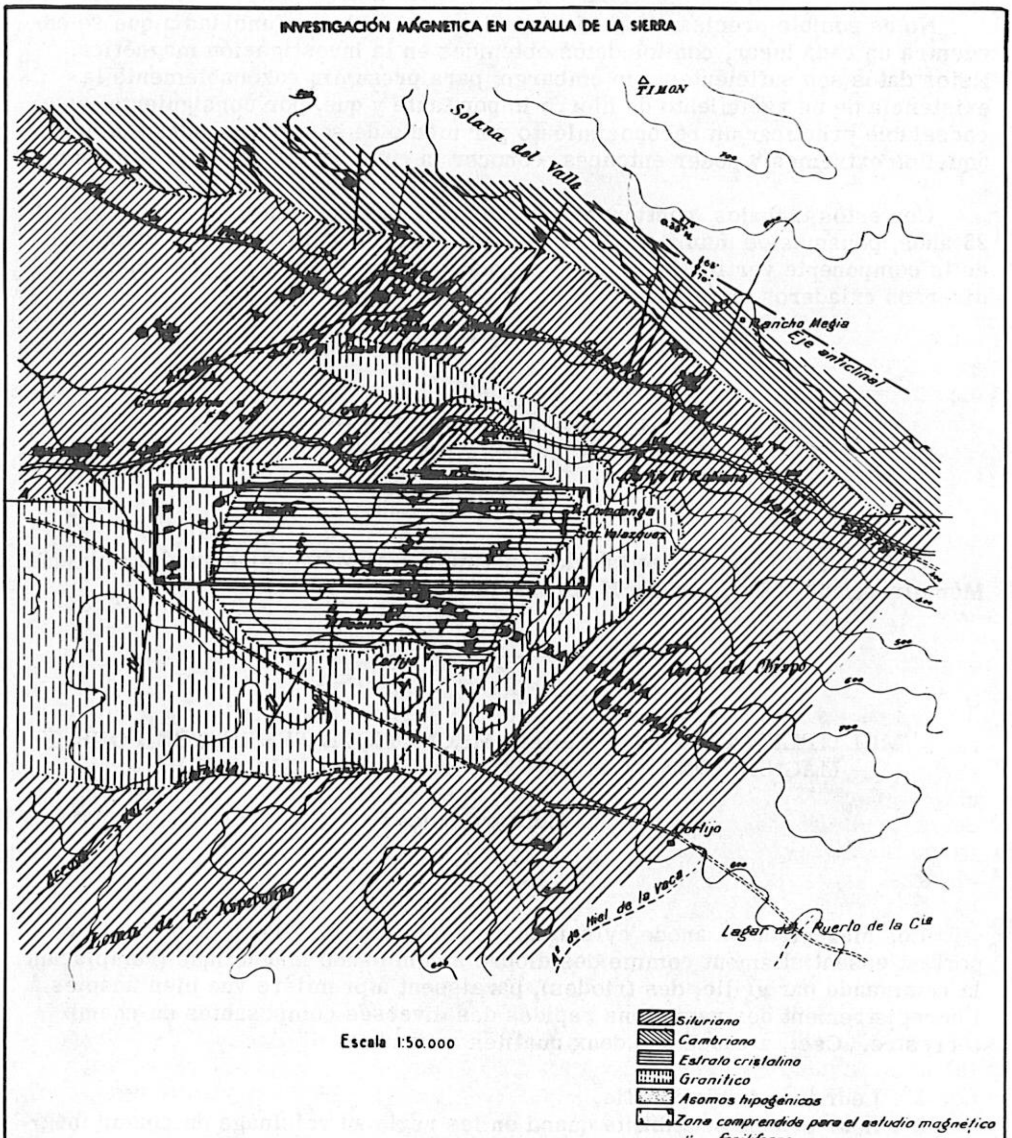


Y CAZALLA DE LA SIERRA

nente vertical

Escala de 1: 5.000




INVESTIGACIÓN MÁGNETICA EN CAZALLA DE LA SIERRA
TIMON
Solana del Valle
Rancho Megia
Eje anticlinal
Cortijo
Corta del Chispo
Lagar del Puerto de la Cia
Escala 1:50.000
Siluriano
Cambriano
Estrato cristalino
Granitico
Asomos hipogénicos
Zona comprendida para el estudio magnético
Fosiliferas

No se puede sentar la misma afirmación respecto de la mitad occidental, puesto que puede suceder que el efecto magnético esté producido por las rocas cuarzosas que contienen magnetita, cuyos afloramientos se encuentran en esa región, aunque tambien puede ser debido a la misma cáusa que en la zona Oriental.

No es posible precisar la potencia del manto, ni la profundidad a que se encuentra en cada lugar, con los datos obtenidos en la investigación magnética. Estos datos son suficientes, sin embargo, para presumir razonablemente la existencia de un yacimiento de hierro impor tante y que, por consiguiente, es a consejable practicar un reconocimiento por medio de sondeos que determinen aquellos extremos y poder entonces, conocer la cubicación del mineral existente.

Con estos trabajos, continuación de los que estamos realizando hace mas de 25 años, ponemos de manifiesto una vez mas, la gran utilidad de las anomalias de la componente vertical del campo magnético terrestre para el estudio de diversos criaderos minerales.

SUR LA RÉALISATION D'APPAREILS DE MESURES MAGNÉTIQUES ABSOLUES

Par J. Bertrand et E. Lahaye

The complete text is published in Institut Royal Météorologique de Belgique Mémoires, vol. XXXI, Annexe II, Brussels (1949).

"MULTIPLICATEUR" DE CHAMP MAGNÉTIQUE TERRESTRE POUR MAGNÉTRONS ET MAGNÉTOPHONES ENREGISTREURS

Par Edouard Selzer

Résumé

Les magnétrons à anode cylindrique non fendue, type de Hull, qui se comportent essentiellement comme des diodes à commande magnétique (remplaçant la commande par grille, des triodes), paraissent à première vue bien adaptés à l'enregistrement des variations rapides des diverses composantes du champ terrestre. Ceci, à cause des deux qualités suivantes:

1°. Leur très faible inertie.
2°. Leur grande sensibilité quand on les règle au voisinage du champ magnétique de coupure H_c.

Rappelons que ce champ a sa valeur déterminée par le rayon a de l'anode (le rayon de la cathode étant supposé négligeable), et la différence de potentiel V entre la cathode et l'anode, en accord avec la formule de Hull:

$$H_c = \frac{6.72}{2} \cdot \sqrt{V} \qquad (1)$$

valable en exprimant les champs magnétiques en gauss, les rayons en centimètres, et les différences de potentiel en volts.

Cependant, les essais qui ont été faits par divers expérimentateurs depuis une vingtaine d'années, n'ont pas donné les résultats que l'on en escomptait, en partie à cause de certaines instabilités accompagnant la grande sensibilité des magnétrons, mais aussi parce que la nécessité de placer le magnétron dans un champ magnétique de l'ordre de grandeur du champ de coupure, toujours très supérieur au champ terrestre (même en opérant avec des magnétrons de grand diamètre et sous des différences de potentiel faibles), augmentait la sensibilité relative nécessaire pour atteindre une sensibilité absolue donnée sur les variations du champ terrestre à enregistrer.

Pour pallier à cette deuxième difficulté, d'ailleurs liée étroitement à la première, nous avons décidé de supprimer tout champ auxiliaire, en essayant d'atteindre la valeur du champ de coupure, par la seule action du champ terrestre convenablement multiplié. Remarquons à ce sujet, qu'un tube qui sous 100 volts (valeur que pour diverses raisons on ne peut trop abaisser) pourrait fonctionner dans le champ terrestre seul, sans effet multiplicateur, devrait avoir un diamètre de l'ordre de 2 m 50, et sa construction, bien que paraissant possible, devrait mettre en jeu des moyens puissants. Nous nous sommes donc proposés de réaliser un "multiplicateur" de champ terrestre, permettant de faire fonctionner des tubes de dimensions plus courantes.

On remarquera que, contrairement aux divers dispositifs de concentration de flux magnétique terrestre, réalisés à maintes reprises précédemment, notre "multiplicateur" n'aura de raison d'être, que si dans chaque cas il permet d'obtenir un champ utilisable, supérieur (ou au moins égal) à une valeur minimum bien déterminée. Cette condition impérative nous a obligés de serrer sa réalisation de très près.

Ce "multiplicateur", étudié principalement par M. Louis Néel, Directeur de l'Institut d'Electro-statique et de Physique du Métal de la Faculté des Sciences de Grenoble, sera fait de deux moitiés identiques, limitant entre elles l'entrefer e dans lequel sera placé le magnétron enregistreur. Chacune de ces deux moitiés comporte un grand disque de tôle perméable, disposé perpendiculairement à la composante du champ que l'on veut enregistrer, et relié par un faisceau de tiges de Mumétal-Molybdène, à un disque plus petit limitant un des côtés de l'entrefer, la distance L entre ces deux disques étant grande par rapport à cet entrefer e.

Une théorie approchée de cet ensemble peut être faite par la méthode électrostatique, en le supposant constitue par un métal parfaitement conducteur, qui serait plongé dans un champ électrique uniforme. Le résultat peut en être résumé par la formule suivante donnant la valeur prévue pour le coefficient de multiplication de l'appareil

$$\frac{H'}{H} = A \cdot \frac{L}{e} \qquad (2)$$

dans laquelle H représente la valeur de la composante du champ terrestre que l'on veut utiliser, H' la valeur du champ multiplié utilisable dans l'entrefer, et A un "coefficient de qualité" compris entre 0 et 2, qui dépend surtout des dimensions latérales des plateaux, et aussi de la qualité des alliages perméables employés. Pour notre appareil, avec les dimensions indiquées plus loin, nous prévoyons une valeur pour ce coefficient de l'ordre de 1,4.

En comparant la formule 2 à la formule 1, et en remarquant pour cette dernière, que pour divers magnétrons homothétiques, des variations de leur rayon a, entraîneront des variations à peu près proportionnelles de l'entrefer e nécessaire pour les loger, on constate le résultat important, que la taille du magnétron choisi n'a théoriquement pas d'influence sur la longueur totale (environ 2L) à donner au Multiplicateur. Ceci entraîne comme contre-partie, qu'il ne faut pas espérer pouvoir, en agissant sur cette taille, rendre plus aisée la résolution du problème expérimental tel que nous l'avons posé.

En définitive, les dimensions choisies pour le Multiplicateur sont les suivantes: une distance L de 2 mètres, des diamètres de 1.08 m pour les grands plateaux, un entrefer e d'environ 8 cm, limité par des petits plateaux de diamètre 18 cm.

Quand au magnétron, nous avons choisi une anode cylindrique de 12 cm de diamètre, aussi plate que possible, soit de 4 cm de longueur, (une réduction plus poussée du rapport longueur sur diamètre nuirait aux qualités techniques du magnétron), ce qui lui permettra de se placer dans l'entrefer de 8 cm.

Un tel ensemble, disposé par exemple parallèlement à une composante du champ terrestre de l'ordre de 0.4 gauss (valeur un peu inférieure à celle de la composante verticale à notre Observatoire de Chambon-la-Forêt), devrait pouvoir donner un champ H' de l'ordre de 13 gauss, suffisant pour assurer le fonctionnement du magnétron sous une différence de potentiel Cathode-Anode pouvant monter jusqu'à environ 120 v, ce qui serait très suffisant.

En terminant ce bref résumé, signalons simplement que nous avons pensé, que le fait de disposer dans l'entrefer du Multiplicateur d'un champ terrestre amplifié, pouvait être mis aussi à profit en utilisant d'autres détecteurs que les magnétrons. Par exemple, on pourrait "imprimer" magnétiquement les valeurs instantanées de ce champ, sur les rubans ou fils d'appareils enregistreurs magnétiques de sons, tels que les "magnétophones". Des calculs préliminaires nous ont montré que les ordres de grandeur requis, permettaient de considérer ces nouvelles possibilités comme non déraisonnables, et nous comptons faire des essais dans ce sens.

Ces diverses méthodes, avec ou sans magnétrons, seraient particulièrement bien adaptées à l'étude des oscillations rapides du champ terrestre, et permettraient même, peut être, de rejoindre le domaine des enregistrements électromagnétiques. Des Multiplicateurs de plus grande envergure que celui dont nous avons donné les dimensions cidessus, seraient alors très probablement nécessaires.

DISCUSSION:

Prof. A. Dauviller suggested that the difficulty of using potentials less than 100 volts in magnetrons could be overcome by using several grids between the anode and cathode.

Dr. Selzer replied that he had in fact used a single-grid magnetron, but that the difficulty lay in the making of a grid that would preserve the geometrical symmetry of the magnetron.

INDUCTION MAGNETOGRAPH FOR RECORDING SUDDEN CHANGES OF TERRESTRIAL MAGNETIC FIELD

By Hantaro Nagaoka and Tsuneto Ikebe

The complete text is published in the Scientific Papers of the Institute of Physical and Chemical Research (Tokyo), vol. 36, No. 915, pp. 183-197 (1939).

A NEW METHOD OF MEASURING THE INTENSITY OF THE EARTH'S MAGNETIC FIELD

By Y. Kato and S. Utashiro

[By title only]

COMPARISON OF INDUCTION MAGNETOGRAPH WITH INDUCTION LOOP AT KAKIOKA MAGNETIC OBSERVATORY

By Hantaro Nagaoka, Tsunato Ikebe, and Syuiti Imamiti

The complete text is published in the Proceedings of the Imperial Academy, Tokyo, vol. XV, pp. 217-219.

SECULAR CHANGES OF TERRESTRIAL MAGNETIC FIELD AT HELWAN, EGYPT, 1908-1944

By M. R. Madwar

Declination: The declination at Helwan has increased continuously during 1908-1944 with a gradient varying from 2'.7 in 1939 and 1943 to 9'.3 in 1916. The curve in Figure 1A, although it shows two remarkable inflections, decreases almost continuously. Figure 1B gives smoothed values [smoothed on basis of Maurain's method of three-year averages].

Inclination: The variations of "I", Figure 2A, show more irregularities than that of "D". "I" has been increasing all the time during 1908-1944 with a gradient varying from 0'.1 in 1910 to 6'.0 in 1936. The smoothed curve [smoothed on basis of Maurain's method of three-year averages], Figure 2B, looks roughly sinusoidal presenting three minima and three maxima.

Horizontal component: "H" has shown some irregularities between 1908 and 1921. Since then it has always increased with a gradient varying from 6γ in 1924 to 52γ in 1931. The curve, Figure 3A, and the smoothed curve [smoothed on basis of Maurain's method of three-year averages], Figure 3B, show an increase from 1917 to 1943.

Solar activities in relation with magnetic secular variations: The secular variations of "D" for the epochs of the maximum activities (1917, 1928, 1938)

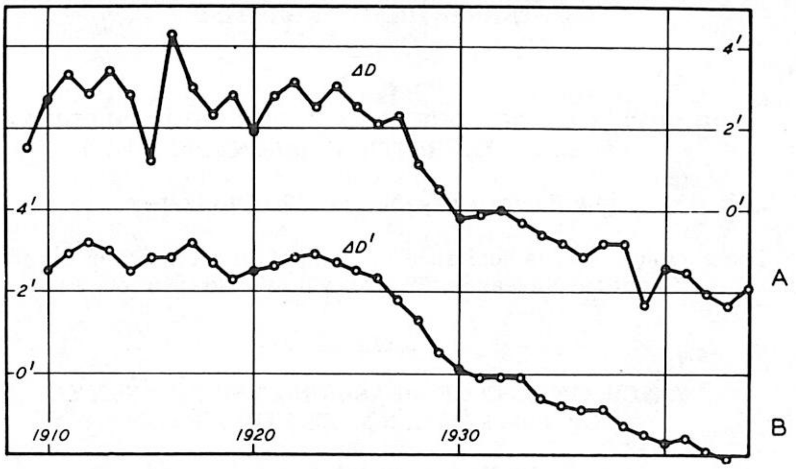


Fig. 1--Secular change of the declination at Helwan

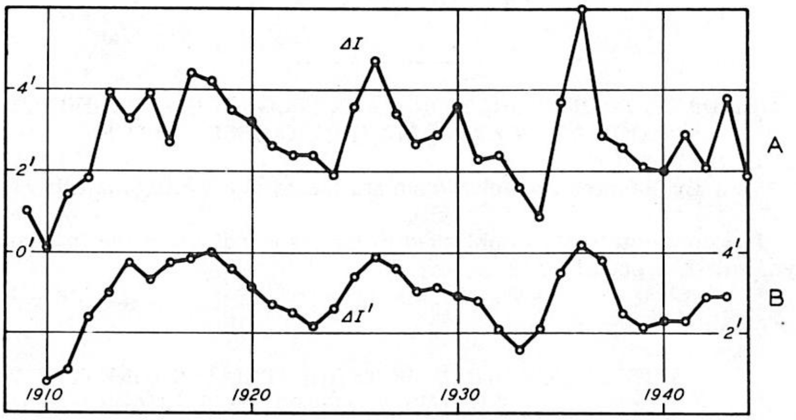


Fig. 2--Secular change of the inclination at Helwan

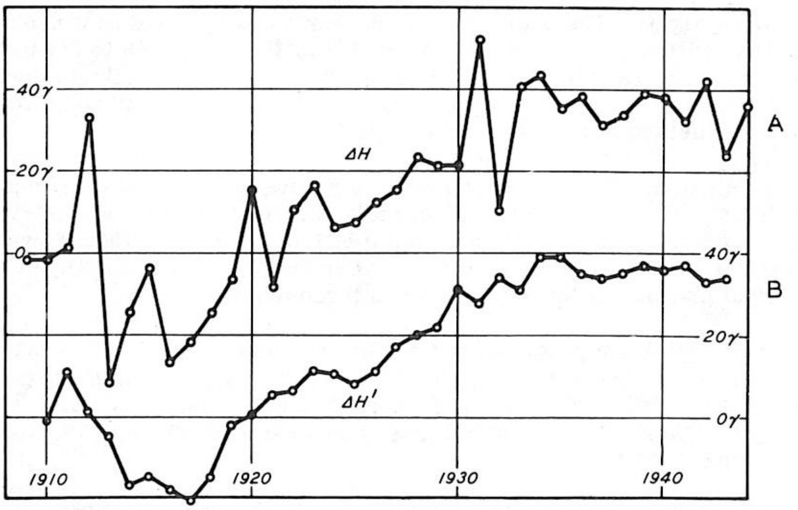


Fig. 3--Secular change of the horizontal force at Helwan

are, respectively, 8ʹ.0, 6ʹ.1, 4ʹ.2 (mean = 6ʹ.1), while for the minimum solar activities (1912, 1923, 1933, 1944) are 7ʹ.8, 7ʹ.5, 4ʹ.7, 3ʹ.1 (mean = 5ʹ.6). For "I" the mean ΔI for the epochs of maximum is 3ʹ.2, and 1ʹ.9 for the minimum, while for "ΔH" it is $+12\gamma$ for the maximum and $+41\gamma$ for the minimum epochs.

TECHNIQUES AND RESULTS OF AEROMAGNETIC SURVEYING

By J. R. Balsley, Jr.*

Other published articles discuss the instrumentation and method of use of the airborne magnetometer, but little has been written of the experience and results of the actual operations. Having completed more than 300,000 traverse miles of aeromagnetic surveys, the U. S. Geological Survey is now in a position to evaluate the usefulness, applicability and economy of the airborne magnetometer as an instrument for geophysical prospecting.

The results of an aeromagnetic survey are compiled into a magnetic contour map or a series of magnetic profiles of the same type as those obtained by ground methods. The interpretation of these maps and profiles involves the same fundamental theories that for years have been applied to the results of ground surveys. Although geophysical ground magnetic surveys usually measure variations in either the vertical or horizontal components of the earth's magnetic field, aeromagnetic surveys measure variations of the total field. However, assuming both the aerial and ground maps to be accurate, there is theoretically no difference in their usefulness. This ideal, however, is at present impossible to fulfill. Therefore, between the two types of survey there exists a difference in usefulness depending upon their relative ability to approach the ideal.

In actual practice the two methods do not compete but complement each other. The usefulness of either method is dependent not only upon cost but upon quality of results. Therefore, let us consider the factors which affect the accuracy of the final results obtained by each method. This overall accuracy or ability to make and duplicate a true magnetic map is dependent upon both the precision of magnetic measurement and the accuracy of position measurement. Thus, the factors affecting both must be considered in making a comparison of the results of the two methods.

The precision of a magnetic measurement is dependent not only upon the accuracy and sensitivity of the instrument used but also upon the accuracy of the corrections for instrument drift and diurnal variation. In magnetic prospecting measurements are relative to one station. Because both drift and diurnal corrections are chiefly a function of time, the precision of the final measurement is to a considerable extent dependent upon elapsed time between measurements at the desired point and at a base station.

The sensitivity and accuracy of the best airborne and ground magnetometers are comparable; neglecting for the moment the time factor, both can generally duplicate measurements to within two gammas. The airborne magnetometer, however, is constantly recording. It not only reduces the elapsed time between

---

* Published by permission of the Director, U. S. Geological Survey.

measurements to the time required to fly between the points but also supplies a continuous magnetic profile between them. The corrections to be applied are therefore generally much smaller, and, instead of being applied independently at each station, they can be applied to a complete profile. By choosing a length of profile short enough to fall within a straight line segment of the combined curves of instrument drift and diurnal variation it is certain that all the features shown on the profile are real and not due to incorrect reading or faulty correction. Because of the speed of flight, the length of this profile, though short in time, is long in distance.

The speed of flight which improves the precision by reducing the correction for instrument drift and diurnal variation nevertheless introduces an error due to the time characteristics of the magnetometer. The major time delay is in the recording system and is therefore highest when the movement of the recording pen is large. However, this delay does not exceed one tenth of a second and introduces a significant error only in low altitude flights in areas of steep magnetic gradients. The airborne magnetometer can generally give a more precise measurement of the difference in magnetic intensity between widely spaced points than the surface magnetometer, but, as previously stated, the overall accuracy of the final result also depends upon the accuracy of position.

Ideally, the accuracy of position of a ground survey can be very high; the position in three dimensions of one station with respect to another can be determined with the accuracy of the surveying methods employed, from the accuracy of the precision transit and level to that of pace and compass and pocket aneroid. The accuracy of position of an aerial survey, however, is restricted by several factors, chief of which is the accuracy of the map of the area flown. Under favorable conditions it is possible to determine the plumb point of the plane on a good aerial photograph within 30 feet. If the base map is good, it is possible by photogrammetric methods to locate the plumb point on it to the same accuracy, but this involves considerable labor and only rarely is the base map of sufficient quality to warrant it. In practice the points are generally transferred by matching or by trisection from the locations appearing on the photograph to the corresponding locations on the base map, and are in error from fifty to several hundred feet, depending upon the quality of the photographs and the scale and local accuracy of the base map.

The elevation of the plane is determined by a barometric altimeter, or better by a radio altimeter, which measures height above ground. The latter provides a measurement accurate to within five per cent, but the absolute elevation is of course dependent upon the quality of the base map.

The accuracy of position in three dimensions of an aeromagnetic map is generally restricted by the local accuracy of the base map of the area flown, and only in rare cases is it within fifty feet. Not only does this error affect the overall accuracy of the map in the same way that similar errors affect a ground survey map, but the particular method of base control used in aeromagnetic maps may also introduce an error into the magnetic measurement. To investigate this error let us consider the survey system employed in aerial work.

Ideally, an aeromagnetic survey consists of a series of parallel traverses, coordinated by a series of base lines at right angles to them. The base lines are flown first in one direction and then immediately in the other, so that any diurnal variation or instrument drift is shown by a slight divergence between the two curves. One half of this divergence is applied to either curve to give a correct base line. Thus, knowing the point at which any traverse crosses a base line, it is possible to assign a corrected magnetic value to that point on the traverse. Essentially the plane returns to the base station every time it crosses a base line. In view of the short span of time required for returning to the base lines, it is correct to assume that the rates of diurnal variation and instrument drift are linear during the time required to fly between the base lines.

It is quite important that an accurate location, in three dimensions, be obtained for the intersection of the traverse and base line, for an error will raise or lower the magnetic value of a whole profile. To reduce this effect to a minimum an attempt is made to fly the base lines along roads, rivers, or other well mapped and easily recognizable lineated physical features which are located in areas where the magnetic gradient is flat. This practically eliminates the magnetic error introduced by horizontal position error; and because such areas have low vertical gradients, it also reduces the magnetic error introduced by a vertical position error. On the other hand if a base line is flown along the side of a magnetic "hill", a slight horizontal position error will materially affect the magnetic results; and if the position error is systematic, the flying of adjacent traverses in opposite directions will alternately raise and lower the magnetic value of the profiles.

As would be expected, it is frequently impossible to establish a satisfactory base line near the ends of the traverses. In this case, the best base line that can be chosen is flown and the intersections with the traverses determined. A plot against time is made of the difference between the magnetic value on the traverse and the magnetic value on the base line. Obviously, if the positions of the intersections were accurate, this plot would be the curve obtained by combining the instrumental drift and the diurnal variation. Originally the drift rate of the airborne magnetometer was high and irregular, but it has now been improved to an essentially linear rate of a few gammas per hour. Hence, the deviation of the plotted points from a simple curve is due either to errors of location, to an irregular diurnal variation, or to both. Depending upon the report of magnetic conditions and upon the quality of the position information, a curve is drawn through the plotted points and is used to determine the corrected magnetic value of the profiles.

It is apparent that the first system which assigns the magnetic value of the controlled base line to the traverse lines at their points of intersection disregards slight positional errors and assumes that no magnetic error is introduced thereby. The latter system, however, recognizes the magnetic errors which may be introduced by slight positional inaccuracies, uses all the positional and magnetic data obtained by each traverse line crossing the base line, and determines drift from the total of these points rather than from one or two points on each traverse line.

The combination of the aforementioned results produces an aeromagnetic map which is generally subject to errors in position of 50 feet, and where base maps are inaccurate, of several hundred feet. The profiles from which the map is made are continuous and highly accurate records of variations of magnetic intensity along the actual lines of flight. However, the small systematic errors previously discussed may exist between adjacent profiles, introducing a "herringbone" or "chevron" effect in the contours. This effect does not usually appear in surface work where similar errors tend to be random.

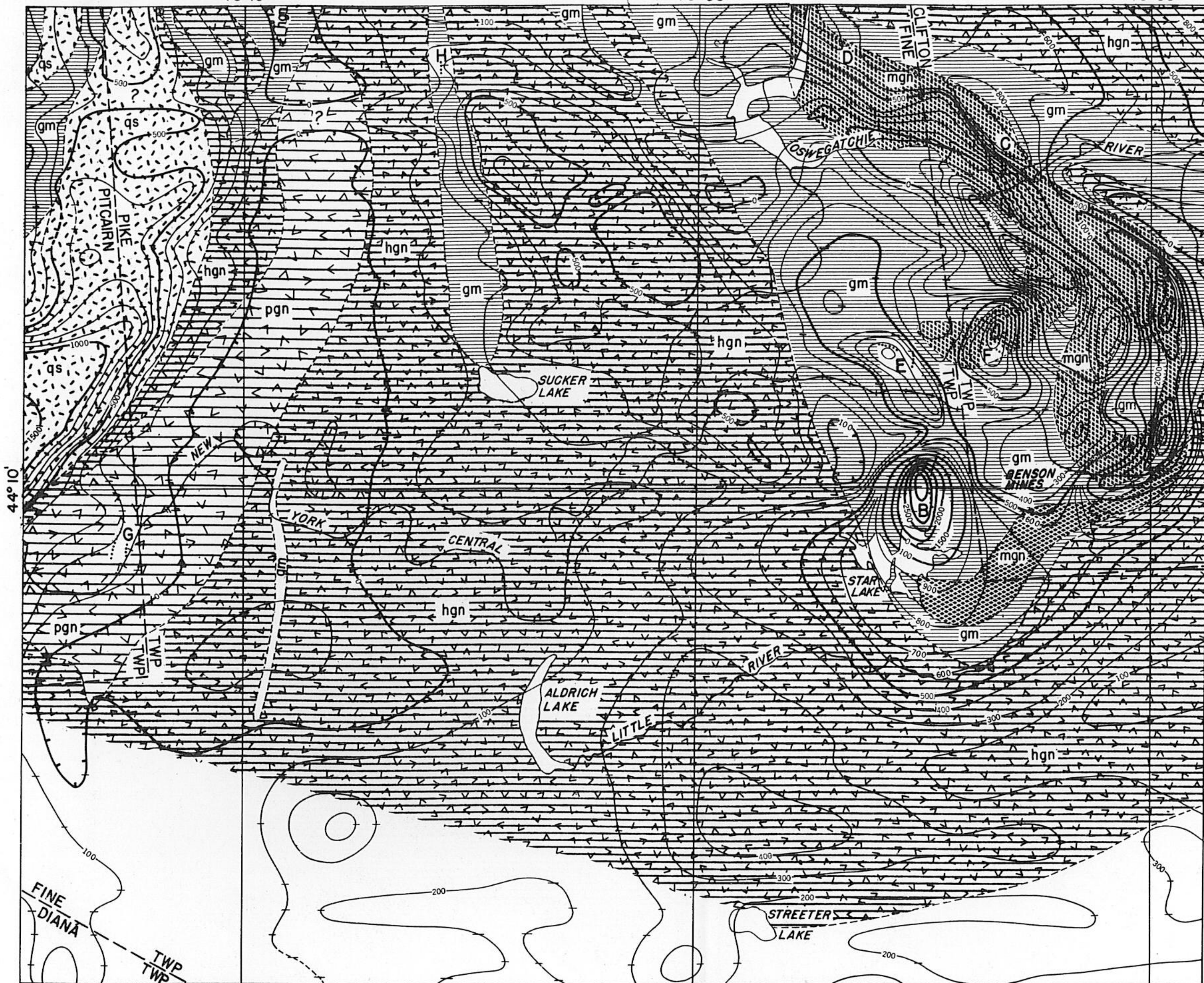
The resulting aeromagnetic map is a map on a surface described by the flight level of the plane. The shape of this surface is generally smoother than the ground surface but frequently contains wrinkles due to the difficulty of maintaining level flight. The map is basically a reconnaissance map but one which is more reliable and much more complete than the usual surface reconnaissance map.

What then is the usefulness of the airborne magnetometer, where can it be used satisfactorily, what are its limitations, and what do aeromagnetic surveys cost? These are the questions most frequently asked.

The most satisfactory use of the airborne magnetometer is as a high-speed, low-cost reconnaissance instrument which localizes areas for more detailed work by slower and more expensive geological or geophysical methods. The airborne magnetometer has been used in this way over the swamp-covered arctic slope in Alaska to guide gravimetric and seismic surveys in the search for oil. It has been used in the wooded mountainous area of the Adirondack Mountains of New York to locate magnetite deposit anomalies for more detailed surface magnetic work. It has been used in the drift-covered Lake Superior area to provide a framework that will enable the geologist to trace formations underground in spite of sparse outcrops. These are only a few examples, yet they are indicative of the wide range of application. The aeromagnetic map of part of the Oswegatchie Quadrangle (Fig. 1), an early survey, is typical and represents the results of about five hours of field work. It shows the relationship between the surface and areal magnetic features and between the geologic structure and the major magnetic trends. In the northwest corner it also shows an area where an error has probably been introduced in the magnetic values due to inaccurate location.

The usefulness of the magnetometer depends, however, upon the results desired and the possibility of attaining them. Obviously it cannot be used in a small detailed survey where accuracies of location within a few feet are required. Likewise, it generally cannot be used where the diagnostic magnetic features are small, complex, or of near-surface origin, for the shallow or small anomalies attenuate even at low altitudes and merge to the extent that they lose their diagnostic character. These disadvantages may be partly overcome by the use of a helicopter which permits somewhat better location and much lower flight generally at a sacrifice of range and at increased cost. Because the U. S. Geological Survey can operate only one aircraft and because it is our belief that any aerial survey should be followed by detailed surface work, we have elected to sacrifice the increased precision and lower flight level for greater range and less cost. In this regard, a choice exists depending upon the particular requirements of the work to be done. However, aeromagnetic surveys are actually superior to ground magnetic surveys where the purpose is to determine the characteristic of the basement. At a height of 1000 feet, the extraneous surface magnetic effects disappear. These are the effects due to surficial magnetic ferruginous concretions, and artificial objects such as pipe lines, bridges and railroads.

The airborne magnetometer has limited usefulness in high and mountainous areas where flight in any type of aircraft is difficult. Two alternatives are presented; one, high flights at a fairly constant barometric elevation that clears most obstacles; or, two, lower flights which attempt within the capabilities of the aircraft to maintain a constant elevation above ground. In the first case, a reasonably accurate map can be made, but frequently at such an elevation that the diagnostic anomalies are too attenuated to be useful. In the second case, the map may be inaccurate because of the necessary violent maneuvers of the plane which increase the position error and thereby introduce the magnetic errors previously discussed.



Aeromagnetic survey by J. R. Balsley, D. L. Rossman, and C. L. Rogers, U. S. Geological Survey, and E. M. Canfield, Aero Service Corporation.

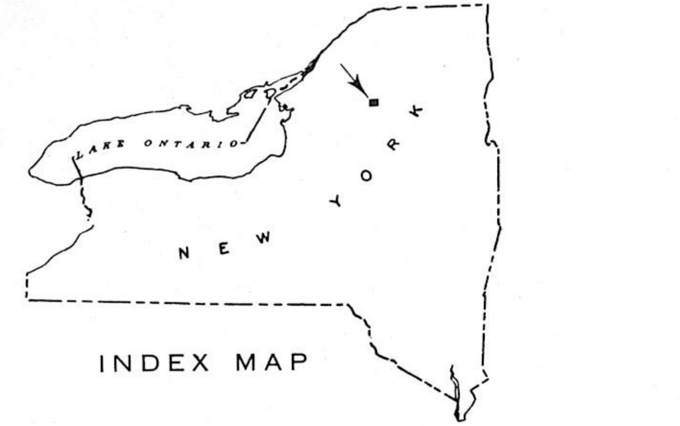
FIGURE 1

Magnetic data compiled by H. E. Hawkes, W. J. Dempsey, M. E. Hill, and J. L. Meuschke, 1945.
Preliminary geology by A. F. Buddington and B. F. Leonard, 1945.

TOTAL INTENSITY AEROMAGNETIC MAP OF PART OF OSWEGACHIE QUADRANGLE, ST. LAWRENCE COUNTY, NEW YORK

1946

1 ½ 0 1 2 3 4 MILES



INDEX MAP

EXPLANATION

MAGNETIC FEATURES

Total intensity isogams showing intersections with traverse lines
(Isogam interval 100 gammas below 1000 and 500 gammas above 1000)

Depression isogam

GEOLOGY

PRE-CAMBRIAN

mgn — Microcline granite gneiss
(Fine grained, generally sillimanitic)

hgn — Hornblende granite gneiss
(Medium grained, with local alaskitic facies)

Quartz syenite series

pgn — Hornblende granite gneiss
(Coarse grained; much of it with phacoidal structure)

qs — Quartz syenite

gm — Metasediments of the Grenville series

B — Magnetite deposit
(Approximately located. Letter indicates locality referred to in text)

Approximate contacts

EXPLANATORY TEXT

In May and June of 1945 the Geological Survey carried out a magnetic reconnaissance survey of an area of approximatøley 3,170 square miles in the Adirondacks of northern New York, using an airborne magnetometer developed by the Navy for anti-submarine patrol. Details of equipment and technique are covered in a separate report by J. R. Balsley. Details of results of dip-needle surveys of anomalies recorded by the Adirondack aerial survey are described in Geological Survey Strategic Minerals Investigations, Preliminary Report (3-194).

The adjoining magnetic map of the Oswegatchie quadrangle is the first of a series of preliminary maps showing the results of the Adirondack aeromagnetic survey. Other maps in the series will be released as fast as the data can be compiled. It is anticipated that these preliminary maps will eventually be included in a final report which will treat problems of geologic interpretation and magnetic theory in more detail.

The Oswegatchie magnetic survey was flown at a constant altitude of 2,400 feet (1,000 feet above ground) on east-west traverse lines. Lines were spaced at quarter-mile intervals over the northern half of the area, and at half-mile intervals over most of the southern half of the area. Field work was done during the morning of June 27, 1945. The location of flight lines where they intersect isogams is shown on the map by short cross lines. A correction of 200 feet for instrumental lag has been applied to all profile curves except over the Benson Mines anomaly, where the intensity of the magnetic gradient has apparently reduced the lag effect to a negligible value. Variations arising from diurnal effects and instrumental drift have been essentially eliminated by adjusting all profile curves to a common magnetic datum established by a magnetic base-line traverse which intersected all the profile traverses. The datum, or zero-anomaly, isogam was selected arbitrarily by inspection. No correction has been made for latitude variations in magnetic intensity.

It is estimated that in general the isogams are correctly placed to within 200 feet. Errors—for the most part negligible—may have crept in due to inaccurate location on the base map of the curves recorded in the air, to inaccuracies in determining the magnetic datum, and to inability to hold the airplane at a constant altitude. Two localities are indicated in the northwest corner of the map by question marks, where inaccurate magnetic datum determinations may have given the profile curves excessively high or low values, probably not greater than 100 gammas.

Two conspicuous features of the magnetic map are (1) the close correlation of high-intensity anomalies and strong magnetic gradients with most of the strong anomalies on the surface, and (2) the correlation of broad magnetic trends with regional geological features. The Benson Mines ("A" on map), Twin Lakes (B), Benson Mines Extension (C), Skate Creek (D), Twin Lakes Stream (E), and Anderson (F) anomalies all appear as conspicuous features of the aeromagnetic map. The Jayville (G) and Greene Farm (H) anomalies, however, gave a much weaker indication on the airborne magnetic record. The negative anomaly west and northwest of the Benson Mines anomaly is probably the effect of the negative magnetic pole of the Benson Mines body. Quartz-syenite, and metasediments of the Grenville series, with associated migmatites and sillimanitic granite, coincide with areas of moderately high intensity; uncontaminated granite, on the other hand, gives very little magnetic relief.

Before undertaking a survey in such a mountainous area it is usually possible to determine from the attenuation rate of the expected anomalies and from the flying characteristics of the plane a rough measure of the accuracy and magnetic detail of the final map, and thereby to decide upon the value of the work. It has been our experience that reasonably accurate surveys approximately 1000 feet above ground can be made in areas where the relief does not exceed 3000 or 4000 feet, if the anomalies are not too complex. We have found, however, that such a survey is not worthwhile if made at an elevation near the service ceiling of the plane because at this level the operation of the plane becomes very difficult. With our heavily loaded small twin-engine plane this ceiling is about 10,000 feet above sea level.

Obviously the most productive projects for the airborne magnetometer are those in relatively flat areas which are difficult to traverse on foot, but it must be remembered that for accuracy of position there must be a sufficient number of photographically identifiable points. In other words, a featureless plain or an area with a homogeneous forest cover could not be accurately surveyed. In areas of this type there is generally some distinctive vegetation pattern which can be used for identification.

Various radio and radar location systems have been used to conduct aeromagnetic surveys over water, but generally their cost is high and their range low. It is of course possible to obtain valuable information by the use of the usual dead reckoning methods, but obviously such methods are useless for detailed surveys.

The cost of an airborne survey can be analyzed best by considering the rate at which it can be accomplished, because the cost of the equipment and fuel, the salaries of the personnel, and the efficiency of operation may all vary.

The flight work requires a plane, preferably twin-engined, capable of carrying three or four persons, and the magnetometer equipment which in our work weighs 400 pounds. For efficient operation it is best to have a plane with at least six hours range so that a minimum of flight time is lost in transportation between the airport and the survey area.

The pilot should have considerable experience, in photo mapping and low-level flight work such as crop dusting, and should be able to interpret photographs rapidly. He is usually assisted by a copilot. The magnetometer operator should be completely familiar with the equipment and able to make minor repairs in flight. He should be also an experienced geophysicist who can make changes in flight pattern indicated by the measurements. An observer is usually carried to take the check points needed for coordinating the records obtained. This four-man flight crew averages about 90 hours of survey flying a month. Depending upon the length of flight lines, difficulty of terrain, and distance to the airport, it produces 6000 to 9000 miles of useful traverse.

The speed of compilation of the aeromagnetic information into useful form depends upon the scale and quality of the maps, complexity of the anomalies, and upon the skill of the compilers, but varies between one and five traverse-miles per man-hour.

The cost and amortization of the equipment are factors which are highly variable and must be considered individually, but it should be remembered that both initial investment and overhead are high. Therefore, efficiency can be obtained only by large scale operations.

In summation it may be stated that for large areas the airborne magnetometer used intelligently provides a low-cost and reasonably accurate magnetic map which can be used to delineate localities for more expensive and detailed ground work, both geological and geophysical. It does not eliminate the need for ground magnetic surveys, but rather relieves the load of reconnaissance work and enables the ground magnetometer to be used more productively on detailed work. Perhaps the best proof of its usefulness is the fact that the U. S. Geological Survey has operated airborne magnetometers for more than four years and is now planning an installation in a larger plane to permit its use in higher and more distant areas.

AIRBORNE EQUIPMENT FOR GEOPHYSICAL MEASUREMENTS

By L. H. Rumbaugh and L. R. Alldredge

The complete text appears in the Transactions of the American Geophysical Union, vol. 30, pp. 836-848 (1949).

DISCUSSION:

Dr. M. A. Tuve asked Dr. Rumbaugh how soon the equipment would be ready for chart making.

Dr. Rumbaugh replied that the apparatus was not yet ready for commercial use. Possibly next year (1949) it might be possible to have instruments for making charts of the total force and the year after it might be possible to make a complete set of charts in all three components.

Prof. S. Chapman in his summing up remarks said that it appeared that within about a year airborne surveys of the total intensity would be practicable and that a complete survey of all elements would be possible in a few years. This should help to settle the question of the external part of the non-potential field.

C. A. Jarman presented a "Report on British work on airborne magnetometers" as follows: The Ministry of Supply in August 1947, undertook, at the request of other Government Departments, the development of: (a) An airborne magnetometer for applied geophysical survey, and (b) Instrument equipment for the determination in the air of the elements of the geomagnetic field.

Due to the great pressure of work on Departmental Experimental Establishments, the Principal Director of Scientific Research (Air) ruled that this work should be carried out by Industry, and appropriate contracts were let.

It was considered advisable in the interests of economy to modify a war-time equipment to a Total Force Magnetic Variometer, particularly since reports of American work in the modification of AN/ASQ-3 were so conclusive regarding the advantages of so doing, and of the use of a Total Force Variometer in applied geophysical survey. Consequently two sets of AN/ASQ-1 equipment, in which the electronic engineering reaches a very high standard, were made available, and a Wellington aircraft was allotted for their air testing.

During the past year the necessary modifications have been made and the magnetometers air tested, an area of some 100 square miles between Reading and Newbury being surveyed during the course of the work. Repeatability of observations has been established and quantitative agreement with the results of the ground survey for the same area was obtained. One of the serious instrumental problems - that of instrument drift - has been successfully countered and after comparison of the variometer with the obsolete instruments at Abinger Magnetic Observatory, the instrument drift was established as not exceeding $\pm 3\gamma$ over 48 hours. The selected location of the magnetometer head in the aircraft was on a rearward boom extension to the fuselage, the position which after compensation gave negligible deviation.

Following the test work in the Reading area, a small survey was carried out at Leigh, near Manchester, over a coal mine being used for the experimental work in geomagnetism under the direction of Professor P. M. S. Blackett, which has been reported in another paper. Again correlation with surface survey was satisfactory and, further, experimental agreement with the theoretical reduction in geomagnetic field above the earth's surface was obtained.

Theoretical consideration has been given the serious problem of providing equipment for determining the magnetic elements in the air, and a small amount of laboratory work is in progress to test principles.

DISCUSSION ON THE ORIGIN OF THE EARTH'S MAGNETIC FIELD

In the absence of Professor Blackett, the discussion was opened by S. K. Runcorn who gave a summary of Blackett's paper (Nature, vol. 159, 658, 1947). Blackett pointed out that the ratio P/U, where P is the magnetic moment and U the angular momentum, is approximately constant for the case of the earth, sun and 78 Virginis and nearly equal to $G^{-1/2}/c$, where G is the gravitational constant and c is the velocity of light. Babcock's measurement of other stars later also conformed to the value of this constant (of the order of 10^{-15}) with the exception of one star whose magnetic field appeared to reverse with time. Because of the difficulty of explaining the empirical relation by classical theory, Blackett tentatively regards the proportionality of P and U as implying a new property of rotating matter.

Runcorn then referred to Bullard's suggestion that measurements of the earth's field in deep mines may decide between the two types of theories ascribing the cause of the earth's magnetism to processes taking place in the core and the distributed theories such as Blackett's, where we must suppose that the whole of the matter in the body is making a contribution to the magnetic field.

The mode of variation of the horizontal and vertical components of the field with depth has been worked out by S. K. Runcorn (Proc. Phys. Soc., vol. 61, 373, 1948) and S. Chapman (Ann. de Géophys., Tome 4, 109, 1948) from theory on the basis of certain assumptions. It is difficult to find a deep mine which is free enough from magnetic anomalies to permit a test of these predictions to be made. However, Parsonage Colliery in Lancashire (400 feet deep) seemed suitable and measurements were made at a point two miles away from the shaft. Runcorn found an increase of about 25γ in the vertical component and a decrease of about 50γ in the horizontal component. These measurements are in fair agreement with the distributed theory, though the decrease in the horizontal force is greater than one might expect. But on core theories one would expect an increase in this component as well.

Runcorn also said that there were no large-scale gradients in the area of measurement. He pointed out the difficulties of deep mine measurements which might have to be distrusted because of local anomalies. Large scale surveying underground would be more necessary to get more definite evidence. For this reason attempts were being made to try and see whether sea measurements could be undertaken, since these would not be vitiated by anomalies.

The Astronomer Royal remarked on the uncertainty of the observational evidence for the existence of the solar magnetic field. The original Mount Wilson plates gave a field of 50 Gauss. Some of the plates were later sent to Mr. Evershed in England for measurement who was unable to find any conclusive evidence of a field of this order. The radial limitation of the magnetic field which Hale deduced from his observations was another difficulty. At the I.A.U. meeting recently held at Zurich some fresh results were given. Thiessen's work on the general magnetic field of the sun was based on visual observations of the pulsation of the fringes and this was counteracted by varying the pressure of the air. His first measurements tended to confirm the old Mount Wilson observations and Thiessen gave for the intensity of the general magnetic field a value of 50 ± 12 Gauss. Heckmann reported at Zurich that Thiessen had collected more observations at Hamburg using more sensitive lines and was now satisfied that the general magnetic field of the sun was not greater than five or six Gauss. Mount Wilson observers have also reported that recent observations have failed to detect a general solar magnetic field, though they do not exclude the possibility of a variable solar field.

S. Chapman pointed out that on Blackett's theory the obliquity of the earth's magnetic axis to the geographical axis could not be explained so that ten per cent of the earth's permanent field would require a different explanation. This fact alone cast doubt on whether such a fundamental theory be true or not. The Astronomer Royal's report on the new evidence about the solar field gave the ratio P/U for the sun as 0.5×10^{-15} instead of 4.9×10^{-15}. But U for the sun is not at all well determined and this is still more true for the stars. Hence, the basis on which Blackett's theory rests is somewhat weak but this does not detract from the interest of the theory.

Laboratory tests cannot be made because of the large rotational speed required to produce observable fields. Bullard's suggestion that the theory could be tested by observing the variation of the magnetic field with depth had been undertaken by Runcorn and his experiments gave some evidence substantiating this theory. Blackett's theory had suggested a new field of investigation worth prosecuting but one must therefore suspend judgment on it for the time being.

On the basis of such a theory, the field within the earth could be calculated on the assumption that the rotary flow of mass is equivalent magnetically to a flux of electrons round the axis of rotation. The calculation was simple but depended to some extent on the variation of density within the earth. In the case of the earth the lines of force have foci at points one-tenth of the earth's radius below the surface. In the case of the sun the position of the foci is deeper down. The maximum value of the magnetic field computed within the earth is about 3000 Gauss and about 2000 Gauss for the sun.

Chapman also considered the possibility of explaining sunspot fields on Blackett's theory. It seemed that these cannot be so explained whatever form of the sunspot field is assumed below the surface of the sun. Thus, if the sunspot is assumed to be of the form of a horse-shoe magnet extending to a depth no greater than the distance apart of the bipolar group, there would be not enough mass in this system to explain the sunspot field - unless unlikely high angular velocities be postulated.

Dr. F. L. Whipple also made some observations regarding the evidence for the existence of the general solar field. The elder Babcock at Mount Wilson reported on the old and new measurements of this field and it appears that in some cases the field appeared but not in others. On the other hand, high stellar fields had been found by the young Babcock and in one case he had found a star with a field varying from 7000 Gauss to -6000 Gauss.

S. K. Runcorn said that there was a certain amount of evidence, apart from the Zeeman effect measurement, for the existence of the general solar magnetic field. The cosmic ray latitude "cut off" effect, for instance, could be explained by a solar magnetic dipole corresponding to fields at the surface of the sun ranging from 5 to 100 Gauss. He was aware that other explanations of the "cut off" might be possible without invoking the sun's magnetic field. As regards stars having variable magnetic fields there were difficulties on any theory to account for such large variations in the magnetic field. Perhaps the stars in question, which were near the Roche limit, were in some type of mechanical oscillation which, combined with the fundamental steady field might give the observed variations.

Dr. M. A. Tuve remarking on the cosmic ray latitude "cut off" said that recent observations did not support the coincidence of this effect at high altitude and at sea level found earlier. Balloon flight experiments suggest that there is no latitude cut off at high altitude. Commenting on Babcock's work, he said that the elder Babcock was quite definite that the solar field must be less than 20 Gauss. As regards variable stars the period of nine days found by the younger Babcock was quite definite.

Prof. H. Alfvèn also thought that the cosmic ray "cut off" provides no evidence for a solar field. He also asked whether the variable stellar magnetic field found by Babcock could not be accounted for by a rotation of the magnetic axis of the star.

E. Medi summarized his paper entitled "Sull'Origine del Campo Magnetico Terrestre E Sulle Tempeste Magnetiche". This paper is published in "Annali di Geofisica", vol. I, No. 4, pp. 509-512, Rome, 1948.

PRE-HISTORY OF THE EARTH'S MAGNETIC FIELD

By E. A. Johnson, Thomas Murphy and O. W. Torreson

The complete text is published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, vol. 53, pp. 349-372 (1948).

DISCUSSION:

Gustaf Ising remarked that the American experiments had been exclusively concerned with the remanent magnetic moment of varved clay and that the conclusions, as to the pre-history of the earth's magnetic field, were based on the assumption that the remanent moment had not substantially changed from the time of sedimentation. This assumption might, perhaps, be regarded as plausible with the quarternary clays but seemed to be rather optimistic as to clays or shales from older geological periods. He referred to his special report included in the Swedish National Report concerning some investigations on the magnetic properties of varved clay, carried out (on a small scale) in Sweden since 1926 and having mainly the same purpose. But these investigations were based on a skeptical attitude towards the persistence of the remanent moment and mainly tried to test this point by studying the magnetic anisotropy of susceptibility acquired during the sedimentation. This anisotropy will remain an invariable property of material, unaffected by any subsequent secular change of the remanent moment of the clay. On account of the very small difference between the two principal values of susceptibility in the (horizontal) strata-plane of the clay, however, there were considerable experimental difficulties (not yet wholly surmounted) to obtain unambiguous determinations of the azimuthal direction of the susceptibility-excess in the strata-plane. He further mentioned some findings, which suggest that there may be variations in clays of different mineralogical constitution, as to their power of retaining an acquired remanent magnetization.

RECHERCHES SUR L'INTENSITÉ DU CHAMP MAGNÉTIQUE TERRESTRE ANCIEN

Par Emile Thellier et Mme Odette Thellier

Des recherches sur le champ terrestre fossile sont activement conduites, actuellement: soit sur des roches sédimentaires, les "varves" (U.S.A., Suède, Japon), soit sur les roches volcaniques et les terres cuites (France, U.R.S.S., Japon). Les études que nous poursuivons appartiennent à la seconde catégorie. Elles ont comporté, avant tout, une étude attentive des propriétés des aimantations (thermorémanence et rémanence isotherme) que peuvent acquérir les terres cuites et les roches (1, 2, 3, 4). Les résultats ainsi acquis, dont l'intérêt théorique va d'ailleurs grandissant, permettent d'aborder plus clairement et plus efficacement la recherche de la direction et aussi de l'intensité du champ terrestre passé.

Nous n'examinerons ici que la partie de notre travail relative à l'intensité.

I. Etat actuel de la méthode utilisée

L'idée de la méthode que nous avons mise en application dès 1937 (5, 6, 1, 7) est de comparer la valeur du moment magnétique d'un fragment de roche ou de terre cuite (moment dû par hypothèse au champ ancien de l'époque de la coulée ou de la cuisson) au moment actuel après qu'il à été désaimanté par un chauffage à température suffisante (pratiquement 670° C). Des perfectionnements successifs ont été apportés à la méthode initiale (8, 9, 10); ils reposent surtout sur une propriété vraiment inattendue que nous avons mise en évidence sur des terres cuites (2) et qui a été étudiée ensuite sur les roches volcaniques par T. Nagata (11) et sur le sesquioxyde de fer par Melle J. Roquet (12, 4). C'est une véritable indépendance de l'aimantation qu'acquièrent ces corps quand ils parcourent, en se refroidissant dans un champ magnétique, un intervalle donné, quelconque, de température. Un corps et un champ magnétique étant donnés, à un intervalle de température t_1-t_2 correspond un moment magnétique bien défini qui est insensible à tout réchauffement à température inférieure à t_2 et qui disparaît complètement par réchauffement à la température t_1. Aux températures inférieures à t_2, ce moment subsiste dans le corps indépendamment des moments acquis dans d'autres intervalles de température et d'autres champs.

Mais cette propriété n'appartient pas, à beaucoup près, à toutes les roches ou terres cuites portant des aimantations permanentes et ces aimantations, d'autre part, ne représentent pas toujours exactement l'aimantation ancienne, seule intéressante. La recherche de l'intensité n'a de sens que sur un corps présentant les caractères suivants, presque évidents:

1° Son aimantation permanente initiale est purement thermorémanente, à l'exclusion de rémanence isotherme acquise "à froid" dans le champ terrestre actuel ou dans les champs intenses dûs aux courants de la foudre;

2° Le champ dans lequel il s'est refroidi était le champ terrestre normal;

3° Son aimantation thermorémanente ne diminue pas spontanément et elle n'a pas subi d'altérations au cours des temps par suite de réchauffements importants (recouvrement par des coulées volcaniques, incendies);

4° Le corps a, au moins en ce qui concerne ses minéraux magnétiques, la même composition minéralogique qu'après son refroidissement;

5° Cette composition minéralogique ne change pas non plus au cours des réchauffements effectués sur lui pendant les essais.

L'examen géologique et minéralogique du corps ne permettant pas de s'assurer que ces conditions sont remplies, nous nous sommes ingéniés à constituer une série d'essais qui assurent cette vérification d'une manière que nous croyons satisfaisante. La succession suivante de des essais constitue notre méthode actuelle de recherche de l'intensité du champ terrestre passé.

1° Essai d'insensibilité aux champs faibles, à la température ordinaire.

Les moments magnétiques dits permanents des échantillons en étude étant déterminés, on soumet ces corps à des champs de quelques gauss, ou plus simplement on les abandonne pendant plusieurs jours dans le champ terrestre dans une position inversée par rapport à celle dans laquelle ils avaient reposé avant la première mesure. Nous avons montré que beaucoup de roches présentent après cela un moment magnétique nettement différent de leur moment initial (1, 13, 14); elles sont à rejeter. Seuls conviennent les corps dont le moment demeure inchangé (mieux qu'au centième près pour beaucoup de terres cuites et certaines roches).

2° Désaimantation et réaimantation par paliers successifs.

Le corps en essai, sur le quel on a défini 3 axes rectangulaires, est porté à une température t_1 et refroidi dans le champ terrestre jusqu'à la température ordinaire dans une position donnée. On mesure les composantes de son moment résultant. Puis on le porte de nouveau à la température t_1 mais en ayant inversé sa position; après refroidissement on mesure les nouvelles composantes de son moment. D'après la propriété d'indépendance des moments, il est facile de voir que la demi-somme des 2 valeurs mesurées suivants une direction représente la composante suivant cette direction du moment ancien relatif à l'intervalle de température 670°-t_1 et la demi-différence des mêmes valeurs, celle du moment relatif à l'intervalle t_1-20° acquis dans le champ terrestre actuel. En répétant la même opération pour quelques températures croissantes on peut obtenir pour différents intervalles de température, les valeurs des moments dûs au champ ancien et au champ actuel. La proportionnalité des moments aux champs pouvant être admise (champs faibles), le rapport des moments ancien et nouveau doit être constant pour tous les intervalles et il représente le rapport des champs ancien et nouveau. On peut montrer que ce rapport n'est constant que si les première, troisième et cinquième conditions posées sont remplies.

Nous utilisons au moins les étapes 100°, 300°, 670°, ce qui nous permet de déterminer les moments relatifs aux intervalles 300°-100° et 670°-300°. L'intervalle 100°-20° est abandonné ce qui revient à débarrasser l'aimantation ancienne des troubles (désaimantation et réaimantations) apportés au cours des temps par les variations "météorologiques" de la température.

3° Contrôle de la stabilité minéralogique dans les chauffages imposés.

La chauffe finale à 670°, relativement très brève, est répétée dans les mêmes conditions. Une différence entre les moments obtenus dans ces 2 essais identiques révèle une évolution minéralogique non achevée dès la 1ère chauffe.

D'autre part, après ces essais, on effectue un réchauffement à 300° pour déterminer le moment acquis dans le champ actuel dans l'intervalle 300°-20°. La valeur ainsi obtenue n'est égale à la valeur correspondante donnée par la première chauffe à 300° que s'il n'y a pas eu évolution minéralogique, au moins aux températures supérieures à 300°.

4° Contrôle de l'evolution spontanée au cours du temps.

Le seul contrôle qui nous paraît actuellement possible est l'egalité des intensités obtenues à partir d'un certain nombre d'échantillons de même âge et aussi différents que possible. Pour des corps hétérogènes comme le sont les terres cuites, une évolution soit de la composition minéralogique, soit de l'aimantation elle-même, doit entraîner des différences notables d'un objet à un autre.

Ces vérifications indispensables sont un peu sévères et beaucoup de séries d'objets ne satisfont pas bien à l'ensemble des épreuves. Les éliminations se faisant à toutes les étapes de l'étude, il faut admettre que souvent beaucoup d'efforts matériels seront perdus.

II. Résultats

Un premier travail a consisté à vérifier la méthode sur une série de briques modernes, cuites quelques années auparavant, dans un champ d'intensité connue (7). Là, nous n'avons pas fait d'étapes dans le réchauffement qui a été effectué directement à 670°; nous n'avons donc pas éliminé l'effet des variations météorologiques de température. Cette précaution aurait amélioré encore la vérification déjà remarquable.

Puis nous avons étudié des séries de briques provenant de monuments historiques français. Dans une étude portant sur le Palais Rihour, à Lille (vers 1460) nous avons inauguré un réchauffement en 2 étapes 60° et 670°; nous avons obtenu pour intensité du champ 0.56 gauss, la valeur actuelle en un lieu de même inclinaison magnétique étant proche de 0.46 gauss (8). D'autres séries ont montré des évolutions minéralogiques importantes et une autre encore (Versailles 1750) très satisfaisante à ce point de vue, nous a conduits à relever à 100° notre limite inférieure de protection. Nous avons ensuite étudié 2 séries de briques gallo-romaines de provenance très différente (Paris et Fréjus dans le Sud-Est de la France). Ces séries pour lesquelles le découpage en intervalles de température a été poussé, ne sont pas sans défaut; elles nous ont donné, pour des dates d'ailleurs mal déterminées, des valeurs élevées: 0.71 et 0.66 gauss (10).

Ces résultats suggérant la possibilité d'une décroissance continue du champ terrestre, nous avons été conduits à étudier des matériaux relativement très anciens (quaternaire supérieur): des échantillons d'andésite de la coulée de Volvic (Puy-de-Dôme), des argiles métamorphiques cuites par des coulées du volcan de Gravenoire (Puy-de-Dôme). Malheureusement la lave de Volvic se modifie par réchauffement et les échantillons d'argile métamorphiques recueillis jusqu'ici sont sensibles au champ terrestre actuel à un degré jamais observé pour des terres cuites. Les essais poursuivis malgré cela conduisent à des intensités faibles, très inférieures à celle du champ actuel. Malgré leur imperfection ils apporteraient au moins cette indication que le champ terrestre n'est pas continuellement décroissant.

Bibliographie

1. Ann. I.P.G., Paris, vol. 16, 1938, pp. 157-302.
2. Notice sur les titres et travaux de E. Thellier, Jouve éd., Paris, 1941.
3. C.R. Acad. Sc., vol. 213, 1941, pp. 59-61 et 1019-1022.
4. C.R. Acad. Sc., vol. 222, 1946, pp. 1288-1290.
5. C.R. Acad. Sc., vol. 204, 1937, pp. 184-186.
6. Ann. I.P.G., Paris, vol. 15, 1937, pp. 179-184.
7. C.R. Acad. Sc., vol. 212, 1941, pp. 281-283.
8. C.R. Acad. Sc., vol. 214, 1942, pp. 382-384.
9. L'Astronomie, vol. 56, 1942, pp. 65-69, 89-93 et 100-104.
10. C.R. Acad. Sc., vol. 222, 1946, pp. 905-907.
11. Bull. Earthquake Res. Inst., Tokyo, vol. 19, 1941, pp. 50-79, 579-596; vol. 20, 1942, pp. 192-213.
12. C.R. Acad. Sc., vol. 222, 1946, pp. 727-729.
13. C.R. Acad. Sc., vol. 204, 1937, pp. 876-879.
14. Ann. Géophysique, vol. 1, 1944, pp. 37-52.

Institut de Physique du Globe de l'Université de Paris
Paris, France

THE ORIGIN OF THE EARTH'S MAGNETIC FIELD

By J. M. Barnóthy

The complete text is published in Publication of the Hungarian Institute for Meteorology and Terrestrial Magnetism, Ministry of Agriculture, Papers of Terrestrial Magnetism, No. 2, pp. 15-46, Budapest (1947).

DESCRIPTION OF THE GEOMAGNETIC VARIATIONS

By E. H. Vestine

The purpose of this note is to indicate briefly the coverage of an extensive new compendium of geomagnetic variations recorded at magnetic observatories [1,2]. A rough and tentative estimate is given, on a world-wide scale, of the geomagnetic variation with sunspot cycle for the years 1905 to 1942. Similar coverage has been obtained for the annual variation, and for the geomagnetic post-perturbation as exhibited by the daily mean departures from the monthly means.

Included also are 12-year averages by months of the solar daily variation, and disturbance daily variations, for the period 1922-33, with indication of the amplitude of the solar daily variation on each day of the period 1905-42. Results for additional stations are provided for the Second International Polar Year, 1932-33, including estimates of the storm-time variation in various latitudes.

Extensive statistics are provided respecting the frequency, amplitudes and durations of the various short-period geomagnetic fluctuations.

References

[1] E. H. Vestine, Isabelle Lange, Lucile Laporte and W. E. Scott. The geomagnetic field, its description and analysis. Carnegie Inst. Washington, Pub. 580 (1947).

[2] E. H. Vestine, Lucile Laporte, Isabelle Lange, Caroline Cooper and W. C. Hendrix. Description of the earth's main magnetic field and its secular change, 1905-45. Carnegie Inst. Washington, Pub. 578 (1947).

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

SOME NOTES ON SECULAR VARIATION

By L. Slaucitajs

The complete text is published in Contributions of Baltic University, No. 63, 4 pp., Pinneberg (1948).

ON THE MAGNETIC FIELD OF Sq IN THE MIDDLE AND LOWER LATITUDES DURING THE II POLAR YEAR

By M. Hasegawa and M. Ota

The distribution of 46 magnetic observatories within the latitudes of 60° N and 60° S in the II Polar Year 1932-1933 is not satisfactorily uniform (Fig. 1). Two regions where the lack of observatories is remarkable are the whole equatorial zone and the Pacific area. The importance of the magnetic observations in the equatorial zone should be advocated in order to research, not only the varying magnetic field itself, but also the allied phenomena such as the ionosphere and the cosmic-ray.

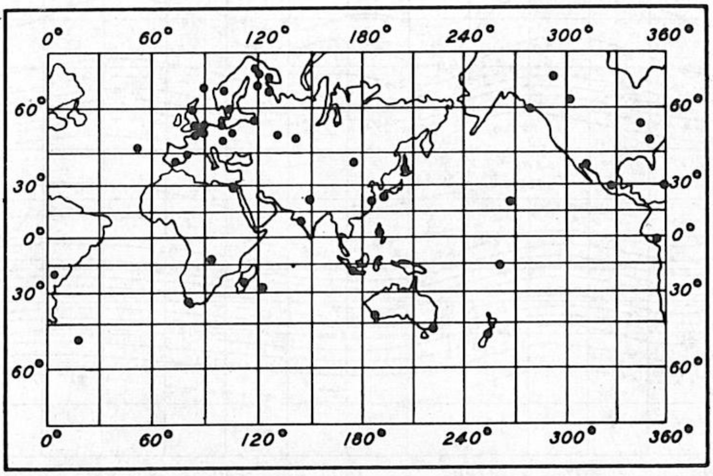


Fig. 1. Distribution of magnetic observatories geomagnetic coordinate.

For representation of the magnetic field of S, we adopted first a numerical method. On the world map the coefficients of harmonic analysis are distributed with lines of equal values as shown in Figures 2 and 3, in which the values of the coefficients at every 15° in latitudes and every 30° in longitudes can be estimated. Comparing these two maps it can be seen that the variations with the longitudes are smaller in the case of the geomagnetic coordinate than that of the geographical one. The more adequate coordinate system may be found in the middle and lower latitudes, but it seems possible to make the values of coefficients constant along the latitude circles of the system. As the coefficients of harmonic analyses a_1, b_1, a_2, b_2,...... are functions of the longitudes λ, the X-component of the magnetic force on the circle of co-latitude θ is given as

$$X_{\theta = \mathrm{const}} = \sum_{l} [a_l(\lambda) \cos l(t+\lambda) + b_l(\lambda) \sin l(t+\lambda)]$$

$$a_l(\lambda) = \sum_{p} [{}_l a_p \cos p\lambda + {}_l b_p \sin p\lambda]$$

$$b_l(\lambda) = \sum_{p} [{}_l a_p \cos p\lambda + {}_l \beta_p \sin p\lambda] \qquad (1)$$

Hence the magnetic potential V can be expressed as follows:

$$V = r_0 \Sigma\Sigma\Sigma\, [{}_l A_n^m \cos(lt+m\lambda) + {}_l B_n^m \sin(lt+m\lambda)] P_n^m(\theta) \qquad (2)$$

The terms within the brackets can be written in the form

$$\frac{\cos}{\sin}(m-l)t \cdot \frac{\cos}{\sin} m(t+\lambda),$$

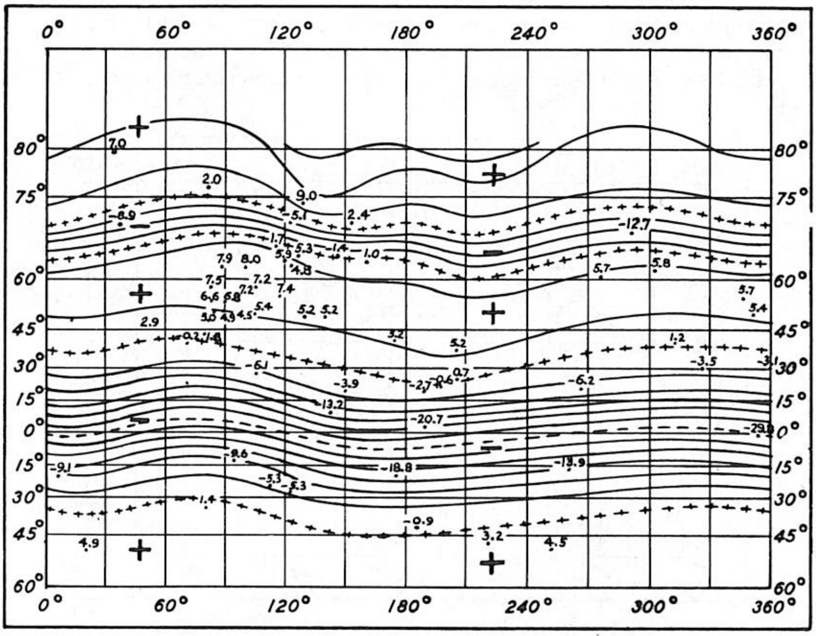


Fig. 2. Distribution of a_1 of 1/2(S + W) of x-component. Geomagnetic coordinate

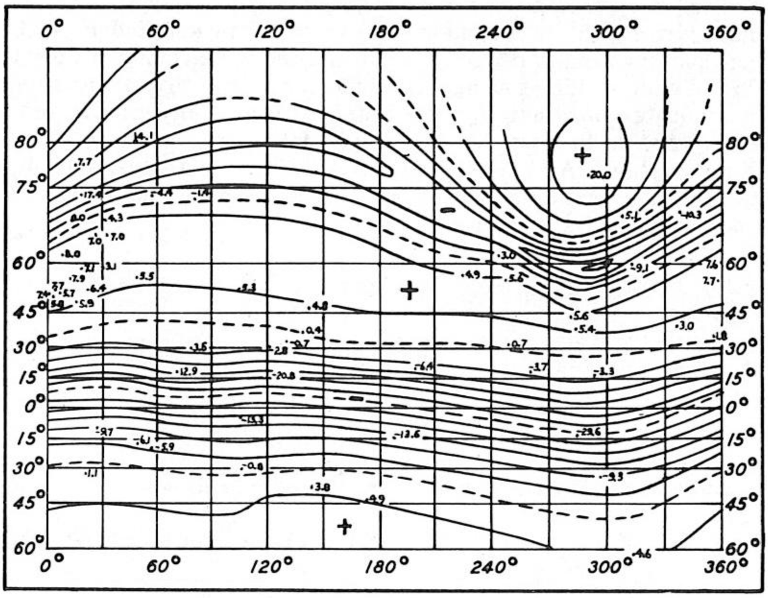


Fig. 3. Distribution of a_1 of 1/2(S + W) of X-component. Geographic coordinate

which means the rotating field varying with the universal time in general. The terms of m=1 represent the variations with the local time, and the terms of m=0 are the pure universal time variations. The local time variations are those investigated hitherto by various authorities and usually called the magnetic field of S. In the results of our analysis, the universal time variations are so conspicuous that we cannot neglect them.

Although a part of them is certainly due to the disuniformity between the adopted coordinate system and the phenomena, and another part must be attributed to errors from various sources, one may be convinced that there is the reason to justify the discussion of them from various aspects, as we have done, if the inequalities in the permanent magnetic field besides those in the geological states on the surface of the earth are taken for account. As for the true nature of them, however, we must anticipate for the future works with new materials of observation, desirously covering various stages of the solar activity. In this short communication we must restrain ourselves to report the figures of coefficients of the main terms in the equation (2).

The following tables contain coefficients A's and B's in (2) using Schmidt's normalized functions and force unit of 10^{-5} c.g.s. The data are from 1932 to 1933, the year of minimum sunspots.

Table I. Local time field (m=1)

Normalized. Force unit = 10^{-5} c.g.s.

m	n	A		B		A	B
		from X	from Y	from X	from Y	from Z	from Z
1	1	3.76	0.28	−0.35	−0.23	−0.30	0.06
1	2	10.10	7.09	−2.47	−2.28	5.18	0.46
1	3	0.78	−0.50	0.29	−0.08	−0.86	−1.44
1	4	−1.90	−1.20	0.14	0.25	−1.66	0.60
1	5	0.33	−0.35	0.03	−0.13	0.30	−1.64
1	6	1.02	0.30	−0.01	−0.21	2.60	2.11
2	2	−0.91		0.29		0.21	−0.00
2	3	−4.96		1.61		−5.71	0.37
2	4	−0.33		−0.15		−0.50	0.29
2	5	0.22		0.05		0.06	−0.54
2	6	−0.24		0.04		−0.97	−0.41
2	7	−0.50		−0.04		−3.58	1.65
3	4	1.25		−0.95		2.1	−0.45
3	6	−0.10		−0.08		−0.5	0.5

Table II. Pure universal time variation (m=0)

m	n	A	B	A	B
		from X	from X	from Z	from Z
1	1	0.23	−0.20	−0.25	5.95
1	2	1.99	−1.50	1.07	−0.79
1	3	−0.06	0.19	0.60	8.88
1	4	0.14	0.18	−1.46	−0.34
1	5	0.16	0.13	−0.38	8.17
1	6	0.75	−0.66	0.66	−0.33
2	1	0.68	−0.03	−5.30	−2.50
2	2	0.77	−0.20	1.27	−0.06
2	3	0.02	−0.16	−8.60	−3.84
2	4	−0.11	0.06	0.18	−0.26
2	5	0.05	−0.18	−4.38	−1.56
2	6	0.19	−0.03	1.97	−0.47

Table III

External Field: $r_0 \Sigma\Sigma E_n^m \cos\left\{m(t+\lambda)+e_n^m\right\}$

Internal Field: $r_0 \Sigma\Sigma I_n^m \cos\left\{m(t+\lambda)+i_n^m\right\}$

m	n	E_n^m	e_n^m	I_n^m	i_n^m	E/I	$e-i$
1	1	2.42	4°	1.36	6°	1.78	−2°
1	2	7.22	11°	3.19	20°	2.26	−9°
1	3	0.32	7°	0.57	324°	0.56	
1	4	1.25	187°	0.66	179°	1.90	
1	5	0.17	50°	0.27	324°	0.63	
1	6	0.77	348°	0.32	31°	2.40	
2	2	0.53	19°	0.42	17°	1.25	2°
2	3	3.70	15°	1.52	25°	2.43	−10°
2	4	0.24	349°	0.13	314°	1.64	
2	5	0.11	191°	0.13	148°	0.85	
2	6	0.20	3°	0.04	38°	5.0	
2	7	0.51	10°	0.13	270°	3.9	
3	4	1.10	35°	0.49	49°	2.24	−14°
3	6	0.11	180°	0.08	83°	1.3	

Table IV. $V = r_0 \Sigma\Sigma C_n^m \cos\left\{m(t+\lambda)+\epsilon_n^m\right\}$

Annual terms 1/2 (S+W). Normalized. Force unit 10^{-5} c.g.s.

Name	Chapman		Schuster	Fritsche	Benkova	Our	
Year	from Y		Y	X & Y	X & Y	X	Y
	1902	1905	1870		Su. 1933	1932-1933	
C_2^1	6.95	10.05	15.42	10.22	7.5	10.40	7.45
ϵ_2^1	35°	24°	24°	30°	19°	14°	18°
C_3^2	4.5	5.9	7.13	4.8	4.24	5.22	
ϵ_3^2	35°	27°	31°	25°	29°	18°	
C_4^3	2.1	2.7	3.2	2.1		1.57	
ϵ_4^3	48°	40°	67°	35°		37°	

Geophysical Institute
Kyoto University
February 15, 1948

THE MAGNETIC DIURNAL VARIATION OF THE HORIZONTAL FORCE NEAR THE MAGNETIC EQUATOR

By J. Egedal

The complete text is published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, vol. 52, pp. 449-451, 1947.

DISCUSSION:

S. Chapman presented an account of his paper entitled "The abnormal daily variation of horizontal force at Huancayo and in Uganda". The complete text is published in the Journal of Terrestrial Magnetism and Atmospheric Electricity, vol. 53, pp. 247-250, 1948.

D. F. Martyn: McNish's theory does not seem able to account for the observed effects. In essence his theory leads to approximate symmetry of the variations about the magnetic equator, but not to any great enhancement there. This approximate symmetry can already be deduced from the "dynamo theory" when account is taken of the term introduced by non-coincidence of the magnetic and geographic poles.

It seems more likely that the enhancement is due to an increase of conductivity of the ionosphere near the magnetic equator. This could be produced by the raising of the ionosphere in this region by the mutual influence of the current therein and the earth's total field. The conducting region would thereby be raised several kilometers, to a region of lower pressure, and hence of enhanced conductivity. If this explanation be correct, then the six-hourly harmonics of both the solar and lunar variations (but especially the former) should be abnormally large near the magnetic equator, and their phase (of maximum) should coincide with the phase of maximum in the total variation.

THE REPRESENTATION OF MAGNETIC FIELD OF Sq WITH POTENTIAL CALCULATED THROUGH A METHOD OF GRAPHICAL INTEGRATION

By M. Hasegawa and M. Ota

While the detailed representation of the magnetic field of S by series of harmonic functions requires a calculation of a considerable number of terms and is yet rather abstract, the demonstration by means of the distribution map of the magnetic potential, obtained through the method of graphical integration of the horizontal forces, is more concrete to indicate the characteristics of the field. As for the Sq field during the II Polar Year, the world maps of the potential for the mean state, of summer and winter, say 1/2(S+W), and the difference of them 1/2(S-W) were drawn at every two hours. Figure 3 shows the map of 1/2(S+W).

Brief description of the method. The distribution of X-component of Sq variations on the meridians of every 30° in longitudes and that of Y-components along the parallel circles of every 15° in latitudes are carefully determined, using all available observations between 60° N and 60° S. The relative values of potential at the point of intersection of the i-th meridian and the j-th parallel circle are obtained as V_{xij} from the graphical integration of X-component along the meridian and as V_{yij} from that of Y-component along the parallel circle. Let the true value of potential at that point (i,j) be V_{ij}, and put

$$V_{xij} = V_{ij} + x_i + \xi_{ij}$$

$$V_{yij} = V_{ij} + y \;\; + \eta_{ij}$$

where x_i is a constant on the i-th meridian, y_j is another constant on the j-th parallel circle, and ξ_{ij} and η_{ij} are the parts due to errors, taking for granted that the field has no non-potential part. Hence we have

$$(V_{xij} - V_{yij}) - (V_{xi+1,j} - V_{yi+1,j}) = (x_i - x_{i+1}) + (\xi_{ij} - \xi_{i+1,j}) - (\eta_{ij} - \eta_{i+1,j}).$$

The values of $x_i - x_{i+1}$ including errors can be determined in this way. By the successive operation of the same calculation on the points along the j-th parallel circle, we obtain $(x_0 - x_1)$, $(x_0 - x_2)$ ....., $(x_0 - x_{11})$, including errors; namely the values of x_1, x_2, ..., x_{11} referred to x_0. Repeating the operation on the nine parallel circles, we have nine values for each x_i. If all errors are accidental, the mean value $\overline{x_i}$ of the nine may be taken as most probable.

We have determined x_0 provisionally so as that the sum of all 108 values of V_{xij} corrected by $\overline{x_i}$, vanishes. In Figure 2 the values of potential, thus deduced from X-components, on the parallel circle of 60° N is compared with the same quantities derived from the study of the north polar region (see report of Washington meeting) in which the potential is calculated by the integration of X-component from the geomagnetic pole down along meridians, putting the initial value at the pole is equal to zero. We must be satisfied with the coincidence of two curves in Figure 2 if we take into consideration the ambiguities in the form and orientation of the elliptic ovals on the sides of little or no observatory. And so far as this is recognized, our method of evaluating the magnetic potential in the middle and lower latitudes, as well as in the polar region, may be admitted as appropriate.

Making use of the Y-component we get also the values of potential, which must be identical with those from the X-component, if the field is without non-potential part. In fact, however, there is a finite difference between the both groups of values, which is taken up as question in a separated paper. Diagrams in Figures 3 and 4 are constructed with the mean values of those from the X- and Y-component.

Figure 3 shows the distribution of potential of the mean rotating field of 1/2(S+W) of Sq in the geomagnetic coordinates, using a unit of 10^3 c.g.s. The mark on the frame shows the position of the sun. Epoch is VIII, 1932-VIII, 1933, a year of the minimum sunspots. The main terms of the spherical expansion of this distribution coincide approximately with those in the article "On the magnetic field of Sq in the middle and lower latitudes, etc" by the present authors.

The world map of Figure 1 in the above-mentioned article must be referred to Figure 4, in which the distribution of potential at the instants of every two hours is shown. The positions and intensity of the maximum and minimum potential are

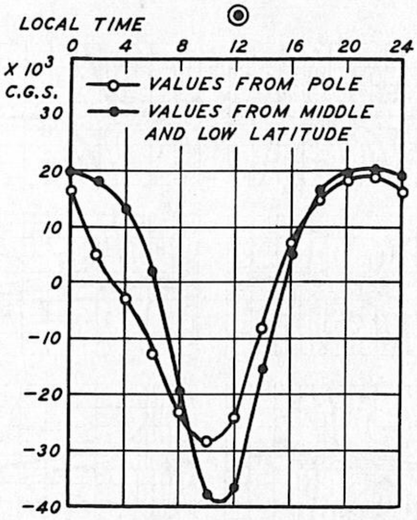


Fig. 2

investigated in a separated copy by one of the authors. That the asymptotic feature of the families of the equipotential lines is partly due to the deviation of geomagnetic pole from the geographic one, is theoretically proved by T. Nagata (Tokyo University). The differences from the mean state of Figure 3 were discussed, but are omitted here.

1/2(S+W) quiet mean state $S(Y+X) = Y+X - (Y+X)_m$ Unit $.825 \cdot 10^3$ c.g.s.

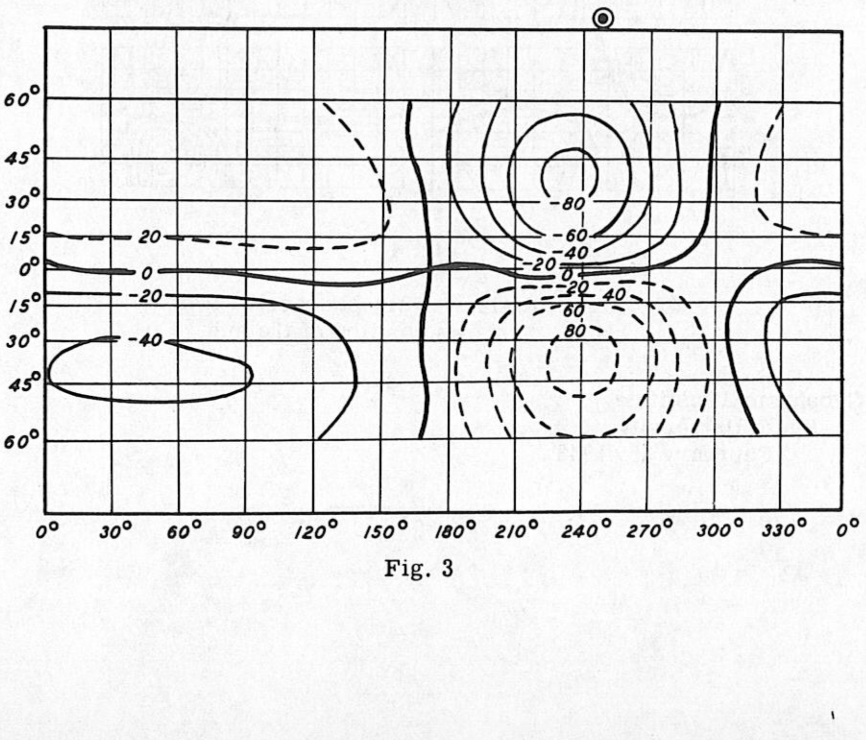


Fig. 3

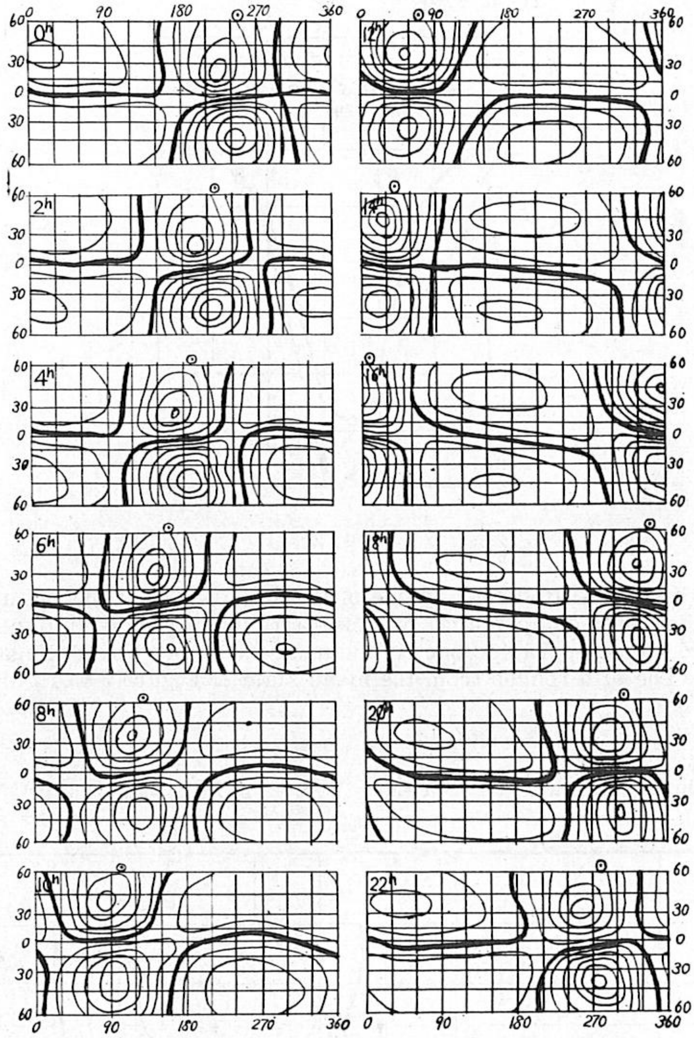


Fig. 4

Equipotentials at every successive two hours. ⊙ shows position of the sun.

Geophysical Institute
Kyoto University
February 15, 1948

INVESTIGATION ON THE BAY-DISTURBANCE AND THE PULSATION OF THE TERRESTRIAL MAGNETIC FIELD AND OF THE EARTH-CURRENT

By H. Hatakeyama

The complete text has been published as a series of three articles in Geophysical Magazine, vol. 12, Tokyo (1938), titled as follows:

"On the bay-disturbance in the terrestrial magnetic field", pp. 15-66.
"On the pulsation of the terrestrial magnetic field", pp. 173-188.
"On the bay-disturbance and the pulsation of the earth-current", pp. 189-210.

ON A NEW THEORY OF THE MAGNETIC STORM

By Y. Kato

[By title only]

THE ELECTRICAL STATE OF THE EARTH'S INTERIOR AS INFERRED FROM VARIATIONS IN THE EARTH'S MAGNETIC FIELD

By T. Rikitake

In order to study in detail the distribution of the electric and magnetic properties of the earth's interior, it is desirable to study electromagnetic induction by various variations, slow and rapid, in the earth's magnetic field. The writer studied electromagnetic induction by S_D, bay-type disturbance, variation connected with solar eruption and sudden commencement of magnetic storm together with S_q and D_{st} which were already studied by a number of investigators (1). The earth is assumed, for the first approximation, to be a conducting sphere having uniform conductivity covered by a non-conducting layer (so-called the "uniform core model"). Magnetic permeability is assumed to be unity throughout the present study because it seems, at the present stage of our knowledge, improbable that the earth's interior is ferromagnetic.

As to the data of S_q, M. Hasegawa's (2) and N. P. Benkova's (3) analyses during the years 1932-33 are used. As pointed out by T. Nagata (4), the electrical conductivity σ in the core amounts to 5.0×10^{-12} e.m.u. and the ratio of the radius of the core to that of the earth q becomes 0.94. These values differ considerably from those obtained by S. Chapman (1) on the basis of his own analysis. Taking into account, then, the remarkable discontinuity at the depth of 2900 km reported from seismology, the writer attempts to determine σ separately inside and outside of this boundary. He gets almost the same values for the mantle as those obtained by Nagata, while larger conductivity is obtained for the inner core though not accurate. In order to study the effect of the induced currents in oceans, electromagnetic induction within a spherical shell bounded by two meridians $\pi/2$ apart is also studied approximately. In conclusion, the ocean-effects for S_q are not so small that we cannot detect them at all if we could eliminate the fields which depend on local time and other irregularities, but which are generally very small. Under some assumptions, the effects of Pacific Ocean are obtained.

As shown empirically by Chapman (5) and theoretically by the present writer (6), the distribution of S_D (solar daily disturbance variation) differs much from that of S_q. In order to check the electrical state of the earth's interior obtained from the study on S_q, the writer studied electromagnetic induction by S_D on the basis of E. H. Vestine's (7) data finding that the electrical state for S_q was approximately applicable for S_D.

Since σ in the uniform core amounts to 5.0×10^{-12} e.m.u., the discrepancy between the studies on S_q and D_{st} by which the conductivity-distribution was hitherto presumed to be non-uniform is almost overcome leaving only small difference. Though the remaining small difference vanishes by introducing high-conducting inner core, as obtained in the case of S_q, the determined value of the conductivity in the inner core is less reliable because only a minor part of the induced currents penetrate into such great depth.

In the next place, the writer treated the electromagnetic induction by bay-type disturbance with the aid of H. Hatakeyama's (8) data. Separation of the external part from the internal one is done with a similar method in the case of D_{st}. With the idealized feature of the atmospheric current-systems obtained both empirically and theoretically in mind, only the coefficients of $Q_1^1(\cos \theta)$, that is the most predominant in the magnetic potential in the low and middle latitudes, are studied. The relation between both parts, for example, is shown in Figure 1 in the case of the bay of February 24, 1933, together with the calculated values of the internal part (broken lines) on the basis of the earth-model already obtained in the case of S_q. Roughly speaking, the results support the induction theory. As the duration time of bay is shorter, amounting to a few hours, than the period of S_q, the obtained conductivity is responsible for shallower region than that in the case of S_q and of course D_{st}.

Magnetic effect associated with solar eruption is also analyzed. In this case, however, the problem is treated as plane-earth induction owing to the shortage in well-distributed data. The data collected by K. Birkeland (9) under the name of "Cyclo-median storm" is used. According to the theory of plane-earth induction, it is concluded that the conductivity increases discontinuously below the depth of 400 km amounting to 10^{-12} e.m.u. while the outer layer is non-conducting. Meanwhile the induced currents decay very steeply with increase of depth showing that the determined conductivity corresponds to that just below the boundary.

In addition to the variations treated above, induction by sudden commencement of magnetic storm, one of the most rapid variations in the earth's magnetic field, is discussed. Analyzing the data collected by L. A. Bauer (10), the ratio of the coefficients of the external potential to that of the internal one is obtained to be, on the average, as much as 3.9 for $P_1(\cos \theta)$. Such a large value is hardly expected from the earth-model obtained from the study on S_q. A possible explanation is effected by taking the conductivity of the earth to be as small as the order of 10^{-15} e.m.u. Hence, taking into consideration the steep decay of the induced currents with increase of depth, it is concluded that even in the non-conducting layer obtained in the foregoing studies the conductivity takes a finite value of the order of 10^{-15} e.m.u. Possible influence of ocean on rapid variation is also discussed. It is noticeable that sudden changes in the earth's magnetic field are sometimes affected considerably by the presence of sea though exact investigation is of great difficulty on account of the irregular distribution of land and sea.

In order to summarize these results, the writer introduced a convenient concept "effective depth". We can obtain the distribution of the induced currents in each case and consequently the contribution of the currents flowing at any depth to the field at the surface as a function of depth D denoted by $\varphi(D)$ or $\varphi(\rho)$ for spherical cases (ρ denotes radial distance divided by the earth's radius). Then we define the most "effective depth" that corresponds to the determined conductivity by

$$\int D\varphi(D)dD \Big/ \int \varphi(D)dD \quad \text{or} \int_0^1 \rho\,\varphi(\rho)d\rho \int_0^1 \varphi(\rho)d\rho .$$

Hence the conductivity can be plotted against the depth as shown in Figure 2, which may be regarded as an approximation for the actual distribution. In the figure small circles correspond to 1 - sudden commencement, 2 - bay, 3 - Dellinger effect, 4 - S_q (Hasegawa), 5 - S_q (Benkova), 6 - D_{st} (Chapman-Benkova), 7 - S_q (Chapman), and 8 - D_{st} (Chapman), respectively.

As to the second approximation, the writer then studied electromagnetic induction within an earth-model in which $\sigma = \sigma'$ for $1 > \rho > q$ and $\sigma = \sigma_0 \rho^{-l}$ for $q > \rho$. Giving suitable values to σ', σ_0 and l, the conductivity-distribution obtained above can be well represented by this analytical expression. Then the constants involved are determined in like manner with the previous studies. The most preferable values are determined to be $\sigma' = 10^{-15}$ e.m.u., $\sigma_0 = 1.0 \times 10^{-12}$ e.m.u., q = 0.94 and l = 11. Hence the conductivity-distribution becomes, for the second approximation, as shown in Figure 2 by the full line. An estimate of the error of the determination was also discussed, but will not be written here.

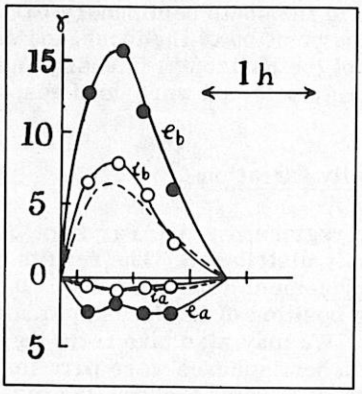


Fig. 1

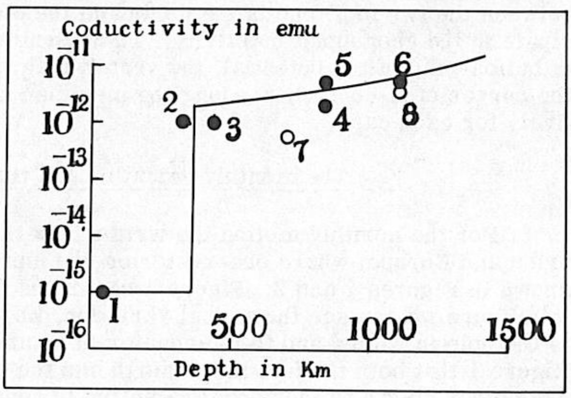


Fig. 2

References

(1) A. Schuster, Phil. Trans. Roy. Soc. London A, 180 (1889), 467.
S. Chapman, Phil. Trans. Roy. Soc. London A, 218 (1919), 1.
S. Chapman and T. T. Whitehead, Trans. Cambr. Phil. Soc., 22 (1922), 463.
S. Chapman and A. T. Price, Phil. Trans. Roy. Soc. London A, 229 (1930), 427.
B. N. Lahiri and A. T. Price, Phil. Trans. Roy. Soc. London A, 237 (1939), 509.
K. Terada, Geophys. Mag. 13 (1939), 63.

(2) M. Hasegawa, Read at the Ann. Meet. of the Phys.-Math. Soc. Japan (1943).
(3) N. P. Benkova, Terr. Mag. 45 (1940), 425.
(4) T. Nagata, Read at the Dec. Meet. of the Geophys. Inst. Tokyo Univ. (1946).
(5) S. Chapman, Proc. Roy. Soc. A, 115 (1927), 242.
(6) T. Rikitake, Read at the Feb. and June Meet. of the Earthq. Res. Inst. (1946).
(7) E. H. Vestine, Terr. Mag. 43 (1938), 261.
(8) H. Hatakeyama, Geophys. Mag. 12 (1938), 15.
(9) K. Birkeland, The Norwegian Aurora Polaris Expedition, 1902-1903, Section 1 (1908).
(10) L. A. Bauer, Terr. Mag. 16 (1911), 85 and 163.

Earthquake Research Institute
Tokyo University
Tokyo, Japan, January 30, 1948

THE POSITION AND MOTION OF THE FOCUS OF THE ELECTRIC CURRENT VORTEX EQUIVALENT TO THE VARIATION-FIELD OF THE TERRESTRIAL MAGNETISM AT MIDDLE LATITUDE

By Masajiro Ota

The object and the methods

It was indicated by Professor Hasegawa that the position of the focus of the equivalent current-vortex for the variation-field of the terrestrial magnetism is not situated at any definite latitude, as it moves around the earth. From the data of the Second Polar Year, the writer determined this position for three cases, i.e. every two-hourly motion, daily and monthly motions. As the conclusion, it was found that the inter-diurnal changes of the position of the focus and the distance between the two foci, one in the north and the other in the south hemisphere participate in the geomagnetic activity. To determine the position of the focus, the distribution-map of the potential, the vector-diagram of the horizontal intensity and the curves of X-component along the meridian suitably selected were used respectively for each case.

The monthly variation and the daily variation

For the monthly motion the writer took three regions, i.e. the Far East, America and Europe, where observatories are uniformly distributed. The results are shown in Figures 1 and 2. Figure 1 shows the displacement along meridian. In this figure we can see the annual variation, i.e. the position of the focus approaches to the pole in winter and to the equator in summer. We may also take from the Figure 1 that both the foci in the north and the south hemispheres were parallel to each other so far as the annual variation is concerned. Figure 2 shows the variation depending upon the local time. Here we can see the regional inequality, i.e. the state in the Far East is in good agreement with that in America, but not with that in Europe. But, if we take the annual means for each region, they are found to occur almost at the same time at different geomagnetic latitudes. (See Table.)

The results obtained for every two-hourly motion are shown in Figures 3 and 4, in which the geomagnetic coordinates are adopted. Figure 3 shows the trace of the focus when it moves around the earth, and also the numerical values of the potential at the focus.

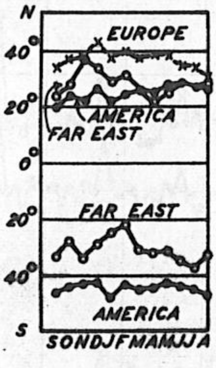


Fig. 1

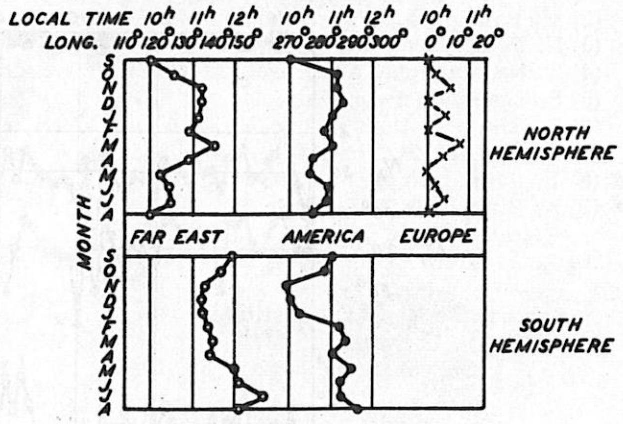


Fig. 2

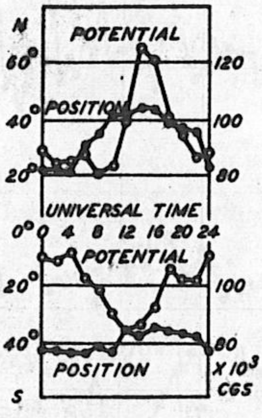


Fig. 3

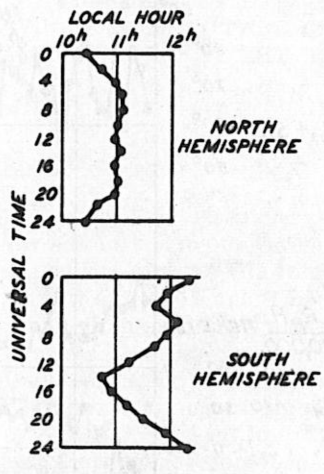


Fig. 4

In this Figure we can see the irregularity in the American region, i.e. the values of the potential are large in the north hemisphere and small in the south, as has been obtained theoretically by T. Nagata.

The results obtained for the above two cases are compared and shown in the table, from which we can see the aspect of their coincidence. But, as to the symmetry about the equator, we cannot determine which of the geographical coordinate or the geomagnetic is the more appropriate. According to the following discussion it will be seen that the position of the focus is related to the magnetic disturbance modifying the position of geomagnetic equator.

The daily change

The results at the Far East Region are shown in Figure 5, where N_{10} and N_{11} are the positions determined by X-curves along the 10^h and 11^h meridian in the north hemisphere, and N + S indicates the distance between the foci in the north and the south. In the lower rows the numerical character numbers, the sunspot

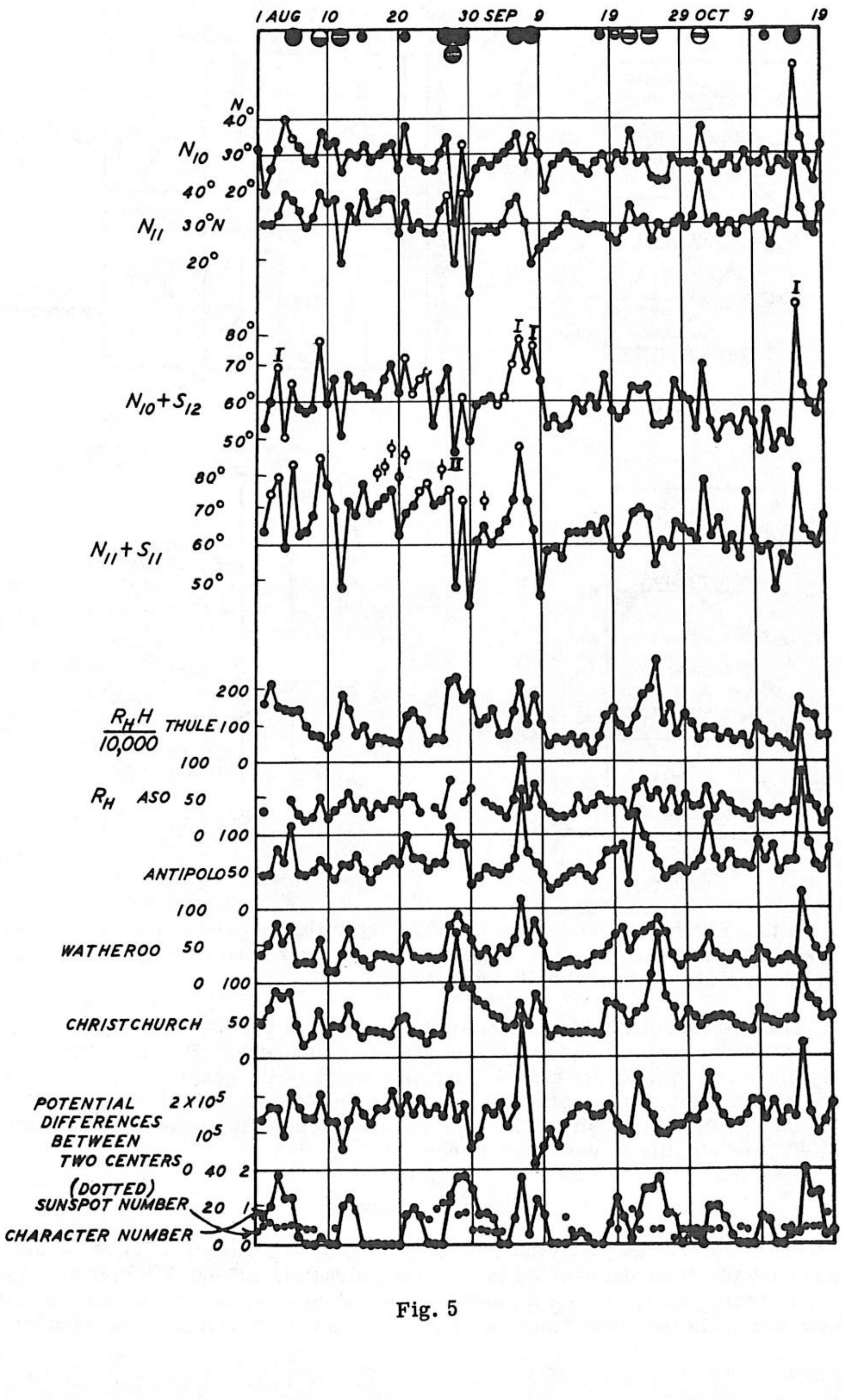

1 AUG 10 20 30 SEP 9 19 29 OCT 9 19
N_0
40°
N_{10} 30°
40° 20°
N_{11} 30°N
20°
80°
70°
$N_{10}+S_{12}$ 60°
50°
80°
70°
$N_{11}+S_{11}$ 60°
50°
200
$\frac{R_H H}{10,000}$ THULE 100
100 0
R_H ASO 50
0 100
ANTIPOLO 50
100 0
WATHEROO 50
0 100
CHRISTCHURCH 50
0
POTENTIAL DIFFERENCES BETWEEN TWO CENTERS
2×10^5
10^5
0 40 2
(DOTTED) SUNSPOT NUMBER 20 1
CHARACTER NUMBER 0 0

Fig. 5

Table giving the position of the focus

Region	local time (longitude)			latitude		
	values from monthly mean		values from every-two-hourly values	values from monthly mean		values from every-two-hourly values
	geograph. h	geomag. h	geomag. h	geograph.	geomag.	geomag.
North of Far East	10.7	10.7	10.9	29°	18°	20°
South of Far East	11.7	11.7	11.8	31°	42°	44°
North of America	10.8	10.8	11.0	25°	36°	40°
South of America	10.9	10.9	10.9	45°	34°	40°
North of Europe	10.2	10.7	11.0	38°	37°	41°

numbers at Zurich and the character numbers (which are the mean values obtained from the observatories in the Far East) are given on corresponding days.

To examine the relation between the positions of the foci at the north and the south, the inter-diurnal changes were computed to eliminate the effect of seasonal variation. Figure 6 shows the relation between the inter-diurnal changes of N_{11} and $N_{11} + S_{11}$ which are denoted by N_{11} and $N_{11} + S_{11}$, respectively. There exists such a tendency that the distance between the two foci is enlarged on the days when the position in the north approaches to the pole, especially with respect to large changes.

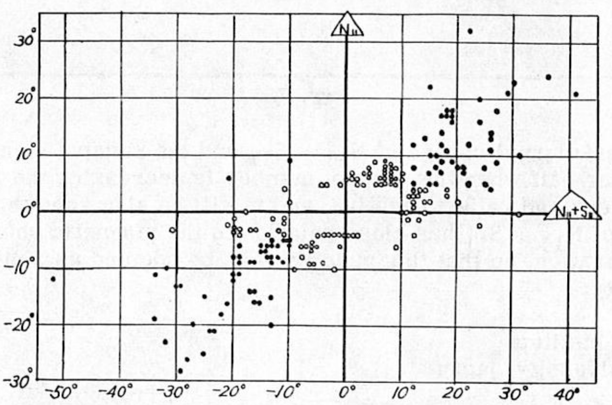


Fig. 6

Means of ten days

In this section the correlation between the quantities shown in Figure 5 is discussed. In order to indicate a certain variability, the inter-diurnal changes of $N_{11} + S_{11}$ were considered. As these individual values are not accurate, the means of ten days were computed. In Figure 7 the international magnetic character number, the inter-diurnal changes of the distance between two foci and the sunspot number are shown. Judging from this figure, it will be seen that, at the former half of this duration when the sunspot number is increasing the correlation

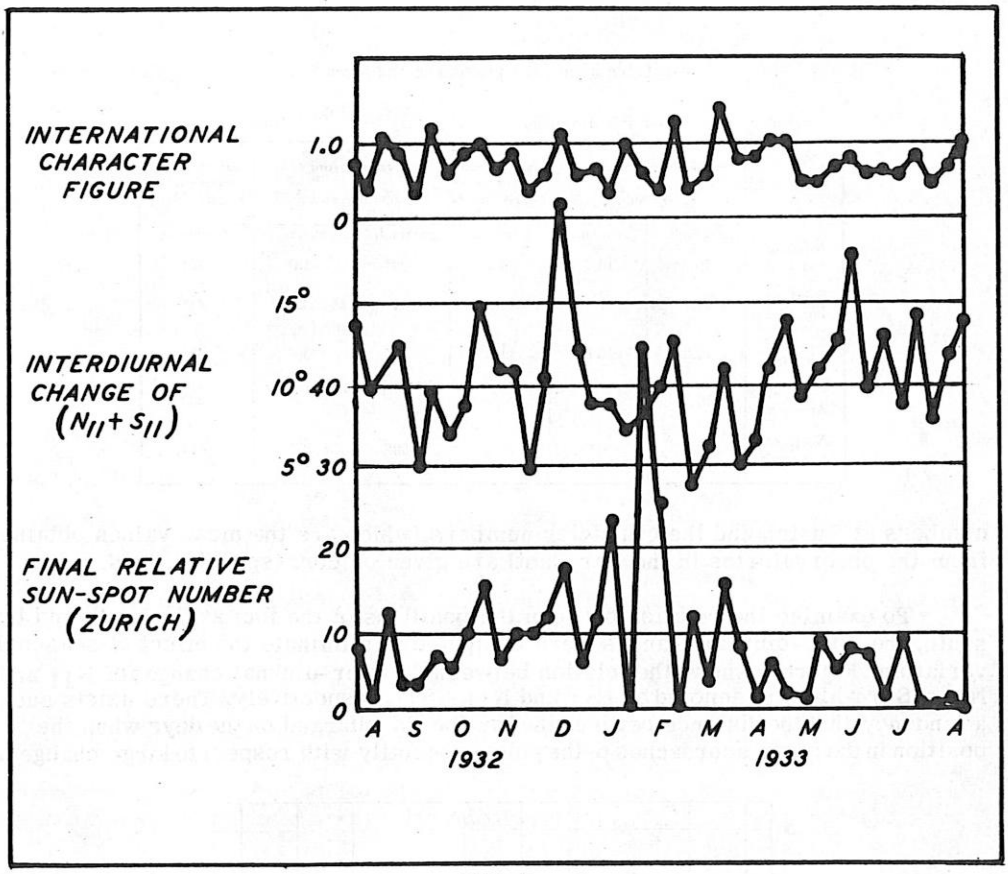


Fig. 7

between the inter-diurnal change of $N_{11} + S_{11}$ and the sunspot number is positive, while at the latter half when the sunspot number is decreasing the above correlation is not so clear and rather negative, and it will be also seen that the inter-diurnal change of $N_{11} + S_{11}$ has close relation to the magnetic character number for the whole duration, so that this quantity may be adopted as a measure of the magnetic activity.

Geophysical Institute
Kyoto University, Japan

SUDDEN COMMENCEMENT OF MAGNETIC STORMS AND ITS PROBABLE CAUSE

By Hantaro Nagaoka

The complete text is published in Proceedings of the Imperial Academy, Tokyo, vol. 17, pp. 250-255, 1941.

COMPUTING MAGNETIC OBSERVATORY RESULTS WITH PUNCHED CARDS

By H. Herbert Howe

(Paper revised September 15, 1949)

Introduction

Deriving hourly values of the magnetic elements, by ordinary multiplication and addition, takes a great deal of time because there are so many computations to make. First, the hourly ordinate (n) must be scaled from the magnetogram. Then the scale value (s) and the base-line value (B) are determined by study of the control observations. Finally, the hourly value (N) is derived from the relation

$$N = B + s\,n$$

These two computations, a multiplication and an addition, must be made for every hour for each of three elements (usually declination, horizontal intensity, and vertical intensity). Each of these computations is normally checked. Thus, for the six observatories of the United States Coast and Geodetic Survey, there are over 600,000 of these computations per year. If the variometers are not compensated for temperature, there are also computations for applying temperature corrections.

Thus simple arithmetic consumes a great deal of time. The highly trained professional staff must spend an inordinate amount of time instructing and supervising the computers who carry out the millions of individual steps. Finally, when a routine process is done over and over again, the computer is likely to become "stale" and make mistakes; even though another computer checks the computations, a few errors escape detection.

For many years, the United States Coast and Geodetic Survey has sought means of shortening this deadly routine. By the method of direct scaling (used from 1926 to 1946; see Terr. Mag., vol. 31, 89-95, 1926), the multiplication and addition were done automatically as part of the scaling. This method did not entirely eliminate routine work, since the various sums and means still had to be computed, and a smooth copy had to be made for lithographic reproduction. Worse, it was found that direct scaling was more difficult than was scaling in millimeters. As a result, serious consideration was given to returning to millimeter scaling.

In 1946, scaling of hourly values was suspended by the Coast and Geodetic Survey. Early in 1948, Captain Elliott B. Roberts, Chief of the Division of Geomagnetism and Seismology, instructed Mr. H. E. McComb, Chief of the Geomagnetism Branch, to make a careful study to determine what method could be used to produce adequate hourly scalings with a minimum of time. After studying various suggestions, he decided that it could probably best be done by using punched cards and the computing machines of the International Business Machines Corporation.

A detailed routine for handling these computations was worked out by the present author. This method is still in process of evolution; but it is unlikely that the general features described below will be changed.

Punched-Card Computing

Punched-card methods are used for jobs in which similar operations are done on a large amount of different data. They are well suited for computing N = B + s n, especially so since B and s remain constant through many different computations.

In punched-card computing, source data are transferred to cards in the form of punched holes. Different machines can be used to sort the cards in sequence; reproduce all or part of the information into other cards; add, subtract, multiply, or divide the figures in the cards, punching the results into the same cards or other cards; and print lists or tables showing alphabetical or numerical data from the cards.

Figure 1 shows a standard punched card. Each of the 80 columns can be given a specific meaning. A digit has been punched into each of the first 25 columns (except column 3, which has 2 digits, as explained below).

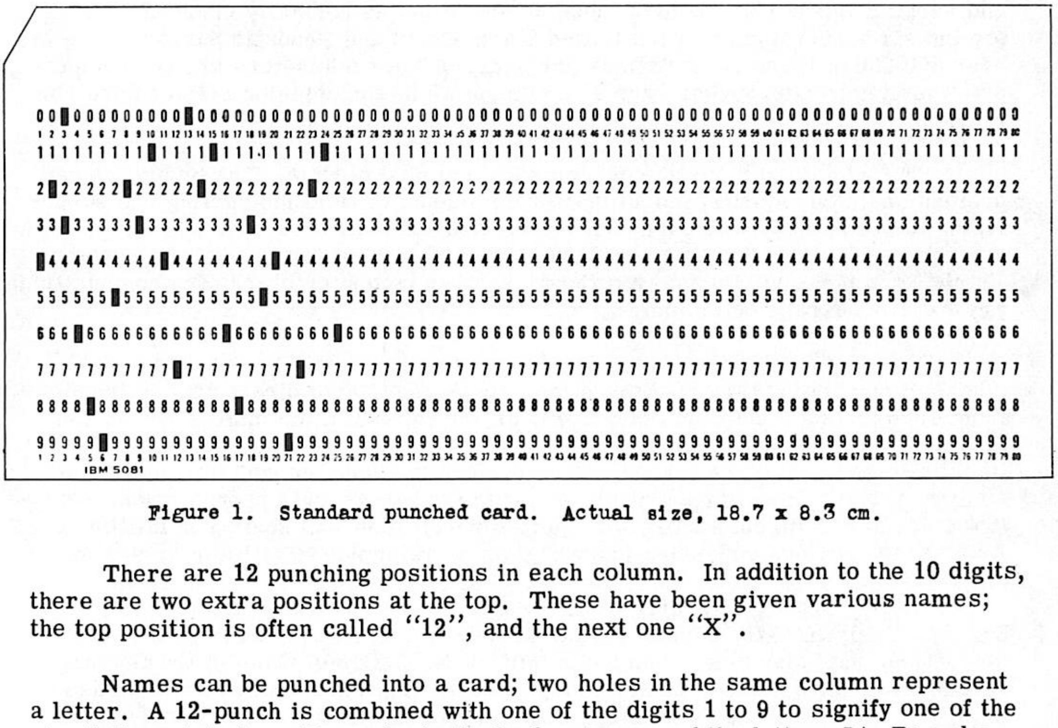


Figure 1. Standard punched card. Actual size, 18.7 x 8.3 cm.

There are 12 punching positions in each column. In addition to the 10 digits, there are two extra positions at the top. These have been given various names; the top position is often called "12", and the next one "X".

Names can be punched into a card; two holes in the same column represent a letter. A 12-punch is combined with one of the digits 1 to 9 to signify one of the nine letters A to I; an X-punch similarly denotes one of the letters J to R; and a zero in conjunction with one of the digits 2 to 9 represents one of the remaining letters S to Z.

When a card is run through a machine, an electrical contact is made through the hole. An electrical current will pass if the external wiring has been arranged to permit it. This current can be made to do various things, depending upon the machine and how the "plugboard" is wired (see Appendix).

Routine for Computing Observatory Results

Figure 2 shows the special "scaling sheet" that is used for recording hourly mean ordinates. It is arranged in the form considered most convenient for punching data into cards, irrespective of its convenience for any other purpose. The ordinates of D, H, and Z for a given day and hour are written side by side, since they will all go into the same card. The hour-number is repeated for each day, since it has to be punched each time. The wide space between days makes it easy to tell where to stop punching a card. A negative ordinate is recorded in red ink, with a

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Division: Geo. & Seis.
Form 404e
(FEB. 1940)

CHELTENHAM (Observatory) 1947 (Year) NOV (Month)

HOURLY MEAN ORDINATES FROM MAGNETOGRAMS

Average values for successive periods of one hour beginning at midnight 75 M.T.
Tenths of millimeters corrected to shrinkage distance of 140.0 mm

Signs reviewed by ____

Char.	1			1			0		
*Shr.	139.6			139.5			139.8		
Day	10			11			12		
Hr.	D	H	Z	D	H	Z	D	H	Z
01	-140	169	183	-175	262	200	-188	236	210
02	-179	209	166	-150	297	209	-161	286	204
03	-184	188	184	-091	370	178	-168	339	199
04	-155	184	199	-199	377	167	-182	286	200
05	-149	221	199	-219	370	188	-165	312	206
06	-160	246	184	-205	386	194	-183	348	210
07	-179	234	203	-183	366	183	-189	349	217
08	-171	159	205	-169	295	174	-200	330	210
09	-190	062	209	-186	065	169	-190	288	209
10	-180	076	225	-099	030	182	-173	273	199
11	-164	179	223	-071	076	189	-161	246	190
12	-150	145	209	-090	010	189	-150	224	195
13	-130	060	226	-050	-025	204	-140	210	200
14	-126	169	239	-100	170	231	-140	249	215
15	-136	249	249	-129	242	247	-139	270	221
16	-161	266	259	-152	250	268	-142	278	225
17	-230	250	280	-157	290	259	-155	327	224
18	-170	213	290	-170	254	249	-170	337	226
19	-198	289	269	-196	276	250	-189	326	225
20	-189	197	285	-178	278	239	-187	327	226
21	-259	254	249	-196	199	245	-190	318	224
22	-184	238	244	-218	182	235	-180	379	208
23	-180	265	239	-167	288	179	-182	338	209
24	-175	266	229	-198	285	206	-179	319	210
Sum	-4139	4788	5447	-3748	5593	5054	-4103	9195	5062
Mean	-172	200	227	-156	233	211	-171	300	211
* Scaled by	JLB	JLB	JLB	RLG	RLG	RLG	RLG	RLG	RLG
*Checked by	RLG	RLG	RLG	JLB	JLB	JLB	JLB	JLB	JLB

*This entry refers to magnetogram which begins on this day rather than to calendar day

M-2608-4

Figure 2. Scaling sheet, especially designed for use in connection with punched-card processes.

minus sign in front of it. The sums are intended principally for checking the punching. The character figure, C, is based on the local day, not the Greenwich day.

The magnetograms are scaled at the observatories, but the rest of the work is done in the Washington Office. The first step is to interpolate values where the record is missing, if there is a reasonable basis for doing so. Missing values greatly complicate the punched-card routine.

The data are then punched into a specially prepared card. (A standard card could be used, but it is easier to examine the cards if the significance of each column is shown on the card.) Figure 3 shows a card for the Cheltenham Magnetic Observatory (CH in columns 19-20), for the 23rd hour of April 30, 1948. It shows the following ordinates: D, -19.3 mm; H, 48.3 mm; Z, 14.5 mm. Broken lines on the card correspond to decimal points. Columns 1-2 are punched with the duplicating attachment of the Alphabetical Duplicating Punch. Columns 3-16 are keypunched by the operator. (Columns 14-16 have "X-punches" for negative ordinates.) C is punched in column 17, for the first hour of each day.

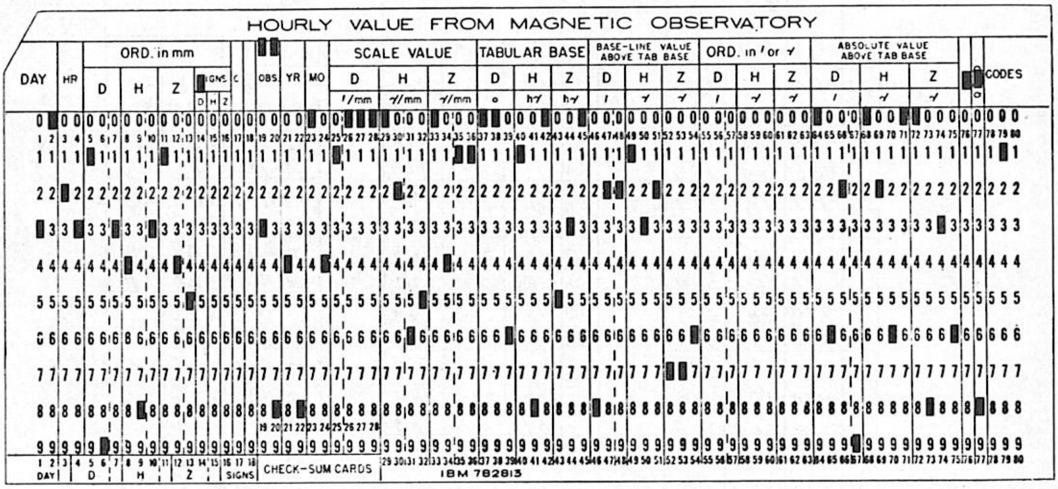


Figure 3. Special punched card, showing hourly means for 23rd hour of April 30, 1948, for Cheltenham Observatory.

The sums shown on the scaling sheet are also punched. These cards are not kept separate; the sums for a day are punched after the 24th hour has been punched. These cards are identified by a 9 in column 3, and the data are in the columns indicated at the bottom of the card. (If a check-sum is 10000 or more, the first digit is omitted.)

When all the cards for a month have been punched, columns 19-24 are gang-punched by the Reproducing Punch. Usually, several observatory-months are done at once, each being preceded by a "master card" showing what is to be gang-punched into the following hourly-value cards. Each master card has an X in column 80 to instruct the machine to start gang-punching from the new master card.

The cards are then run through the Alphabetical Accounting Machine, which prints the data from the cards on long "proof-lists". At the same time, it adds together the 24 hourly values for each day, and then subtracts the check-sum (it distinguishes the check-sum by the 9 in column 3). The machine automatically takes a total whenever the day-number changes. If the resulting sum is zero, the cards are considered correct; a non-zero sum shows that an error was made, either in the adding or in the key-punching. (The machine is wired to carry out this computation algebraicly, responding to X-punches placed in the appropriate columns to denote negative quantities.)

The machine is also wired to print the sum of all the hourly values for a month, by an independent summation. It automatically takes this sum whenever the year, month, or observatory changes.

Figure 4 shows a specimen section of one of the resulting "proof-lists". The subtraction of the check-sum for June 9 balanced the counters, and we assume that those cards are correct. But for June 10, there is an error, as shown by the figures in the right part of the sheet. These figures are the sums of the listed figures--when the sum is zero, nothing at all is printed.

When an error is indicated, the necessary corrections are made, and the cards are relisted as necessary to insure accuracy.

Next, master cards are prepared, showing the adopted base-line values and scale values; each of these cards has an X-punch in column 80. A new card is needed whenever any scale value or base-line value changes. These cards could be "merged" with the hourly-value cards, either by hand or on the Collator, and the data could be punched into the hourly-value cards with the Reproducing Punch, controlling on the X in 80. The base-line value is separated into two parts, the "tabular base" and the "base-line value above tabular base". (The former will appear at the head of the printed tabulation of hourly values.) The tabular base is given in degrees or in hectogammas (1 hγ = 100γ). In figure 3, the base-line values are: D, 7° 22!2; H, 18132γ; Z, 53776γ. The scale values are D, 1.000 '/mm; H, 2.65 γ/mm; Z, 4.11 γ/mm.

In practice, however, it is more convenient to use master cards that show the international quiet and disturbed days as well as the base-line values. Efficient preparation of these is a rather complicated process. In figure 3, the Q in column 77 shows that this hour falls on an international quiet day; the 1 in column 79 shows that it falls in the portion of a quiet day (based on Greenwich time) that comes on the previous day by observatory time; and the X in 76 shows that it falls on a selected day for a month different from that shown in columns 23-24. (I.e., it is April 30 by Cheltenham time, but May 1 by Greenwich time.) All three of these columns have been found to be necessary for the efficient processing of the results.

We now have B, s, and n punched in each card. The cards are then run through the Calculating Punch, which computes N = B + s n in one step, and punches N into the same card, at a rate of about 35 cards per minute. It is run separately for D, H, and Z.

If the scale value is a function of ordinate, a special deck of master cards is prepared, showing the ordinate in gammas as a function of ordinate in millimeters. These cards and the hourly-value cards are then run through the Sorter, and arranged in sequence according to the H ordinate. Then they are gang-punched to show the ordinate in gammas, and are sorted again by day and hour.

Obs'y	Yr.	Mo.	Day	Hr.	C	D ord.	H ord.	Z ord.	
Tu	49	06	09	01	0	143	256	162	
			09	02		161	286	161	
			09	03		158	278	160	
			09	04		167	270	160	
			09	05		175	296	165	
			09	06		199	317	173	
			09	07		230	317	174	
			09	08		261	297	169	
			09	09		253	278	150	
			09	10		225	280	125	
			09	11		176	269	112	
			09	12		121	239	107	
			09	13		110	239	117	
			09	14		73	310	109	
			09	15		43	322	82	
			09	16		69	309	93	
			09	17		81	328	118	
			09	18		99	310	141	
			09	19		125	291	147	
			09	20		130	290	143	
			09	21		121	275	146	
			09	22		134	260	146	
			09	23		138	269	148	
			09	24		135	273	150	
			09	9		-3527	-6859	-3358	⟸ Check-sums
Number of cards ⟶					24				

Tu	49	06	10	01	0	138	280	151
			10	02		143	283	151
			10	03		152	284	151
			10	04		152	308	152
			10	05		167	307	153
			10	06		178	317	156
			10	07		210	327	163
			10	08		258	309	160
			10	09		239	301	139
			10	10		200	313	115
			10	11		148	327	117
			10	12		101	343	128
			10	13		80	328	125
			10	14		81	316	120
			10	15		92	287	121
			10	16		96	265	132
			10	17		102	263	147
			10	18		129	263	161
			10	19		141	271	159
			10	20		134	287	150
			10	21		130	296	151
			10	22		130	293	152
			10	23		290	152	
			10	24		142	292	152
			10	9		-3479	-7150	-3458
					24			

Amounts by which check-sums fail to check		
D	H	Z
154	.00138	-00152

Figure 4. Proof-list, used for checking the key-punching of the hourly values. The figures at the right show that the sums for June 10 do not check, because of an error in punching a card. (A period is here equivalent to a minus sign.) The correct ordinates for the 23rd hour are: D, 136; H, 290; Z, 152. All ordinates are in tenths of a millimeter.

The cards are then run through the Accounting Machine again, to get the daily sums; then they are sorted by hour, and are added again, to give hourly sums. During these processes, the Accounting Machine and the Reproducing Punch are connected together, and the latter punches the results of the addition into new cards called "summary cards". In addition to summing the "absolute value above the tabular base", we also sum the "ordinate in mm", and the "base-line value above the tabular base". The last two are used only in checking the computations of the Calculating Punch. The Accounting Machine and Reproducing Punch are also used for computing the sums for the selected days. Each summary card shows the number of days that entered into its totals.

The Calculating Punch may then be used to divide the sums on the summary cards by the number of days; one run is needed for each element. Division is a relatively slow process; the work may be expedited by separating the cards according to number of days involved, and for each group multiplying by the reciprocal.

The Accounting Machine is used once more, to tabulate the hourly values and the means on a form suitable for lithographic reproduction. Since the machine cannot tabulate 24 hours side by side, only 12 hours are put on a sheet. A special form has been printed for this purpose. Consecutive cards are automatically printed on the same line until there is some change in the observatory, year, month, or day. Suitable "dummy" cards are inserted to provide extra spaces at the desired points. Part of the heading is printed, and the rest is entered by the Accounting Machine from special "heading cards", one or more cards being required for each line of the heading.

The cards will be available indefinitely for any other computations that may be considered desirable, such as computation of daily variation, or solar or lunar harmonic analyses. It is to be noted, however, that as time goes on, storing the cards will be a serious problem. A cardboard box holding 10,000 cards measures 38 by 45 by 21 centimeters. Such a box will just hold the cards for one observatory for one year, including the summary cards. The cards for six observatories will fill about 0.22 cubic meter per year.

Conclusion

Effective organization of a project of this type requires careful study, founded on an intimate knowledge of the capabilities of punched-card machines. Hence, such a project should not be undertaken without rather extensive preparation.

It is still too early to be able to give any definite estimate as to how long the routine processing of observatory scalings will take. A great deal of time has been spent in getting set up to do the job efficiently, and this is not quite finished. It seems quite certain, however, that when the computations are on a routine basis, they can be done with punched cards much more efficiently than by ordinary means.

IBM punched-card machines are rented rather than sold. The minimum equipment that would do the job costs about $7,000 per year. Even if the machines were used only for computing the results of six observatories, they would pay for themselves. Actually, the installation includes other machines than the bare minimum, and magnetic observatory work is only a small part of the work done on them.

The Coast and Geodetic Survey would be glad to make its detailed procedures available to any agency that is interested in trying out punched-card methods for processing observatory scalings.

Appendix--Punched-Card Machines Used by the Coast and Geodetic Survey

Type 031 Alphabetical Duplicating Punch. This has a keyboard similar to that of a typewriter, and is used for punching cards with data from any type of document. For greater speed, the punch and the carriage are power-driven. Part of a card may be reproduced from a master card in a duplicating rack, with the rest of the card key-punched.

Type 1 Mechanical Punch, and Type 36 Alphabetical Printing Punch. These key-punches are also on hand.

Type 080 Sorter. This will distribute the cards into pockets according to the hole punched in any selected column of the card, at the rate of 450 cards per minute. For arranging cards in sequence according to a three-digit number, the cards must be run through the Sorter three times.

Type 075 Card Counting Sorter. This also sorts cards, at a rate of 400 per minute, and counts the number of cards that go into each pocket.

Type 405 Alphabetical Accounting Machine. This machine reads the holes in the cards, and transforms the information into lists printed on long sheets of paper, perforated for convenient separation. At the same time, it will add data and print totals. The model used by the Coast and Geodetic Survey will sum, at one time, 16 different series of numbers, containing a total of 80 digits. It lists at a rate of 80 cards per minute, with a brief delay for taking totals. A "plugboard" determines which card columns are to be listed and in what part of the paper, which columns are to be added, and where the totals are to be printed. The plugboard is very flexible; for example, the choice of data for listing is entirely independent of choice of data for adding. By means of "selectors", the machine may be made to add or list one set of columns for one type of card, and different ones for other cards; the cards of one type are distinguished by an "X-punch" or "digit-punch" in a specified column.

Type 513 Reproducing and Summary Punch. This will "reproduce" cards; i.e., cards may be run through two separate feeds, at the rate of 100 cards per minute in each feed, and the pattern of holes encountered in each card of one feed may be reproduced in the corresponding card of the other feed. This is controlled by a plugboard, so that only the desired columns are reproduced, and they may be transposed into any desired arrangement in the second feed. It will also "gang-punch"; i.e., punch identical patterns into any specified columns of a whole group of cards. In "intermittent gang-punching", data are punched from a certain master card until a new master card is reached (identified by an X-punch in some particular column), whereupon the machine starts punching from the new master. For "summary-punching" this machine is connected to the Accounting Machine, so that the Reproducer punches into "summary cards" the results of additions made on the Accounting Machine. The Machine can do any two of these operations at once, or all three of them.

Type 602 Calculating Punch. This machine reads numbers from a card, multiplies, divides, adds, or subtracts them (according to the wiring of the plugboard), and punches the results into the same card. Its speed depends upon the amount of computing involved; multiplication is much faster than division.

Type 077 Collator. One use of this machine is to merge in sequence two sets of cards, each of which is already in sequence.

Type 552 Alphabetical Interpreter. (Not included in the installation of the Coast and Geodetic Survey, but available for limited use in the nearby installation of the Maritime Commission.) This machine reads the holes in a card, and interprets them, printing the interpretation at the top of the card. It operates at 60 cards per minute. It has a plugboard, so that only the desired columns need be interpreted; and the interpretation can be put into any part of the top of the card.

U. S. Coast and Geodetic Survey
Washington 25, D. C.

CONTRIBUTION À L'ÉTUDE DE LA VARIATION SÉCULAIRE DE LA CONSTANTE MAGNÉTIQUE LOCALE G

Par A. Romañá et C. Gaibar

On a calculé la carte de distribution dans le globe de la constante magnétique locale G pour l'époque 1933.0, en s'appuyant sur les données d'environ 200 observatoires permanents ou stations magnétiques temporaires, tirées pour la plupart de la "List of geomagnetic observatories and thesaurus of values" de Fleming et Scott. On a déduit aussi sa variation séculaire à l'aide de 142 courbes de variation pour autant de stations, comprenant en tout plus de 4000 valeurs de G. Les courbes ont été classifiées dans les trois groupes signalés par Rougerie, mais, avec quelques modifications. Le type américain embrasse aussi l'Afrique du Sud d'un côté et de l'autre il s'étend sur le Pacifique jusqu'à Honolulu et Samoa. Au type européen on y adjoint l'orient moyen et l'Australie. Pour le type asiatique aucune modification. La classification précédente permet d'établir la périodicité de la variation de G dans le monde entier et non seulement en Europe. Pour celle-ci et l'Asie septentrionelle la sémipériode semble être d'environ 35 années, résultat corroboré par la période complète d'environ 70 ans trouvée pour les observatoires de Greenwich et Coimbra; pour l'Amérique elle est évidemment plus longue, sans que l'on puisse encore fixer la durée. On a étudié ensuite le déplacement progressif de l'aire de ΔG positif pour les époques 1903-1913, 1913-23, 1923-33, 1933-43. On remarque que celle-ci, qui pour la première époque ne couvrait qu'une petite extension dans le SE de l'Asie, n'a cessé de grandir depuis lors, en s'étendant dans la direction SE-NW; elle a englobé déjà dernièrement l'observatoire de San Juan de Puerto Rico en Amérique. Dans tous les cas on a étudié aussi en même temps la distribution géographique et les variations de la force magnétique totale F, pour en faire ressortir la ressemblence avec G. Le travail tout entier sera publié dans un des prochains fascicules de "Geofisica pura e applicata".

Observatorio del Ebro
Tortosa, Spain

RAPPORT SUR LA RÉALISATION D'UN CENTRE D'ÉTUDES GÉOPHYSIQUES EN BELGIQUE

Par Edmond Lahaye

A complete account of this new establishment is given in Institut Royal Météorologique de Belgique Mémoires, vol. XXXI, "Le Centre de Physique du Globe à Dourbes" par Edmond Lahaye (24 pp. and 8 plates). The volume contains, as Annexe 1, the text of the paper presented at Oslo.

SUR LA CARACTÉRISATION MAGNÉTIQUE DES JOURS

Par Edmond Hoge et Edmond Lahaye

Le but de cette brève communication est simplement de soumettre à l'Assemblée une suggestion relative à l'activité magnétique. En général, les différents modes de caractérisation proposés jusqu'ici tiennent compte de l'allure de la courbe et de l'amplitude des perturbations. La difficulté a toujours été de rechercher un mode objectif de caractérisation. Outre l'attribution d'un chiffre qui tient compte de l'amplitude des perturbations, ne pourrait-on envisager également la longueur de la courbe, soit pour une journée entière, soit pour un intervalle de temps déterminé (3 h. par ex.)? Cet élément seul ne pourrait évidemment suffire, car une seule perturbation conduirait à une longueur de courbe qui pourrait être la même que pour une série de perturbations de plus faible amplitude. Neanmoins la longueur de la courbe, que l'on déterminerait à l'aide d'un curvimètre précis, tiendrait compte à la fois du nombre et de l'amplitude des perturbations. Il faudrait y ajouter un chiffre tenant compte de ce dernier facteur. Nous pensons que de cette façon, nous aurions à notre disposition un ensemble plus complet pour caractériser l'agitation magnétique. Toutefois, il y aurait lieu d'examiner quel serait le procédé le plus adéquat:

Soit adopter deux chiffres, l'un se rapportant à la plus grande amplitude observée, l'autre tenant compte de la longueur de la courbe.

Soit adopter un seul chiffre tenant compte à la fois de ces deux éléments.

Uccle, Belgique
le 10 août 1948

GEOMAGNETIC INDICES, C AND K, 1940-47

By H. F. Johnston, W. E. Scott and Ella Balsam

The geomagnetic indices, C and K, 1940-47 were published in 1948 as Bulletins 12 and 12a of the Association of Terrestrial Magnetism and Electricity of the International Union of Geodesy and Geophysics.

LOCAL GEOMAGNETIC ANOMALIES IN VOLCANIC REGIONS AND THEIR INTERPRETATION

By T. Nagata

During recent ten years, systematic magnetic surveys in the neighborhood of various volcanoes in Japan were carried out for the purpose of clearing a particular distribution of magnetic field due to volcanoes. They are Mt. Asama, Mt. Fuji, Volcanic Island Miyake-shima surveyed by Minakami, and Mt. Usu, Mt. Amagi, Mt. Sakurajima surveyed by the writer and his colleagues. Those data being added, total number of volcanoes in Japan, on which the magnetic survey was carried out, amounts to twelve. Almost all of the magnetic surveys were made by means of three-component magnetometers, number of observing stations amounting to 15-40 for individual volcano. The mode of distribution of local geomagnetic anomaly at these volcanoes is quite similar to each other, though the intensity of anomaly varies according as what kind of rock composes the volcano. The anomalous field observed is in a good agreement with the calculated one assuming to be due to the circular symmetric body of volcano which is uniformly magnetized, as will be seen, for an example, in Figure 1.

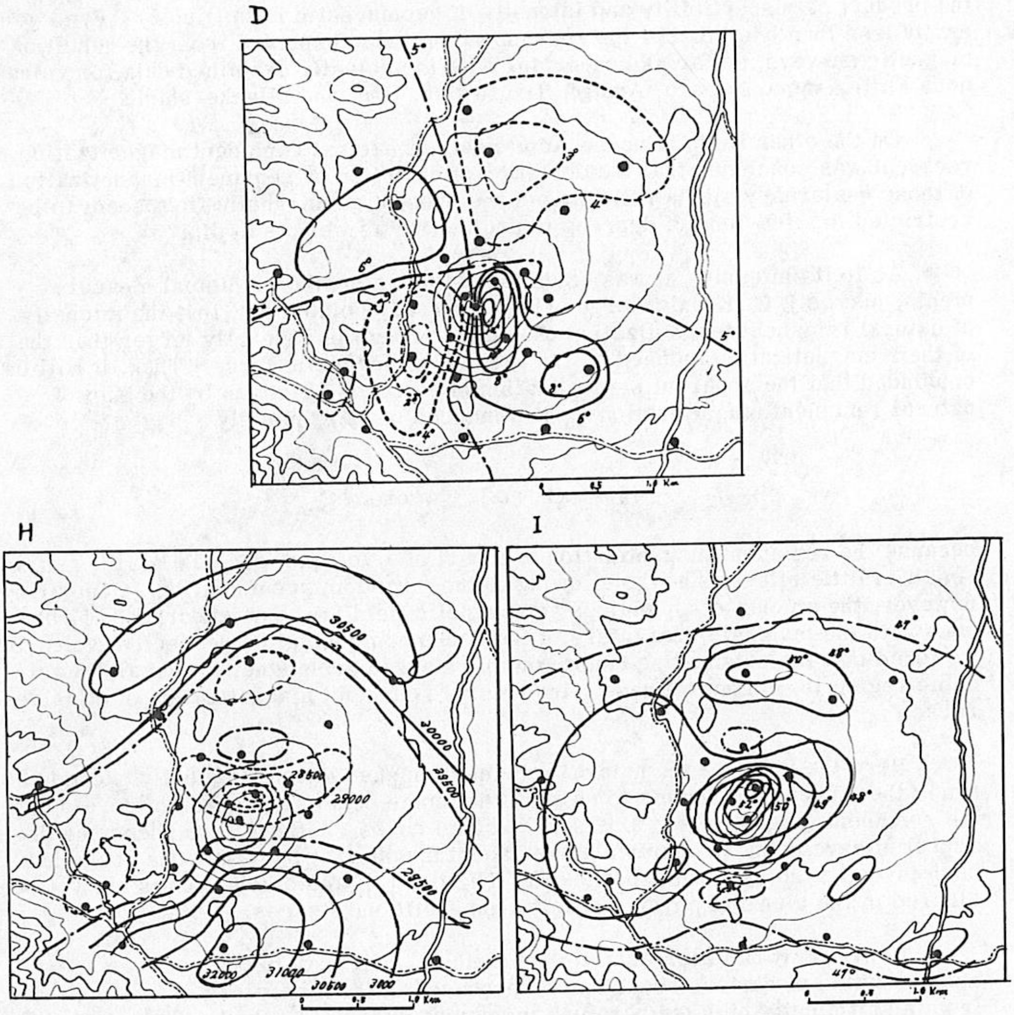


Fig. 1--Local magnetic anomaly on Volcano Ohmuro, Izu Peninsula

From the comparison of the observed distribution with the calculated one, the direction of magnetization of these volcanoes was determined, the result showing that it nearly agrees with that of the present geomagnetic field in both declination and dip within the error of $\pm 20^\circ$ in every case. This fact will show that those quaternary volcanoes in Japan are magnetized almost in the same direction as that of the present geomagnetic field. However, it cannot be directly concluded that all of the magnetization of these volcanoes is induced by the present geomagnetic force. The average intensity of magnetization of volcanoes derived from the results of magnetic surveys is between 2×10^{-3} e.m.u. and 2.5×10^{-2} e.m.u. according as the rock composing the volcano varies from acidic rocks to basic ones.

The intensity of induced magnetization of rock samples, which is given by the product of susceptibility and intensity of geomagnetic field, i.e. $\kappa \times F$, is generally less than one third of the corresponding value expected from the result of magnetic surveys, so far as concerning with the actually examined data for volcanoes Fuji, Asama, Mihara, Amagi, Sakurajima, Usu, and Miyake-shima.

On the other hand, from the actual data of natural remanent magnetization of rocks, it was concluded that the deviation of direction of remanent magnetization of those quaternary ejecta from that of the present geomagnetic field seem to be restricted to a few tens of degrees in declination as well as in dip.

As to its intensity, it was established from a number of actual measurements, just as J. G. Koenigsberger [1] has already pointed out, that the intensity of natural remanent magnetization of volcanic rocks is generally larger than that of their magnetization induced by the present geomagnetic force. Then, it will be concluded that the apparent magnetization of volcano $\vec{J}$ is given by the sum of natural remanent magnetization $\vec{J_n}$ and induced one $\vec{\kappa F}$, namely

$$\vec{J} = \vec{\kappa F} + \vec{\alpha J_n}, \quad \text{where } \alpha < 1$$

because the remanent magnetization of a part of a volcano, such as lapilli, ash, etc. result in little effect as a whole, owing to their random accumulation. Comparing, however, the amount of anomalous geomagnetic field in the neighborhood of volcanoes with the magnetic characters of the rocks composing the respective volcanoes, we found that the outstanding cause for this marked geomagnetic anomaly in volcanic region is, in general cases, the natural remanent magnetization of effusive rocks.

Here the fact that the natural remanent magnetization frequently exceeds 20 times the induced one seems to suggest that some peculiar process of developing the remanent magnetization exists in volcanic rocks. Although the phenomenological aspect of developing the particular remanent magnetization of igneous rocks has been investigated by Koenigsberger [2], Thellier [3], and others, it has not yet been cleared in the views of physics of ferro-magnetic substances.

However, it has been established, without fail, that the natural remanent magnetization of igneous rocks can be produced in the laboratory by cooling the rock from a sufficiently high temperature in geomagnetic field. Further, the fact that large masses of lava flow newly ejected were permanently magnetized in just the same direction as that of geomagnetic field, having the so-called thermo-remanent magnetization, was actually observed by the writer in the cases of recent volcanic eruptions of Miyake-shima in 1940 [4], Mt. Mihara in 1940 [5], and Mt. Sakurajima in 1946. Moreover, from the change in anomalous geomagnetic field at places just near a cooling lava flow, the process of causation of local anomaly due to increase in remanent magnetization of rocks with decrease in temperature was also observed, and the reliability of the above-mentioned feature was ascertained by examining directly the magnetic properties of the rocks.

For the purpose of clearing the mode of developing the thermo-remanent magnetism in igneous rocks, the fundamental researches on the magnetic properties of these rocks were carried out as systematically as possible. The specimens examined in the laboratory were about a hundred samples of volcanic rocks, the chemical and petrological constitution of which were also determined by petrologists.

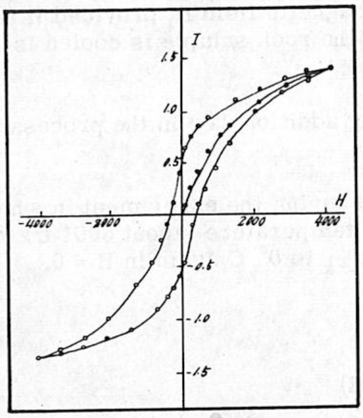


Fig. 2--Magnetic hysteresis curve of a basaltic rock ejecta of Volcano Miyakeshima

First, the magnetic hysterisis curve of various volcanic rocks was almost perfectly determined in the field from zero to 4000 Oe, an example of the results being shown in Figure 2. Although the intensity of saturation magnetization of various rocks is nearly proportional to the amount of Fe_3O_4 contained in them, ranging from 0.6 to 3.0 Gauss/gr., their coercive force ranges from 60 to 450 Oe.

Next, the magnetic susceptibility and its change with temperature in a weak magnetic field of a variety of rocks were examined. The magnetic susceptibility is approximately proportional to the norm amount of magnetite in them, while it disappears at a certain temperature below 600° C. Taking

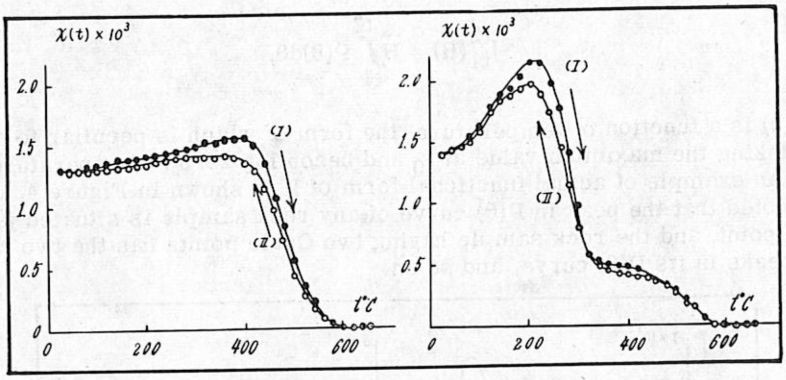


Fig. 3--Change in magnetic susceptibility of volcanic rocks with temperature

these observed facts into consideration, we can presume that the ferro-magnetic character of volcanic rocks is largely due to magnetite or its solid solution with other elements that are scattered as phenocrysts or micro-crystals in the groundmass among various minerals that are almost non-magnetic. Strictly speaking, however, susceptibility is not exactly proportional to the norm of magnetite, and the Curie point is not always uniquely given at 580° C-600° C, some rock specimens having a second Curie point at temperatures of 200° C-300° C, as shown for example in Figure 3. A comparison of chemical composition of some rocks with their behavior of thermal change in susceptibility leads to the conclusion that not only magnetite but TiO_2 also affects the magnetic property of volcanic rocks to a marked degree. With those rock samples, the magnetic and petrological characters of which were previously examined, the feature of development of marked remanent magnetization in a weak magnetic field was studied in the laboratory.

The residual permanent magnetization, which remains after the test rock sample is cooled in a weak magnetic field, is called the thermo-remanent magnetization, and written as T.R.M. in short [6]. The direction, then, of T.R.M. of volcanic rocks agrees with that of the magnetic field applied to them during the cooling, while its intensity is almost proportional to that of the magnetic field H, provided H is small and the range of temperature through which the rock sample is cooled is kept constant.

From a number of experiments, the following addition-law in the process of developing of T.R.M. was concluded.

Let $J_{ti-1}^{ti}(H)$ denote the T.R.M at 0° C caused during the experiment in which a rock specimen is cooled from a sufficiently high temperature (about 600° C) to t in H = 0 space, from t_i to t_{i-1} in H = H, and from t_{i-1} to 0° C again in H = 0.

Then we have the relation

$$J_{t'}^{t}(H) = \sum_{ti-1=t'}^{ti=t} J_{ti-1}^{ti}(H)$$

which always approximately holds in any example. Thus, it was finally established that, provided H is small, an ideal phenomenological aspect of development of T.R.M. in rock is expressed by

$$J_{t1}^{t2}(H) = \vec{H}\int_{t1}^{t2} P(\theta)d\theta,$$

where P(θ) is a function of temperature, the form of which is peculiar to each rock sample, taking the maximum value at t_0 and becoming zero at temperatures above 600° C. An example of actual functional form of P is shown in Figure 4, where it must be noted that the peak in P(θ) curve of any rock sample is situated just below its Curie point, and the rock sample having two Curie points has the two corresponding peaks in its P(θ) curve, and so on.

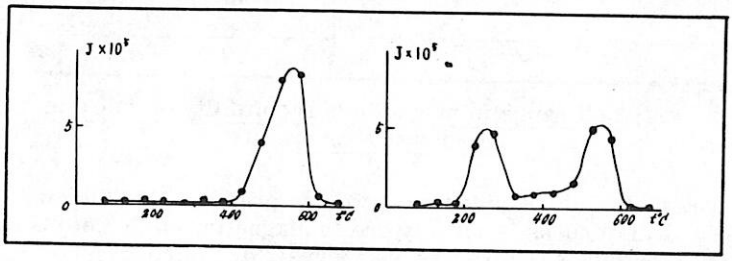


Fig. 4--P-curves for thermo-remanent magnetization. The samples examined are the same as those in Fig. 3

Next, the results of other experiments show that the T.R.M. $J_{ti-1}^{ti}(H)$, caused during cooling from t_i to t_{i-1} in H, always disappears during heating through the same temperature range, regardless of intensity and direction of magnetic field that is applied during the heating process.

Further, the modes of development and disappearance of T.R.M. were directly observed at any temperature during its development in cooling and disappearance in heating, an example of results being shown in Figure 5.

The curves in Figure 5 show that T.R.M., which is caused during cooling from 550° C to 500° C in H, gradually increases along the curve I with decrease in temperature in H = 0 space, and that according as the rock sample is re-heated or

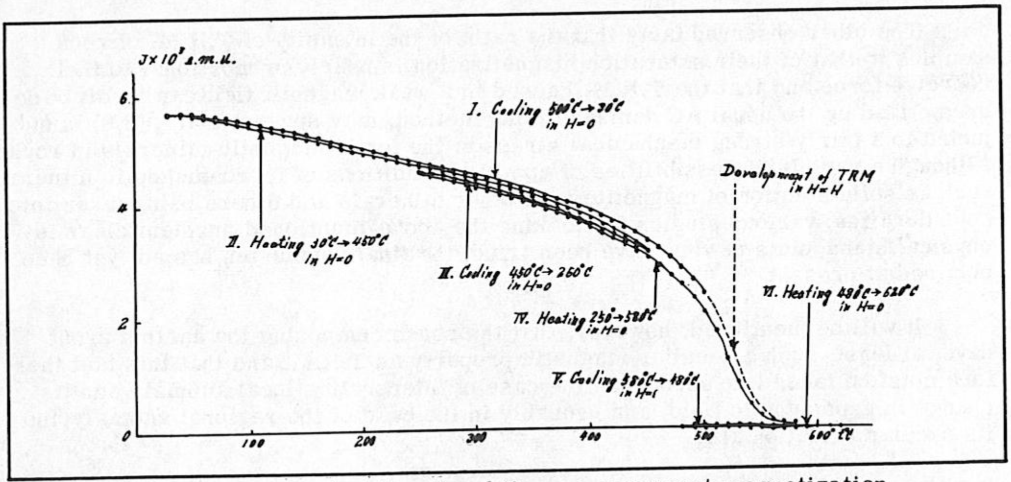


Fig. 5--Change in intensity of thermo-remanent magnetization with temperature

re-cooled in H = 0 space, the magnetization changes almost reversibly with the change in temperature, provided that the temperature does not exceed 550° C, while the T.R.M. disappears irreversibly if the temperature exceeds 550° C, as will be seen in curves (V)-(VI). The feature of change in magnetization mentioned above always holds in any example. Then we found that the intensity of T.R.M. at temperature t, $J_{t1}^{t2}(H,t)$ caused during cooling from t_2 to t_1 in H, is given by

$$J_{t1}^{t2}(H,t) = \vec{H}\cdot\int_{t1}^{t2} P(\theta,t)d\theta \quad (t<t_1<t_2)$$

$$P(\theta,t) = I(\theta,t)\cdot\phi(S,\theta)g(\theta), \quad \text{and} \quad P(\theta,o) = I(\theta,o)\,\phi(S,\theta)g(\theta) = P(\theta),$$

$$\frac{\partial}{\partial t}I(\theta,t)<0 \quad (t<\theta),$$

where $I(\theta,t)$, $\phi(S,\theta)$, and $g(\theta)$ denote, respectively, the intensity of spontaneous magnetization at t of the ferro-magnetic mineral that has its Curie point at θ, the probability of irreversible magnetization of the elemental domains in the ferro-magnetic minerals being subjected to both of Curie point θ and internal stress S which resists against the magnetization, and the density of distribution of ferro-magnetic minerals with respect to the Curie point temperatures. Here, $I(\theta,t)$ is an unique function of t, changing reversibly with the change in temperature. While $\phi(S,\theta)$ takes place only during the cooling process of rocks, and vanishes during the reverse heating process. The above-mentioned hypothesis harmonizes well with all the observed facts, and the most important problem remaining in this particular phenomenon of T.R.M. will be concentrated to what is the physical mechanism of causation of $\phi(S,\theta)$. Although the experimental studies on single crystals of magnetite and some other ferro-magnetic alloys were carried out in the same way with the aid of the cooperation by specialists for physics of ferro-magnetic substance, it has been concluded that nothing but ferromagnetic minerals composing rocks cannot get the T.R.M. The phenomenon of T.R.M., therefore, will be a particular characteristic of the rocks, so far known at present.

The other observed facts that the ratio of the intensity of T.R.M. of rock samples to that of their saturation magnetization is nearly proportional to their coercive force and that the T.R.M. caused in a weak magnetic field can hardly be demagnetized by the usual AC demagnetizing method, may suggest that $\phi(S,\theta)$ is subjected to a fairly strong mechanical stress in the ferro-magnetic minerals in rocks. Although a variety of possibilities of complex conditions of ferro-magnetic minerals such as solid solution of magnetite with other minerals and others being taken into consideration, various studies for making the above-mentioned problem clear in physical standpoints of view have been tried, the final conclusion has not yet been obtained at present.

It will be mentioned, however, that the rocks composing the earth's crust have, at least, such a peculiar magnetic property as T.R.M. and that this fact therefore must be taken into account in the case of interpreting local anomaly and its change in geomagnetic field, and probably in the case of the regional anomaly and its secular variation also.

References

[1] J. G. Koenigsberger, Zs. Geophys., vol. 6 (1930), 190.
[2] J. G. Koenigsberger, Terr. Mag., vol. 43 (1938), 119; 299.
[3] E. Thellier, Ann. Phys. Globe, vol. 16 (1938), 157.
[4] T. Nagata, Bull. Earthq. Res. Inst., vol. 19 (1941), 304.
[5] T. Nagata, Bull. Earthq. Res. Inst., vol. 19 (1941), 402.
[6] T. Nagata, Bull. Earthq. Res. Inst., vol. 21 (1943), 1.

Geophysical Institute
Tokyo University
Tokyo, Japan

SUDDEN MAGNETIC VARIATION DURING THE VOLCANIC ACTIVITY OF ASAMAYAMA

By H. Nagaoka and T. Ikebe

The complete text has been published in Proceedings of the Imperial Academy, Tokyo, vol. 13, pp. 34-37 (1937).

MAGNETIC VARIATION DURING AN EXPLOSION OF ASAMAYAMA AND ITS MECHANISM

By H. Nagaoka and T. Ikebe

The complete text has been published in Proceedings of the Imperial Academy, Tokyo, vol. 13, pp. 251-256 (1937).

L'EVOLUTION DIURNE LUNAIRE DE LA DECLINAISON MAGNÉTIQUE AU VAL-JOYEUX

Par Paul Rougerie

Malgré l'impulsion donnée par S. Chapman aux recherches se rapportant à l'influence de notre satellite sur l'évolution des phénomènes géophysiques on ne dispose actuellement que d'un nombre restreint de résultats concernant la distribution effective de la "marée géomagnétique" sur l'ensemble du Globe. A ma connaissance, les observations magnétiques françaises n'ont jamais fait l'objet d'une analyse en vue de la détermination de l'effet lunaire. Aussi afin de combler cette lacune et d'apporter une contribution nouvelle avons-nous essayé dans ce travail de dégager les principales caractéristiques de ce genre de variations magnétiques à partir des mesures continues recueillies durant 25 années environ à l'Observatoire du Val-Joyeux près de Paris.

Les données initiales sont constituées par les valeurs horaires de la déclinaison magnétique enregistrée entre le 1er Janvier 1912 et le 31 Mars 1937. Ces observations se répartissent régulièrement sur 312 lunaisons complètes et comportent 8897 journées lunaires utilisées. La majeure partie de la variation diurne solaire a été éliminée en retranchant de chacune des 24 valeurs horaires journalières la valeur moyenne mensuelle correspondant à celle-ci. Les écarts horaires exprimés en minutes ont été ensuite reclassés en fonction du temps lunaire en rapportant le début du jour lunaire (Oh) à l'heure solaire ronde la plus voisine de l'heure du passage supérieur de la Lune au méridien. Ces "écarts lunaires" pris par rapport au temps solaire ont servi à établir pour chacun des mois de l'année 24 séries de tableaux contenant les divers jours lunaires utilisés, ainsi représentés par 26 valeurs horaires. La 26ème colonne de ces tableaux (24h lunaire) a permis de tenir compte de la variation non périodique dans le calcul des marches diurnes lunaires moyennes. Chacune de ces 24 séries de 26 valeurs se rapporte aux jours lunaires débutant successivement par 1h, 2h, ..., 24h solaires, c'est à dire à des âges de la lune régulièrement espacés. Ces divers écarts horaires considérés d'après les saisons ont été enfin rassemblés en trois groupes saisonniers correspondant aux mois d'été (mai-août), d'hiver (nov.-fév.), d'équinoxes (autres mois), et un groupe annuel réunissant l'ensemble des données. Ce sont ces quatre résumés numériques fournissant l'évolution lunaire moyenne de la déclinaison magnétique au cours d'une lunaison complète qui ont été utilisés pour la détermination des quatre ondes lunaires principales de la forme $L_n = C_n \sin(n\tau + \varphi_n)$.

Pour ce but une méthode de calcul relativement simple et rapide indiquée par S. Chapman (1) a été employée. Elle consiste à compenser le mieux possible, par des groupements et des décalages convenables des écarts horaires, les changements graduels de phases pendant la lunaison, lesquels sont respectivement -2π, $+2\pi$ et $+4\pi$ pour les ondes diurnes, tiers et quart diurnes. Ce procédé analytique revient à effectuer des séries de sommations obliques sur les tableaux résumés, sauf pour l'onde semi-diurne dont la phase reste constante. L'analyse harmonique habituelle des résultats ainsi obtenus conduit à une valeur très approchée de L_n. Il est facile ensuite de trouver les vraies valeurs des coefficients de Fourier C_n et φ_n au moyen de facteurs correctifs aisément calculables une fois pour toute pour chacune des composantes harmoniques.

Pour chaque jour lunaire nous avons noté l'amplitude de la variation diurne restante laquelle se compose de la variation diurne lunaire, d'un résidu de la variation diurne solaire et des variations accidentelles résultant notamment de l'agitation magnétique (perturbations). Le graphique cidessous donne la répartition des amplitudes (pourcentage des jours) au cours des trois saisons et de l'année.

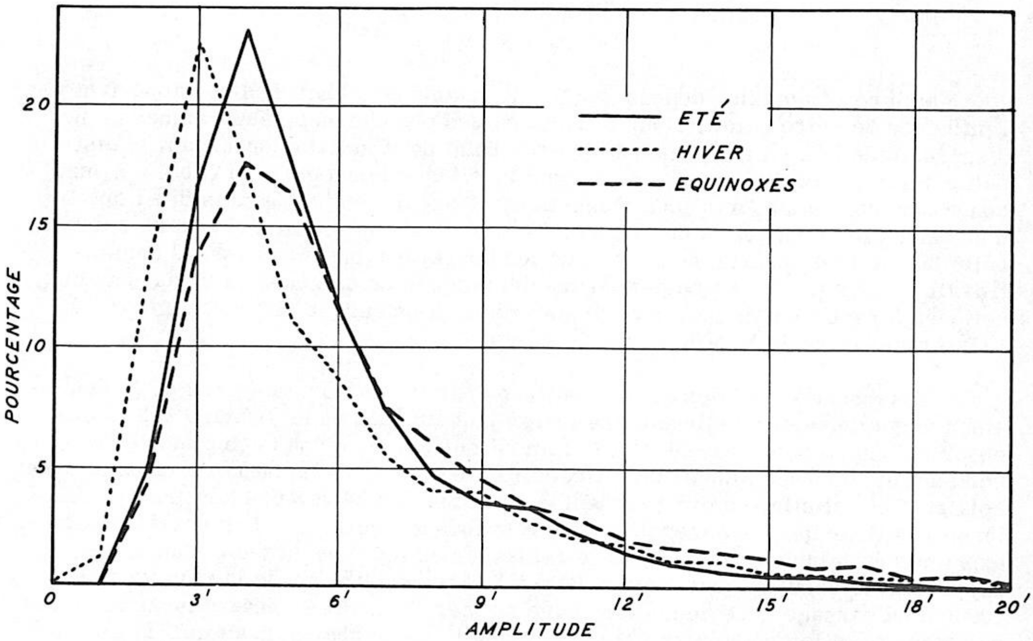


Fig. 1. Fréquence des jours lunaires de différentes amplitudes.

L'amplitude maximum rencontrée atteint 58' et 7 journées d'oscillation diurne supérieure à 36' ont été rejetées de notre statistique. L'amplitude la plus fréquente est de 3' en hiver et de 4' pendant les autres saisons. Le maximum d'agitation magnétique apparaît durant les mois d'équinoxes au cours desquels les journées calmes sont beaucoup moins nombreuses qu'en été ou pendant l'hiver qui présente un minimum marqué.

L'analyse harmonique des inégalités lunaires se rapportant à une lunaison moyenne complète tirée de l'ensemble des données fournit une vérification satisfaisante de la "loi des phases" illustrée par le graphique cidessous.

Les valeurs C_n ne restent pas parfaitement constantes pendant le cycle lunaire. Nous avons trouvé les écarts absolus moyens suivants:

$$C_1 \pm 0'.04$$
$$C_2 \pm 0.03$$
$$C_3 \pm 0.02$$
$$C_4 \pm 0.01$$

Ainsi l'amplitude de la composante semi-diurne L_2 a varié de 14 per cent environ de part et d'autre de sa valeur moyenne 0'.22. Pour ces mêmes composantes les écarts absolus extrêmes sont respectivement 0'.11, 0'.09, 0'.05 et 0'.04, valeurs élevées probablement imputables à une compensation insuffisante des écarts horaires anormaux provenant des fortes agitations magnétiques dans la sommation des inégalités lunaires.

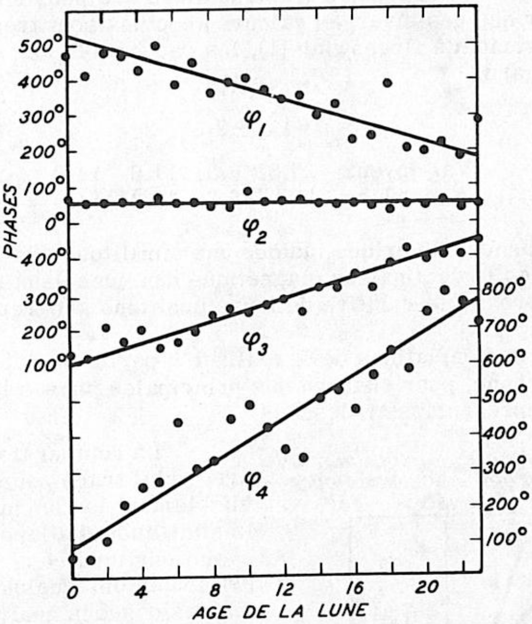


Fig. 2. Vérification de loi des phases.

Voici d'une part les variations saisonnières des coefficients C_n exprimés en minutes, et φ_n en degrés ramenés à Oh de la nouvelle lune:

	C_1	φ_1	C_2	φ_2	C_3	φ_3	C_4	φ_4
Eté	0ʹ.17	116°	0ʹ.36	63°	0ʹ.09	103°	0ʹ.02	34°
Equinoxes	0.10	161	0.20	67	0.09	181	0.05	80
Hiver	0.10	223	0.13	9	0.02	19	0.01	135
Année	0.09	149	0.22	55	0.07	102	0.02	92

et d'autre part les mêmes coefficients pour la variation diurne solaire correspondante, l'origine des temps choisie étant midi solaire:

	C_1	φ_1	C_2	φ_2	C_3	φ_3	C_4	φ_4
Eté	3ʹ.26	40°	2ʹ.43	47°	0ʹ.88	63°	0ʹ.08	91°
Equinoxes	2.71	59	2.10	37	1.10	53	0.47	71
Hiver	1.67	78	1.02	21	0.46	69	0.33	57
Année	2.46	55	1.82	38	0.81	60	0.28	68

La comparaison de ces deux tableaux met en évidence pour les deux groupes d'ondes L_n et S_n des variations saisonnières d'amplitudes et de phases beaucoup plus grandes pour L que pour S. A la fois, pour S et pour L, C_1 et C_2 sont plus importants en été qu'en hiver, tandis que C_4 moins bien déterminé dans le cas de L, semble passer par un maximum pendant les mois d'equinoxes. De plus, la composante principale de L est semi-diurne alors que pour S elle est diurne. Il y a lieu de souligner que ces diverses valeurs absolues sont très voisines de celles trouvées antérieurement à Greenwich (1), les rapports S_n/L_n ci-dessous sont assez suggestifs à cet égard.

	1	2	3	4
Val-Joyeux	27.3	8.3	11.6	14.0
Greenwich	29.2	8.3	13.2	14.0

Cette coincidence numérique indique une similitude des régimes diurnes solaire et lunaire de la déclinaison magnétique dans ces deux observatoires, attribuable à une proximité relative de leurs positions géographiques.

La synthèse des variations de L réalisée à partir des coefficients C_n et φ_n de la lunaison moyenne, pour chacune des principales phases lunaires est traduite par les courbes représentées ci-dessous.

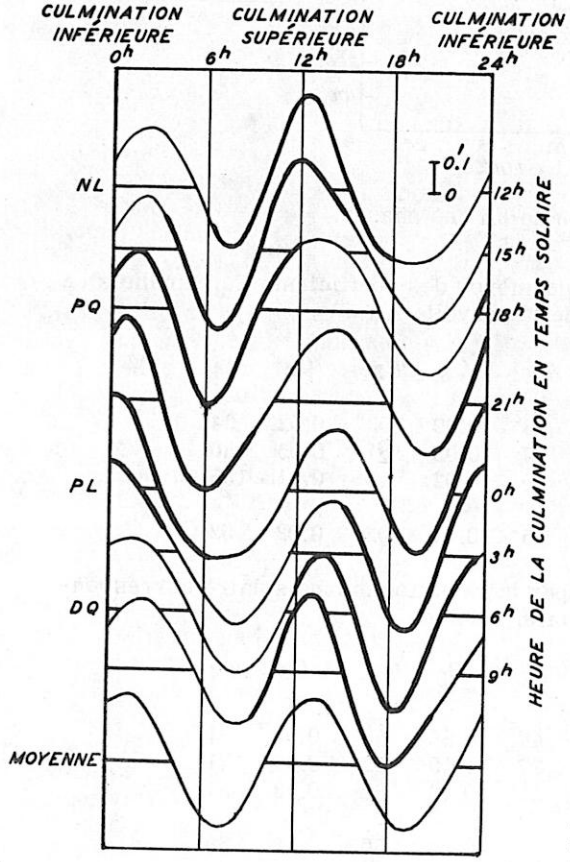


Fig. 3. Variation lunaire de D au Val-Joyeux.

La comparaison de ce graphique avec celui tracé pour Greenwich confirme visiblement la conclusion précédente sur la similitude d'allure générale des deux évolutions lunaires. Cette coincidence est néanmoins quelque peu surprenante, car les données analysées de Greenwich s'étendent sur 63 années d'observations (1848-1863, 1868-1914) alors que notre statistique n'en comporte que 25. De plus les courbes magnétiques des journées perturbées ont été pour Greenwich préalablement "adoucies" ou parfois même rejetées tandis que nous avons toujours conservé les valeurs horaires déduites de la lecture directe des magnétogrammes, n'éliminant que sept journées seulement sur l'ensemble des observations.

Malgré des modifications régulières avec l'époque de la lunaison, les diverses courbes de ce graphique n'offrent pas de déformations fortement accusées comme celles constatées avec les courbes correspondantes de Batavia. L'amplitude de la variation lunaire globale est environ 14 fois plus petite que celle de la variation solaire. Aussi les courbes magnétiques de la déclinaison enregistrées au Val-Joyeux ne sauraient présenter du fait de la superposition des deux évolutions des changements systématiques de forme analogue à ceux remarqués sur les magnétogrammes de la composante horizontale pendant les jours calmes à Huancayo (2).

References

(1) S. Chapman. The lunar diurnal magnetic variation at Greenwich and other observatories. Phil. Trans. Roy. Soc. London, série A, vol. 225, 1926, pp. 49-91.

(2) J. Bartels et H. F. Johnston. Some features of the large geomagnetic tides in the horizontal force at Huancayo. Amer. Geophys. Union, April 1940, Report of Terrestrial Magnetism, pp. 273-287.

SUR LA VARIATION SÉCULAIRE DU MAGNÉTISME TERRESTRE

Par M. A. Dauvillier

L'exploration magnétique du Globe a montré que le magnétisme terrestre était un phénomène très superficiel dépendant étroitement de la géologie. D'après la radioactivité des roches superficielles et leur conductibilité thermique, on peut estimer que le siège du géomagnétisme ne dépasse pas la profondeur d'une vingtaine de kilomètres sous les continents et d'une trentaine sous les océans. Sa distribution réflète étroitement celle des continents et des aires océaniques et il y a des raisons de croire que les fonds océaniques jouent un rôle important dans sa manifestation.

La variation séculaire a donné lieu à de nombreux travaux, parmi lesquels il faut citer ceux de H. Wilde, J. Bartels, L. Bauer, Bidlingmaier, Fisk, A. Schmidt. Elle a été considérée, soit comme un phénomène planétaire périodique, soit comme un phénomène régional accidentel. Parmi les hypothèses proposées pour en rendre compte, celle de Bidlingmaier (1910) nous paraît la plus satisfaisante. Elle est basée sur la variation de niveau, au cours du temps, de la surface isotherme de 580° C, point de Curie de la magnétite. On conçoit ainsi les variations importantes, rapides et toutes locales des éléments magnétiques.

Ayant, sur de nouvelles bases, calculé le bilan thermique interne du Globe (1), nous avons trouvé que la production de chaleur interne excédait considérablement le flux décelé par le gradient géothermique. L'excès représenterait l'énergétique du volcanisme mondial. Il en résulterait une relation entre la variation séculaire du géomagnétisme et la distribution du volcanisme. Les aires continentales, peu volcanisées, montrent, en effet, des variations séculaires beaucoup plus accentuées que les aires océaniques riches en volcans. Elles deviennent ainsi le siège des courants de magma postulés par Vening-Meinesz et dûs à l'accumulation de la chaleur interne. Il suffit d'une variation de niveau relativement faible de la surface isotherme critique pour produire une variation magnétique séculaire notable.

L. Bauer a montré que le moment magnétique du Globe décroissait actuellement d'environ un millième par an. Une telle variation ne pourrait persister, à ce taux, durant un cycle volcano-orogénique. Si cette variation séculaire a bien une cause thermique, nous concevons, au contraire, comment elle est susceptible de s'inverser et comment le moment magnétique est demeuré, en moyenne, constant, au cours des périodes géologiques.

Les diverses théories relatives à l'origine, à l'entretien et aux variations périodiques et accidentelles du géomagnétisme, sont d'accord pour admettre que celui-ci ne s'est jamais inversé dans le passé. L'existence d'anomalies magnétiques, sous forme de dykes présentant une aimantation inverse de celle du champ générale du Globe pose un problème demeuré sans solution. Tous les cas d'inversion connus ne peuvent s'expliquer par la fulguration, bien que ce phénomène soit géologiquement localisé et qu'il soit nettement polarisé. Ces dykes sont considérés comme des épanchements basaltiques s'étant aimantés dans le champ du Globe à l'époque de leur refroidissement, au point de Curie de la magnétite. Les dykes de Pilansberg sont proches de l'équateur magnétique, mais ceux d'Irlande, d'Alsace, de l'Arctique, en sont très éloignés. Ce phénomène nous parait devoir être rapproché de l'existence de houille, de coraux et de fossiles tropicaux dans les actuelles régions polaires et nous paraît devoir être expliqué par la même cause, à savoir par une dérive lente de l'écorce terrestre, au cours des époques géologiques, par rapport à la presque totalité de la masse du Globe. Une telle dérive due aux forces luni-solaires et à la dissymétrie des fosses océaniques, demeure toute superficielle. Elle respecte la permanence des continents et des océans et ne doit pas être confondue avec celle postulée par Taylor et Wegener. Les dykes inverses se seraient ainsi aimantés dans l'hémisphère magnétique inverse de leur hémisphère actuel. Si l'âge de tous ces accidents peut être déterminé avec quelque précision, leur répartition géographique permettra de retracer l'histoire de cette dérive, beaucoup plus aisément que ne l'aurait permise l'hypothèse de la dérive individuelle des continents.

Reference

(1) A. Dauvillier. Arch. Sc. Phys. Nat. (Genève), (5), t. 24, pp. 5-24, pp. 125-159 (1942); Genèse Nature et évolution des planètes, 1 vol, 350 pp. Ac. Sc. Ind. No. 1031, Paris, Hermann (1947).

DIE MAGNETISCHE ANOMALIE IM JORAT

By P. L. Mercanton and E. Wanner

The complete text has been published in German and French in the following:

Die magnetische Anomalie im Jorat, I Teil: Vertikalintensität, Annalen MZA 1943. II Teil: Horizontal Intensität. Deklination. Versuch einer Deutung, Ann. MZA 1946.

L'anomalie magnétique du Jorat: I Composante verticale. Bulletin de la Société Vaudoise des Sciences Naturelles, Vol. 63. II Composante horizontale. Declinaison, Essai d'interprétation. Ibidem, vol. 270.

D. The Aurora

VISUAL AURORAL OBSERVATIONS IN CANADA, 1943-47

By Frank T. Davies

This communication is included in the Report of the Committee on Aurora, pp. 255-273.

ANALYSES OF VISUAL OBSERVATIONS OF AURORA

By E. H. Vestine

Since the meetings of the Association at Washington in 1939, some progress was made in summarizing particulars respecting the geographical distribution of auroral displays. A tentative revision was made of the isochasms of Fritz, for the Northern Hemisphere, on the basis of data accumulated since 1871 [1]. This was a task of considerable difficulty because the procedures of recording visual observations of aurora have been by no means uniform, especially with regard to the absence or presence of cloudiness, and position of aurora in the sky. Charts showing estimated hourly frequencies of aurora were also constructed. A highly tentative chart showing probable isochasms for the Southern Hemisphere was also constructed, which should prove useful in planning further necessary auroral observations [2].

References

[1] E. H. Vestine. The geographic incidence of aurora and magnetic disturbance, Northern Hemisphere. Terr. Mag., vol. 49, 77-102 (1944).
[2] E. H. Vestine and E. J. Snyder. The geographic incidence of aurora and magnetic disturbance, Southern Hemisphere. Terr. Mag., vol. 50, 105-124 (1945).
[3] E. H. Vestine, I. Lange, L. Laporte and W. E. Scott. The geomagnetic field, its description and analysis. Carnegie Inst. Washington, Pub. 580 (1947).

Carnegie Institution of Washington
Department of Terrestrial Magnetism
Washington 15, D. C.

NOUVELLES SUGGESTIONS AU SUJET DE L'INTERPRETATION DU SPECTRE DES AURORES

Par M. Nicolet et R. Dogniaux

Abstract

For any identification of auroral radiations, a convenient method for a first approach is to represent each rotational line of a band by a rectangle of width Δ and of height I. Δ is the width in Ångstrom units of the monochromatic image of the slit on the plate and I is the theoretical intensity of the rotational line.

Numerical calculations have been carried through making use of the auroral synthetic spectra which are represented by the sum of the superposed rectangles.

This method explains at once the following features of the auroral bands: (a) The different aspects of the N_2^+ bands and the structure of R and P branches distorted by the temperature effect; (b) the results obtained for the first positive system of N_2, where comparison of the wave-lengths of the system as deduced from the synthetic spectra with the list of Vegard shows excellent agreement; (c) evidence for the occurrence of the O_2^+ bands and also a possibility for identification of certain auroral emissions not yet interpreted; the absence of the first negative system, which was rather unexpected, was only apparent; (d) a possibility for the presence of a NO system of bands.

Further considerations, in particular on the excited metastable states of long life, are also reported.

The complete paper will be published in the Journal of Geophysical Research, vol. 55, March 1950.

Département de la Radiation
Institut Royal Météorologique de Belgique
Uccle 3, Belgium

DISCUSSION

L. Vegard: In dealing with intensity distribution within a spectrum it is of course very important to take into account the influence of the properties of the spectrograph and photographic plates. In many cases the difficulty is overcome by using comparable spectrograms, and when relative energies are wanted a comparison spectrum with known intensity distribution is used. As pointed out in papers published long ago, the picture and apparent relative intensity we get from a band will vary greatly with dispersion and the width of the slit. If e.g. we would compare the intensity of an atomic line and a band, the relative band-intensity would increase with the width of the slit. Although the influence of the width of the slit on band spectra is well known, still Dr. Nicolet's theoretical treatment will call for interest.

E. Vassy remarque que, non seulement la finesse de la fente du spectroscope utilisé, mais encore le pouvoir séparateur du microphotomètre servant à examiner les clichés, interviennent de facon analogue pour modifier l'apparence du résultat final.

M. Nicolet répond qu'il est bien de cet avis, mais que son exposé était intentionnellement limité à la partie spectroscopique du montage.

A RECORDING METER FOR AURORAL RADIATIONS

By W. D. Penn and B. W. Currie

The complete text is published in Canadian Journal of Research, A, vol. 27, pp. 45-52 (1949).

REMARKS ON THE EXCITATION OF HYDROGEN AND HELIUM IN THE UPPER ATMOSPHERE

By William Petrie

There is little doubt that on certain occasions hydrogen lines appear in the auroral spectrum. Vegard (1) has obtained spectra which show relatively strong lines at wave-lengths coinciding with the first two members of the Balmer series. The rare appearance of these lines raises an interesting question regarding the source of the hydrogen and the excitation of the spectrum. It is not likely that the hydrogen in the earth's atmosphere is the source of the observed Balmer spectrum since we would then expect these lines to be a permanent feature of the auroral spectrum. This spectrum shows that excitation conditions in the upper atmosphere are sufficiently high to produce the Balmer lines, but little is known regarding the hydrogen content of the auroral region. The percentage by volume of hydrogen in dry tropospheric air is 5×10^{-5}. Due to the differential densities of the various constituents of air, the percentage of hydrogen should increase with altitude. There is experimental evidence (2) to show that the percentage of helium is increasing at a height of 20 km, and the same should be true to an even greater degree for hydrogen. On the other hand, the lighter gases are undoubtedly escaping from the upper atmosphere, which fact probably explains the usual absence of hydrogen lines from the auroral spectrum. Vegard (1) suggests that on occasions showers of hydrogen from the sun enter the earth's atmosphere; at such times the auroral spectrum shows the Balmer lines. This suggestion is very reasonable; it is known that solar "eruptive" prominences eject matter into space, and these prominences are largely hydrogen.

We will discuss the intensity distribution in the Balmer spectrum for different methods of excitation, and attempt to decide which method applies to the hydrogen lines in the auroral spectrum.

Excitation of the Balmer spectrum

It might be thought that the hydrogen lines in the auroral spectrum are produced by the recombination of electrons and protons. However, we would expect such a process to operate continually and result in the hydrogen lines being a permanent feature of the auroral spectrum. Furthermore, the recombination process produces a spectrum in which the intensities of the lines $H\alpha$, $H\beta$, $H\gamma$-------decrease relatively slowly unless the temperature of the free electrons is very high. To compute the relative intensities of the Balmer lines in a pure capture spectrum, we need to know the fractions of electrons captured on the various levels of the atom. This problem has been investigated by Zanstra (3) and more recently by Baker and Menzel (4). We have made calculations based on the theory of the latter and find that the relative intensities of the first three members of the Balmer series in a capture spectrum are 2 : 1 : 0.5. The relative intensities are not sensitive to the temperature of the free electrons, at very high temperatures the intensities still decrease slowly. See for example the experiments of Herzberg (5). On the other hand, Vegard (1) gives the relative intensities of H_α to H_β in the auroral spectrum as 6 : 1. Hence we can say with some certainty that the hydrogen lines in the auroral spectrum are not the result of proton and electron recombination.

A second possible but unlikely excitation process is the absorption of ultraviolet radiation from the sun. It is readily understood that the atmosphere is not exposed to short wave-length solar radiation during the night, hence any excitation from this source must come about by absorption of energy during the day and the subsequent release of this energy at night. For example, oxygen and perhaps other molecules may absorb ultra-violet radiation and dissociate into atoms. During the night, recombination will take place, and the energy released in this process may excite certain constituents of the atmosphere. However, there is no apparent dissociation and recombination process which will supply the energy necessary to excite hydrogen atoms and produce the observed intensity distribution in the spectrum. Furthermore, the observed intensity changes in auroral structure are difficult to explain by a radiation excitation process.

Collisional excitation is a process which will certainly operate to a certain extent in the upper atmosphere. It is well known that colliding electrons are effective in producing the hydrogen spectrum, and the many experiments with hydrogen discharge tubes indicate that the intensities of the Balmer lines decrease rapidly towards higher members of the series. For example, Bongers (6) has measured the intensities of the Balmer lines in a long discharge tube, and gives the relative intensities of the first three members of the series as 79 : 10: 2. Since hydrogen cross-sectional areas for electron excitation are not known, we are unable to compute the numbers of atoms excited to the various energy levels, and hence determine the intensities of the Balmer lines. However, the experimental evidence indicates that when hydrogen atoms are excited by electron impact the relative intensities of the Balmer lines are comparable to the relative intensities observed in the auroral spectrum. In a recent paper, Bernard (7) has attributed some fifteen lines in the auroral spectrum to the neutral helium atom. He shows that the intensity distribution in these lines is comparable to the intensity distribution in the spectrum of the radiation from a helium discharge tube. In view of this evidence, we believe that electron collisions are the source of the excitation of hydrogen and helium in the upper atmosphere.

Excitation temperatures in the auroral zone

For a volume in thermal equilibrium, the emission per cm^3 per second in a spectral line $E_{nn'}$ is given by $N_n A_{nn'} h\nu_{nn'}$, N_n being the number of atoms in the upper level involved in the production of the line. Furthermore, for a condition of thermal equilibrium, N_n may be represented by the Boltzmann law, i.e.

$$N_n = N_o(\tilde{\omega}_n/\tilde{\omega}_o)\exp[-x_n/kT]$$

N_o is the number of atoms in the ground level, $\tilde{\omega}_n$ and $\tilde{\omega}_o$ the statistical weights of levels n and the ground level, and x_n the excitation potential of level n. Hence.

$$E_{nn'} = N_o(\tilde{\omega}_n/\tilde{\omega}_o)A_{nn'}h\nu_{nn'}\exp[-x_n/kT] \tag{1}$$

It is very unlikely that the auroral region as a whole approximates thermal equilibrium. However, the free electrons are not able to absorb energy (neglecting free - free transitions) and as a result of collisions will reach a certain velocity distribution which is probably close to a Maxwellian distribution. If this is so, atoms excited by collisions with these electrons will be distributed among the various energy levels according to the Boltzmann law. It is worth while then, to apply the equation for $E_{nn'}$ to the intensities of the hydrogen and helium lines in the auroral spectrum. The relative intensities of the first two members of the Balmer series will be given by,

$$\frac{H\alpha}{H\beta} = \frac{\tilde{\omega}_3}{\tilde{\omega}_4}\frac{A_{32}}{A_{42}}\frac{\nu_{32}}{\nu_{42}}\frac{\exp[-x_3/kT]}{\exp[-x_4/kT]}$$

Putting the equation in logarithmic form and expressing the x values in volts,

$$\log\frac{H\alpha}{H\beta} = \log\frac{\tilde{\omega}_3}{\tilde{\omega}_4} + \log\frac{A_{32}}{A_{42}} + \log\frac{\nu_{32}}{\nu_{42}} + \frac{5040(x_4-x_3)}{T}$$

For the hydrogen levels the $\tilde{\omega}$ values are $2n^2$. Hence $\tilde{\omega}_3 = 18$, $\tilde{\omega}_4 = 32$. Also $A_{32} = 4.39 \times 10^7$, $A_{42} = 8.37 \times 10^6$, $\nu_{32} = 4.57 \times 10^{14}$, $\nu_{42} = 6.17 \times 10^{14}$, and

$(x_4 - x_3) = 0.66$ volt. Substituting these values we find T is approximately 7600° K. The above results do not indicate whether or not the hydrogen energy levels are populated according to the Boltzmann law. On the other hand, this problem may be investigated by considering the intensities of the helium lines in the auroral spectrum. Table 1 gives the intensities of these lines as determined by Bernard, and other relevant data.

Table 1

λ	$E_{nn'}$	Transition	$A_{nn'}$	$\tilde{\omega}_n$	x_n	log D	log $\frac{E_{nn'}}{D}$
5876	6	$3p-3D$	64.7×10^6	15	23.0	23.70	-22.92
4471	10	$3p-3D$	25.9×10^6	15	23.6	23.43	-22.43
4026	4	$3p-3D$	12.8×10^6	15	23.9	23.16	-22.56
5016	12	$1s-1p$	14.0×10^6	3	23.0	22.40	-21.32
3965	6	$1s-1p$	8.13×10^6	3	23.6	22.27	-21.49
4922	5	$1p-1D$	19.7×10^6	5	23.6	22.79	-22.09
4388	4	$1p-1D$	8.67×10^6	5	23.9	22.49	-21.89
4009	1	$1p-1D$	2.82×10^6	5	24.2	22.05	-22.05

Writing equation (1) in logarithmic form and letting $\frac{N_o}{\tilde{\omega}_o} h = C$, we have

$$\log E_{nn'} = \log C_1 + \log \tilde{\omega}_n - \frac{5040 x_n}{T} + \log A_{nn'} + \log \nu_{nn'}$$

Let $\tilde{\omega}_n A_{nn'} \nu_{nn'} + D$. Then $\log \frac{E_{nn'}}{D} = \log C_1 - \frac{5040 x_n}{T}$ ----- (2)

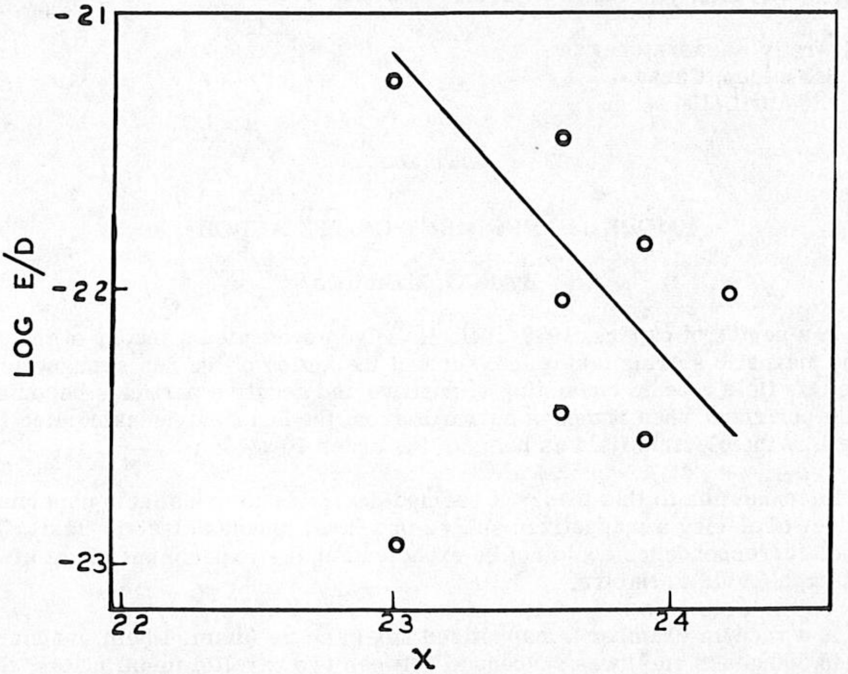


Fig. 1

A plot of log $\frac{E_{nn'}}{D}$ against x will produce a straight line if the energy levels are postulated according to the Boltzmann law. Figure 1 shows this plot for the HeI lines. It is apparent that deviations from the Boltzmann law are appreciable, and the slope of the line $\frac{5040}{T}$, gives a rough average excitation temperature for the various levels. The temperature obtained from this slope is 4600°. This method has been used by Goldberg (8) and Petrie (9) to compute the temperature of the solar chromosphere.

The results indicate that hydrogen and helium atoms are excited by particles which have velocities characteristic of a high temperature. Similar results have been obtained by Petrie (10) from a study of the intensities of a number of OII lines in the auroral spectrum. On the other hand, Vegard has found that the energy responsible for the excitation of nitrogen molecules is characteristic of a temperature of 300° K. These results show that the upper atmosphere deviates considerably from a condition of thermal equilibrium. This condition is not surprising since undoubtedly different excitation mechanisms are operating in the upper atmosphere.

References

1. Vegard, L., Geofys. Publikasjoner, 12(14):1-23, 1940.
2. Paneth, F. A., Quart. Jour. Roy. Met. Soc., 63:433-38, 1937.
3. Zanstra, H., Astrophy. J., 65:50-70, 1927.
4. Baker, J. G. and Menzel, D. H., Astrophys. J., 88:52-64, 1938.
5. Herzberg, G., Ann. d. Phys., 84:553-604, 1927.
6. Bongers, I. A., Utrecht Dissertation, 1927.
7. Bernard, M. R., Comptes Rendus, 225(7):352-354, 1947.
8. Goldberg, L., Astrophys. J., 89:673-678, 1939.
9. Petrie, W., J. Roy. Astron. Soc. Can., 38:137-142, 1944.
10. Petrie, W., Can. Jour. Res. A, 25:293-301, 1947.

University of Saskatchewan
Saskatoon, Canada
April, 1948

MODEL EXPERIMENT ON THE AURORA

By K. G. Malmfors

In a series of papers, 1939-1940, H. Alfvén presented a theory of the aurora and the magnetic storms taking into account the action of the Sun's magnetic field. Due to this field a beam consisting of positive and negative particles becomes electrically polarized when it moves outwards from the Sun. Alfvén calculated the strength of the electric field as being of the order 10 μV/cm.

In connection to this theory it seemed desirable to investigate experimentally the effect of placing a magnetized sphere in a homogeneous electric field. Of course a direct correspondence could not be expected but the experiment might give some results applicable to Nature.

In a vacuum chamber a magnetized steel sphere (diam. 10 cm, magnetic moment 48,500 gauss cm^3) was suspended between two parallel metal plates, the distance between the plates being 25 cm and the magnetic axis of the sphere being parallel to the plates. The chamber was evacuated to a pressure of about 10^{-4} mm Hg. If a voltage of some thousand volts was applied between the plates there arose one luminous ring around each pole on the sphere, which was covered with fluorescent powder. The rings were situated about 45° from the pole and were only slightly displaced towards the equator when the voltage was increased from 500 to 8000 volts. The rings were somewhat eccentric with respect to the pole, the least polar distance pointing towards the negative plate. Applied to Alfvén's theory this corresponds to the fact that the auroral zone is closer to the pole in the morning than in the evening.

This experiment has many features in common with Birkeland's classical investigations. The rings observed by Birkeland were interpreted as due to electrons entering the magnetic field from a source far away from the magnet. The present experiment shows, however, that the rings are due to electrons which take part in a discharge near the magnet. It could be shown that the electrons oscillate through the equatorial plane along the magnetic lines of force, simultaneously driving round the magnet.

It is difficult to draw some definite conclusions from these experiments as regards the nature of the aurora but they may indicate the possibility that an electric field, sweeping over the Earth, will give rise to a discharge which strikes the Earth at narrow rings round the poles.

REPORT ON AURORAL INVESTIGATIONS AT THE UNIVERSITY OF SASKATCHEWAN, CANADA

By B. W. Currie

Other demands on staff and facilities stopped all auroral investigations at the University of Saskatchewan from early in World War II until late in 1946. A study of the directional and diurnal characteristics of auroras at some places in Canada, based largely on data from the International Polar Year, 1932-33, was completed early in this period and published in the Journal of Terrestrial Magnetism, September, 1941. A large number of polar and night-sky auroral spectrograms was taken during 1938 and 1939 with the same spectrograph that was used at Chesterfield in 1932-33, but a detailed study of these has still to be made. Present activities are of two types, namely, the development of a recording meter for overhead aurora by Currie and the investigation of auroral spectra by Petrie, Associate Professor of Physics.

The directional characteristics of aurora in Canada were determined mostly from single- and double-station photographs and diagrams on star maps of homogeneous arcs and bands. In the eastern part of Canada, the average directions are about the same as the lines of geomagnetic latitude, but in central and western Canada, the directions deviate by 15° to 20° in a clockwise sense (when viewed from above), from parallelism with these lines. Maximum auroral activity occurs on an average before astronomic midnight, and is apparently not a function of the time for geomagnetic midnight. A secondary maximum occurs just before sunrise.

As nearly the same procedures as possible were followed at Saskatoon (geomagnetic lat. 60°.5 N) as at Chesterfield (geomagnetic lat. 73°.5 N) in obtaining polar and night-sky spectrograms in order to detect possible differences in the spectra across the auroral zone and to clarify certain confusions in the nature of some of the radiations observed at Chesterfield. A preliminary study of the spectra show no marked differences between the two places. Typical auroral spectra were frequently obtained at Saskatoon on nights following bright displays although auroral forms were not visible, indicating that the same excitation process in the upper atmosphere persists for at least 24 hours after the main display. The use of a sodium source for comparison purposes showed that the radiation, reported as having a wave length of 5940Å in the Chesterfield spectrograms, was actually the sodium yellow radiation. The twilight effects for this radiation, reported for the Chesterfield spectrograms, were verified by the Saskatoon spectrograms. These spectrograms also indicate that the sodium yellow radiation can be obtained at any time of the night, if the exposure is sufficiently long. However, times do occur (even in twilight) when this radiation does not appear on spectrograms, indicating that the sodium has a patchy distribution in the atmosphere and is probably of cosmic origin. A radiation of somewhat longer wave length (probably 5990Å) appears on both the Chesterfield and Saskatoon spectrograms during times of active aurora. It is subject to considerable enhancement of intensity during twilight and moonlight for reasons that are not certain.

The development of an auroral recorder was undertaken with the hope of getting a continuous quantitative measure of overhead auroral activity that could be compared with magnetic and ionospheric records. A unit is now in operation that makes use of a multiplier photo-tube. Such tubes are subject to a "fatigue" effect when exposed to a high flux density, making their use inadvisable during twilight and moonlight unless some means is provided for either reducing the flux incident on the cathode or reducing the dynode voltage with increasing flux. The former method was adopted. A neutral filter in the form of a wedge with a linear density scale, placed in front of the photo-tube, is moved by a servo mechanism so that the incident flux on the cathode is kept substantially constant. A pen, attached to the filter, traces a record on a clock-driven chart. The transmission range of the wedge varies from 1 to 10^{-4} for a displacement of 20 cm, and the chart moves at a rate of 10 cm per hour.

Experience with the recorder shows that it can be run from shortly after sunset to shortly before sunrise, and during moonlight periods; that it gives precise times for the occurrences and durations of overhead auroras; and that it gives relative measures of a combination of auroral brightness and extent in the zenithal sky. Some of the objections to the recorder are the large, controlled power supply (1400 volts), the electronic units to actuate the servo mechanism, and the decreased sensitivity to aurora coincident with bright moonlight. Attempts are under way to build a modified recorder that can be used in isolated regions.

A short paper, giving most of the established facts on aurora and outlining the current methods of investigation, was prepared and published in the September-October issue of the Journal of the Royal Astronomical Society of Canada. It is hoped that this may be of some value to the many individuals in Canada who are showing a renewed interest in auroral investigations.

Plans are under way to make single- and double-station photographs of aurora at Saskatoon.

Dr. W. Petrie's report on his investigation of auroral spectra is added to this report.

Auroral Studies at the University of Saskatchewan, by Dr. W. Petrie

1. A number of theoretical problems dealing with the spectrum of the aurora are being investigated. A study has been made of the relative intensities of a number of atomic oxygen lines which appear in the auroral spectrum, and it is shown how these intensities may be used to give information on the temperature of the earth's upper atmosphere. Two other problems are being studied; one the source of excitation of the hydrogen lines which occasionally appear in the spectrum, and the other deals with the excitation of oxygen atoms to the levels producing the forbidden lines.

2. A laboratory investigation of discharges through oxygen and nitrogen is in progress. The purpose of this work is to attempt to reproduce the faint atomic lines of these elements which appear in the auroral spectrum.

3. Optical parts are on order for the construction of a high light-gathering power spectrograph.

Published Paper: Excitation Conditions in the Upper Atmosphere as Determined from a Study of Atomic Emission Lines in the Auroral Spectrum. Can. Jour. Research 25, 293, 1947.

General Discussion

E. Sucksdorff: In the year 1944 the observatory at Sodankylä was entirely destroyed due to war actions, and on that occasion an auroral investigation which I had been carrying on was lost. Among the results of the work the following items may be mentioned.

In observing auroras during many years in Sodankylä I have got the impression that we have to do with at least three different phenomena or processes, which we see as (1) quiet arcs, (2) moving forms, often with ray structure, and (3) the flaming aurora. It seems to me that the quiet arcs are the basic form of aurorae and that they have no correlation at all with magnetic disturbances. The moving forms appear only during magnetic disturbances, and the flaming aurora only after very intense auroral displays, in the first morning hours. Further, I have got the impression that in the quiet arcs the process proceeds (magnetically) downwards, in the moving forms chiefly upwards, and in the flaming more or less horizontally.

I am sorry I cannot certify these assumptions in a more definite way, as my papers were lost, but I should like to draw the investigators' attention to the possibility that in auroral displays perhaps we really have to do with at least three separate and essentially different kinds of processes.

E. Physics of the Upper Atmosphere and the Ionosphere (Joint Meeting with the International Association of Meteorology)

LABORATORY STUDIES RELATED TO THE PHYSICS OF THE UPPER ATMOSPHERE

By Joseph Kaplan

This report will present in a brief form some of the results of the writer's experiments on the laboratory studies related to the physics of the upper atmosphere. These results have been achieved principally by the discovery and study of two distinctive afterglows in nitrogen and one in oxygen. These two nitrogen afterglows are to be distinguished from the famous Lewis-Rayleigh (active nitrogen) afterglow since their spectral characteristics are different, and, therefore these will be referred to as the strong and weak auroral afterglows of nitrogen. The afterglow in oxygen, first described in Nature (17 May 1947) is an entirely new phenomenon.

The spectrum of the strong auroral afterglow resembles that of polar auroras, since the allowed radiations of molecular and atomic nitrogen are stronger than the forbidden ones. The spectrum of the weak auroral afterglow resembles that of non-polar auroras, since the forbidden radiations of nitrogen and oxygen are much stronger than the allowed ones. Finally, the spectrum of the new oxygen afterglow consists of the atmospheric bands of molecular oxygen in emission. This is a system of forbidden bands in molecular oxygen observed in emission for the first time in this afterglow. These spectra will now be described in greater detail.

The most significant characteristic of the production of the polar or strong auroral afterglow in pure nitrogen is that the spectrum of the exciting discharge must contain the first-negative bands of N_2^+. Furthermore, the intensity of these bands relative to the second-positive system (N_2) must be very great compared to that normally obtained in glow discharges through nitrogen. The strong auroral afterglow has now been observed at all pressures ranging from about 150 mm. Hg down to the lowest pressure at which a discharge is possible, and this remarkable enhancement of the first-negative bands is characteristic of the discharge spectra whenever a strong auroral afterglow is present.

The most striking characteristic of the strong auroral afterglow is that its spectrum changes with time. It starts out as a polar auroral spectrum and ends as a non-polar auroral spectrum. This change is a gradual one and its description will be given by assuming that a strong auroral afterglow is photographed in three successive time intervals of three seconds each. At this point it should be noted that the weak auroral afterglow is one which is generated by a very weak electrical discharge in nitrogen, and its spectrum resembles that of a non-polar aurora throughout the entire duration of the afterglow, while that of the strong auroral afterglow does so increasingly as one observes it later in its lifetime. The following description will be that of the early middle and late portions of the strong auroral afterglow. Later in the report a description will be given of the early and late spectra of the weak auroral afterglow.

The spectrum of the early part of the strong auroral afterglow in pure nitrogen is a remarkably good reproduction of that part of the spectrum of a polar aurora which is due to nitrogen. It is strong in the first-negative bands, and in addition it includes the first-positive and second-positive bands of N_2 with about the same relative intensity as one observes in the average auroral spectrum. The Vegard-Kaplan bands of molecular nitrogen, and the forbidden atomic nitrogen line λ 3467 (^2P-^4S) are present, but are weak, as they should be in the spectrum of a polar aurora.

The spectrum of the middle part of the afterglow is characterized by the increase in intensity of the atomic nitrogen line and the Vegard-Kaplan bands. Recent observations have shown that interesting intensity changes occur within individual band systems when the afterglow is studied as a function of time, and one of the most striking of these is the change in relative intensity of the (0,0) band of the first-positive system. The photography of this band on Eastman I-Z plates has presented great difficulties, but it is now clear that this band increases in relative intensity as one goes from the early to the middle portion of the afterglow. This is the new infrared radiation at 10,440 $\pm$ 25A (which was reported in 1945 by Stebbins, Whitford and Swings[1] and which is far more intense than the ordinary persistent aurora giving the green line at 5577A. The enhancement of this infrared radiation appears to be associated with "infrared outbursts" in the night sky and further study of this radiation in the laboratory is desirable. The absence of other N_2 bands led the above authors to ascribe the emission of the (0,0) band to the conversion of the energy of dissociation $D(N_2)$ into excitation in a three-body collision

$$N+N+N_2 \rightarrow N_2+N_2^{exc.} \qquad (1)$$

Another possible origin of the (0,0) band is the following reaction

$$N_2A^3\Sigma(v=0)+N^2P \rightarrow N_2B^3\pi(v=0)+N^2D$$

$$6.14\ ev+3.56\ ev \rightarrow 7.31\ ev+2.37\ ev. \qquad (2)$$

This collision of the second kind should occur very frequently if one accepts current ideas as to probabilities of such collisions. The writer's most recent studies in the laboratory have led him to the tentative conclusion that neither reaction (1) postulated by Stebbins, Whitford and Swings, nor reaction (2) occur as often as reaction (3):

$$N'+N''+M \rightarrow N_2B^3\pi(v=0)+M' \qquad (3)$$

Where N' and N'' represent nitrogen atoms in one of the two low-lying metastable states and M is a third body, e.g. N_2 or O_2. These results indicate (1) that collisions of the second kind as in reaction (2) are far less probable than has been hitherto assumed; (2) that molecular formation by recombination of atoms occurs most frequently when the two atoms are in electronic states which represent the products of dissociation of the proposed molecular state; and (3) that the probability of producing v=0 in the resulting electronic state, when two atoms recombine, is greater than that of producing higher vibrational levels. These ideas are based on many studies of auroral afterglows, but much experimental and theoretical work must be carried out before they are finally accepted. They do appear to fit the facts of polar and non-polar auroral spectra.

The spectrum of the last part of the afterglow consists almost exclusively of the atomic nitrogen line and the Vegard-Kaplan bands. A few plates have been obtained in which the spectrograph has been shielded from all but the last second of the afterglow and in these the Vegard-Kaplan bands increased in intensity relative to the nitrogen line. More careful studies of this time variation are now under way, in particular quantitative studies of the intensity changes in each of the features of the spectrum, e.g. the forbidden nitrogen line λ 3467. These studies should result in useful contributions to the study of basic processes in the upper atmosphere.

Attempts to extend the afterglow spectra to the ultraviolet below λ 2200 have met with little success, probably because only quartz instruments have been available in the laboratory. Long exposures have revealed no members of the Lyman-Birge-Hopfield system of nitrogen, and it is important therefore to extend these studies into the vacuum and fluorite ultraviolet as well as to develop better observations in the infra-red. Plans are under way to make these extensions.

The addition of oxygen to a tube in which a strong auroral afterglow has been produced has led to some striking results. Among these is the remarkable intensity of the green auroral line λ 5577, in the afterglow. This intensity may become so great as to overshadow all other features of the available spectrum, a phenomenon which is strikingly characteristic of some polar and practically all non-polar auroras. Further studies of this phenomenon by other than purely spectrographic methods are planned and these should prove to be very interesting.

At this point in the report it is of interest to note two things that have long been recognized by the writer, but not discussed in writing. The first is the important role of the nitrogen molecular ion N_2^+ and of the first-negative bands in the physics of the upper atmosphere. It is therefore appropriate that the strong auroral afterglow is so closely related to the production of nitrogen molecular ions. It suggests that many of the important phenomena of the high atmosphere may be tied to variations in solar emission whose primary effect on the earth's atmosphere is the production of nitrogen molecular ions, which in turn undergo changes suggested by the time variation of the strong auroral afterglow.

A second interesting point is the probability that the time variation in the spectrum of the strong auroral afterglow essentially reproduces in the laboratory an interesting discovery made by V. M. Slipher[2] of the Lowell Observatory. Slipher found the negative nitrogen bands in the morning and evening skies when he made brief exposures at the moments, when the last and first traces of sunlight touch the high atmosphere. Slipher stated "that the day, as it were, begins and ends with a sort of auroral flash". Elvey has shown the development of the "auroral flash" in a series of spectrograms taken at the McDonald Observatory. "The spectra were taken with the nebular spectrograph pointed toward the eastern horizon, the first two exposures of three hours and fifty minutes and of one hour, respectively, show the usual spectrum of the night sky. The next exposure of half an hour duration just preceding astronomical dawn shows the enhancement of the red oxygen lines and the appearance of the negative bands of N_2^+". This spectral change is in effect the reverse of the one described for the time variation of the strong auroral afterglow.

The characteristics of the weak auroral afterglow in pure nitrogen and in nitrogen-oxygen mixtures will now be presented. This afterglow is produced by means of a very weak glow discharge in which the N_2^+ negative bands are absent. The afterglow was first reported by the writer in 1935[3] and the spectrum which was reproduced at that time contained the Vegard-Kaplan bands with an intensity much greater than that of the second-positive and first-positive bands of N_2. The forbidden nitrogen line λ 3467 was missing. Addition of oxygen resulted in the presence in the afterglow spectrum of the green auroral line λ 5577 and the associated ultraviolet forbidden line of oxygen λ 2972. The beta bands of nitric oxide, whose strongest members happen to lie on the long wave-length side of λ 2900 (where ozone absorption in the atmosphere is strong), are absent in the weak afterglow, but the gamma bands, which fall below λ 2900 are present. Furthermore only these gamma bands are observed which originate on v=0. The absence of the beta bands in the weak auroral afterglow and their weakness in the strong auroral afterglow are two well established facts. These facts point to the danger of concluding that nitric oxide is absent from the upper atmosphere, just because the beta bands have not been observed in polar or non-polar auroral spectra. It may be that in non-polar auroral spectra only the gamma bands are excited, and these will not be transmitted through the ozone layer. Further studies of the excitation processes in weak auroral afterglows are now under way.

A striking, and as yet unexplained difference between the originally reported weak auroral afterglow spectrum, and those which are now being studied, is the absence of λ 3467 in the former and its remarkably large intensity in the latter. Except for this difference, the spectra appear to be the same. The absence of this line, or at least its small intensity in non-polar auroras, has been noted many times, and its peculiar role in the laboratory as noted above, may give us a clue as to its role in the upper atmosphere. One must be careful in concluding that atomic nitrogen does not exist in the upper atmosphere, from the failure to observe λ 3467.

Because of the weakness of this second auroral afterglow, it has been difficult to study the time variation of its spectrum, but a few plates so far obtained have consistently indicated that the spectrum does change with time, and that a study of this change may lead to a better understanding of reaction mechanisms involving metastable atoms and molecules of oxygen and nitrogen.

A third, and in some ways the most interesting, afterglow is the new afterglow in oxygen. The spectrum of the exciting discharge is predominantly that of atomic oxygen and the indications are that most of the atoms which are produced in this discharge are in the normal (^3P) level. Therefore the resulting afterglow has been interpreted as giving us information regarding the important reaction (1)

$$O + O + M \rightarrow O_2 + M'$$

This is an important reaction in the upper atmosphere and the new oxygen afterglow presents the most definite evidence regarding it that has been obtained so far. This conclusion is at least qualitatively in agreement with the large intensity of the afterglow and with the fact that the spectrum of the afterglow consists only of those atmospheric bands of O_2 which originate on $A^1\Sigma(v=0)$. This restriction to v=0 is so remarkable in the case of the oxygen afterglow that it led the writer to note the similar restriction in the cases of the gamma bands of nitric oxide and the Vegard-Kaplan bands of nitrogen when these are produced in the weak auroral afterglow. It is reasonable to assume that in all three of these examples, the radiations are produced by the recombination of two atoms to form the excited molecule and thus one can state the hypothesis that excitation by recombination favors v=0.

One further theoretical note will conclude this report and this will be a discussion of the mechanism by which N_2^+ disappears in the upper atmosphere and in strong auroral afterglows. In their paper on the basic reactions in the upper atmosphere, Bates and Massey[4] divide recombination into two main types, electronic recombination and ionic recombination. Under the heading of electronic recombination are listed several reactions known as dissociative recombination. The ones listed by these authors are $O_2^+ + e \rightarrow O' + O''$ and similarly for N_2^+. It seems reasonable to suggest that a similar reaction should have been given for NO^+ in spite of the absence of direct evidence that NO^+ exists in the upper atmosphere. Bates and

Massey say that the "importance of the dissociative reactions is rather difficult to assess. Similar reactions between electrons and neutral molecules leading to attachment proceed comparatively rapidly. Detailed investigations are clearly required".

For some time now the writer has been convinced that the dissociative recombination $N_2^+ + e \rightarrow N' + N'$ was the reaction principally responsible for the large absolute and relative intensities of the forbidden nitrogen line in these auroral afterglows. If one assumes that the nitrogen atoms which are obtained as products of the dissociative reaction are in the ^2P level (3.56 volts) and if one assumes further that the energy of dissociation of N_2 into two normal atoms is 7.38 volts, then it is clear that the reaction proposed is energetically correct. The first ionization potential of molecular nitrogen is 15.58 volts and the energy required for the dissociative recombination is 14.5 volts. The writer has called attention to this process in a number of symposia during the past year.

Failure to publish these ideas was due principally to two facts. The first of these is the small intensity of the atomic nitrogen line during the early stage of the afterglow. The fact that this agreed with its small intensity in polar auroras was clearly recognized, but in view of the process that had been postulated to explain the presence of metastable nitrogen atoms in the afterglow, it was felt that some reason for this small initial intensity of the forbidden line should be found. The second fact was the large relative intensity of the atomic line late in the afterglow. Because of the large intensity of the Vegard-Kaplan bands in this part of the afterglow, one is reminded of the light of the night sky or non-polar auroral spectrum. The Vegard-Kaplan bands are one important contributor to this radiation, but available evidence indicates that the atomic nitrogen line is either absent entirely or is very weak.

A simple explanation for these observations is now presented in order to account for the delay in the appearance of the forbidden nitrogen lines and the Vegard-Kaplan bands in the afterglow, as well as for their low intensities in the spectra of polar auroras. It is postulated that electron-atom collisions involving metastable atoms of nitrogen in the ^2P level, and in the upper atmosphere also oxygen atoms in the $^1S_0$ level, are responsible for removal from the metastable states. These collisions obviously also involve the ^2D state of nitrogen and the $^1D_2$ state of oxygen, but since the observations which are discussed here are limited to the $^4S \leftarrow {}^2P$ transition, these remarks will also be limited to that state. In his paper on forbidden lines, Bowen[5] pointed out that for a collision of the first kind, i.e., one in which kinetic energy is transferred to potential, the available evidence indicates that the collision cross section is very large when the kinetic energy of the electron is only slightly above that necessary to raise the atom to an excited state and the electron is therefore able to give up practically all of its kinetic energy. For electron energies higher than this the collisional cross section falls off rapidly. He also states that by the principle of microscopic reversibility a large collisional cross section should be expected for the reverse process in which a low velocity electron collides with an excited atom and takes up its potential energy in a collision of the second kind, and that likewise this collisional cross section should fall off rapidly as the velocity of the impinging electron increases.

It is therefore proposed that both in the upper atmosphere and in the auroral afterglow low velocity electrons remove both atoms and molecules from metastable states and on subsequent collisions excite allowed radiations such as the first-negative bands. It should be noted here that the first-negative bands require from 3.15 to 4.0 volts above the ground state of the nitrogen molecular ion and that slow electrons which have collided with nitrogen in the ^2P level or oxygen in the $^1S_0$

level will possess from 3.56 to 4.19 volts of kinetic energy. It certainly looks as if the phenomena of dissociative recombination and of collisions of the second kind between slow electrons and metastable atoms and molecules should play significant roles in the upper atmosphere and in particular in the excitation of polar and non-polar auroras.

References

1. Stebbins, Whitford, and Swings, Astrophysical Journal, 101, 155 (1945).
2. C. T. Elvey, Rev. Mod. Phys., 14, 140 (1942).
3. J. Kaplan, Pub. Astr. Soc. Pac., 47, 257 (1935).
4. Bates and Massey, Proc. Roy. Soc. A, 187, 261 (1946).
5. Bowen, Rev. Mod. Phys., 8, 55 (1936).

Institute of Geophysics
University of California
Los Angeles, California

DISCUSSION

L. Vegard: As stated in my suggestions for further studies, experiments like those of Professor Kaplan, made with the object of studying the physical conditions for obtaining auroral lines, are of vital importance. We have been doing a good deal of such experiments also at our Institute. I wish to say that the beautiful and interesting spectrograms shown by Professor Kaplan no doubt give important contributions to the clearing up of the excitation processes responsible for the auroral and night sky luminescence. I should like to add, however, that we must be careful not to transfer the physical conditions of a laboratory experiment to the luminescence phenomena in the upper atmosphere, but the particular conditions here must be duly considered.

PROPERTIES OF THE UPPER ATMOSPHERE REVEALED THROUGH SPECTRAL ANALYSES OF AURORAE AND TWILIGHT

By L. Vegard

For the study of the physics of the upper atmosphere we have up to the present mainly had two methods at our disposal: (a) Spectral analysis of the aurorae and other luminescence phenomena from the upper atmospheric layers. (b) The study of the influence of the upper atmosphere on the propagation of electric waves. [In the future we may expect that important results may be obtained from rocket observations.]

The first method gives possibilities for obtaining a detailed knowledge regarding the chemical elements composing the upper atmosphere and the state in which they exist, including the temperature. Further, it enables us to draw important conclusions regarding the electrical state of the auroral region and the way in which the density of matter varies with altitude.

The second method gives us means of measuring more directly and at any time the position of layers of maximum electron- and ion-density, the number of electrons or ions in unit volume in these layers independent of the geographical position of the spot of observation.

As my own investigations on the physics of the upper atmosphere have been mainly restricted to the first method, I intend, as a contribution to this joint meeting, to give a short summary of the knowledge regarding the upper atmosphere gained from spectral analysis of the luminescence phenomena, particularly those of aurorae and twilight, and to point out certain new results obtained during the last years.

In the lower part of the atmosphere near the ground the composition is known from direct chemical analysis. In order to determine the composition at great altitudes the common procedure has been to calculate the variation of density and pressure by means of the barometric height formula:

$$dp = \rho g \, dh \qquad \text{or} \tag{1a}$$

$$\frac{dp}{p} = -\frac{Mg}{RT} dh = -\frac{dh}{H} \tag{1b}$$

where $H = \frac{RT}{Mg}$ is the reduced height, M is the molecular weight, and T the absolute temperature.

But when we are going to apply this formula for greater height intervals we are faced with the important questions: How does the temperature, and how does the average molecular weight vary with altitude?

In the troposphere we may assume a perfect mixing of the components which means that the average molecular weight is constant. While the temperature in the troposphere on an average decreases fairly rapidly upwards, in the part of the stratosphere where temperatures have been directly measured, it keeps nearly constant. From the lower part of the stratosphere and upwards it was commonly assumed that the mixing by diffusion is so great compared by the mixing through wind and turbulence that the partial pressure and density of one component varied upwards as if the others were not present. Taking the temperature to be constant in the stratosphere, the pressure and density of a component (i) as a function of height would be given by the formula:

$$\frac{p_i}{p_{oi}} = \frac{\rho_i}{\rho_{oi}} = e^{-\frac{h-h_o}{H_i}} \tag{2a}$$

And for the total density, ρ_t

$$\rho_t = \Sigma \rho_i = \sum_i \rho_{oi} \, e^{-\frac{h-h_o}{H_i}} \tag{2b}$$

p_o is the pressure, ρ_o the density at the lower limit of the stratosphere situated at a height h_o.

As H is inversely proportional to the molecular weight, the rate of decrease of ρ upwards will be much smaller for hydrogen and helium than for O_2 and N_2, and it was found that above say 100 km the atmosphere according to these calculations should mainly consist of the light gases hydrogen and helium, which are found to be present in a small concentration near the ground.

As most aurorae just appear in the region above 100 km, the assumptions on which these results are based could be checked by the spectral analyses of the auroral luminescence. Already, during the winter 1922-23, a number of strongly exposed auroral spectrograms were obtained. They were dominated by the famous green line and nitrogen bands emitted from nitrogen molecules partly in the neutral, partly in the ionized state; but no trace of either hydrogen or helium lines could be detected.

This showed that the hydrogen-helium layer which the theory had predicted did not exist. The assumption that the mixing due to diffusion is great compared to that of wind and turbulence had to be given up.

We thus come near to the truth if we calculate the variation of the total density with altitude on the assumption that the relative concentrations of the elements composing the atmosphere keep constant below the auroral region and that the total density (ρ) at a height (h) in this interval can be calculated by the formula:

$$p = p_o e^{-\int_o^h \frac{dh}{H_m}} \tag{3}$$

Here the reduced height H_m is equal to $\frac{RT}{M_m g}$, where M_m is the mean molecular weight of the air, which approximately is constant below the auroral region. Thus, H_m is only a function of temperature. If p_o is the pressure, and ρ_o the density at the lower limit of the stratosphere of height, h_o, and assuming as before constant temperature, we have:

$$\frac{p}{p_o} = \frac{\rho}{\rho_o} = e^{-\frac{h-h_o}{H_m}} \tag{4}$$

This formula does not take into account the transformation in the composition of atmospheric matter produced by the action of ultraviolet light and which results in the formation of ozone, for which the maximum concentration is situated about 25 km above the ground. As the relative ozone concentration is very small it has a very little influence on the average molecular weight, and therefore we make a very small error by assuming M_m to be constant below the auroral region.

In the winter 1922-23 it was found that the intensity of the nitrogen bands relative to that of the green line was increased towards greater altitudes, and as the green line can be followed to the very top of the longest auroral ray streamers, this showed that molecular nitrogen existed in quite noticeable densities in altitudes up to 800-1000 km.

A calculation of the density of molecular nitrogen by the barometric height formula (2a) leads to the result that the N_2-concentration should be practically zero at an altitude of 130 km. This result showed that the barometric height formula (4) breaks down in the auroral region.

The density of matter is found to increase much more slowly than can be accounted for by the barometric height formula. If this formula should give a distribution of density in accordance with the observed facts, we should have to assume that the reduced height H had a very large value and increases rapidly upwards. H increases when the average molecular weight diminishes and the temperature is large.

The molecular nitrogen is a predominant component all through the auroral region, and therefore the average molecular weight will be of the same order of magnitude as that of nitrogen and from the nitrogen bands appearing in the auroral spectrum it was at once evident that the emitting N_2 molecules had a temperature considerably below 0° C.

The only possible explanation of the observed facts is that the matter within the auroral region is ionized through the influence of a solar radiation of the type of soft X-rays, which produce high-speed electrons which in turn will set up electrostatic fields which will act on the positively charged matter with an upwards directed force, which partly counterbalances gravity.

This theory of the upper atmosphere led to the probable existence of three ionization maxima in the auroral region and further to an explanation of the zodiacal light. It should be borne in mind that this theory of the upper atmosphere was developed before these ionizing layers were directly explored by means of their power to reflect electric waves.

The analysis of the auroral spectrum had thus shown that the conditions existing in the auroral region are very different from those existing in the lower atmosphere. The matter in the upper atmosphere is transformed by solar activity and takes the shape of a coronal structure similar to that of the sun, and the theory of the upper atmosphere gives at the same time an explanation of the development and structure of the solar corona.

In the terrestrial, as well as in the solar corona, matter is not distributed in such a way that it can be regarded as a gas in equilibrium under the influence of the field of gravitation only.

The state is to be regarded as forming a dynamical system which at certain moments may be regarded as being in a stationary state which, however, is subject to more or less rapid variations.

Solar rays composed of photons or electrically charged corpuscles of fairly high energy will produce dissociation and ionization - and as also streams of atoms or positive ions from the sun may enter the atmosphere, the composition and state of the auroral region may differ essentially from that of the lower atmosphere.

Since the results from 1922-23 referred to were obtained, the spectral analysis of the aurorae has been continued at Oslo and Tromsoe partly together with a number of collaborators of which I may mention E. Tønsberg, L. Harang and G. Kvifte.

We have first of all tried to detect, measure, and identify the lines which appear. The change of color of the aurorae corresponds to changes in the spectral composition and a large number of variability effects have been detected and studied. Finally, a great deal of work has been devoted to the determination of the temperature from the intensity distribution of rotational band series.

A very great advance is marked by the interpretation of the green line by McLennan and collaborators, who showed that it originated from the transition $(^1D_2 - ^1S_0)$ between metastable ground states of the neutral oxygen atom. His interpretation also predicted that a red triplet corresponds to the transition $(^3P_{0,1,2} - ^1D_2)$ of the oxygen atoms. Very accurate wave-length measurements by interferometers have proved that this interpretation is correct.

Thus we have found so far that the auroral spectrum is dominated by lines from neutral oxygen atoms and from nitrogen molecules partly in neutral and partly in the ionized states.

In addition to these strong lines and bands, a large number of weak lines and bands appear. Especially during the last 10 years we have obtained with spectrographs of fairly great dispersion a considerable number of spectrograms from the aurorae, from which we have detected and measured a large number of weak lines. The total number of auroral lines and bands now amounts to about 170.

A complete list of auroral bands and lines as yet detected and measured is given in a paper recently published (1). With regard to details, I must refer to this and previous papers, most of which have appeared in Geof. Publications of Oslo.

Lines from atomic oxygen in various states of ionization

In addition to the green line and the red doublet which are so-called forbidden lines, a number of auroral lines are referred to permitted lines from neutral O-atoms; among these we have the fairly strong line 4368,3 which has been measured very accurately from spectrograms of great dispersion.

A large number of weak but distinct lines are found to originate from singly ionized O-atoms.

The nebular lines 5006,7, 4959, and 4363, which originate from the metastable ground states of the O-atoms which have lost two electrons, appear quite distinctly on spectrograms of great dispersion and their identification can be considered as certain. A few lines are identified with permitted OIII-lines. This result shows that atomic oxygen in the form of neutral atoms and in two states of ionization exist in fairly great abundance in the auroral region.

Lines from atomic nitrogen

If nitrogen in the upper atmosphere was dissociated to any marked degree we should expect to find lines from atomic nitrogen in the auroral luminescence. First of all we might expect to find lines originating from the metastable ground states of neutral and ionized nitrogen atoms similar to those we found for oxygen, such as the strong green and red OI-lines and the nebular OIII-lines.

The transitions between metastable NI states of the neutral atom should give a green doublet (5197,7, 5200,8) with an average wave length 5199,3 and a line 3466,5.

On a considerable number of auroral spectrograms of fairly great dispersion we have observed a weak but sharp line with a wave length 5203 Å. This differs from the mean wave length of the doublet by 4 Å and this difference is by far too great to be accounted for by errors.

We have also observed a moderately strong line 3467,5 in the ultraviolet. The difference of 1 Å unit between the wave length of this line and the forbidden NI line is greater than the possible error, but the difference may possibly be due to the fact that this line lies close to a band (3469) of the second positive group of nitrogen and this band might produce an apparent displacement of the line towards longer waves. It is therefore not excluded that the forbidden NI line 3466,5 appears in the auroral spectrum.

Slipher and Sommer (2), Gøtz (3), Dufay (4), and Barbier (5) have observed the so-called "second green line" on auroral spectrograms and have identified it with the green NI-doublet. Bernard, observing at Tromsoe, obtained a line in ultraviolet which he identifies with the forbidden NI line 3466,4.

In all these cases, however, the spectrograms have been taken with spectrographs of very small dispersion so the errors may amount to several Å units. We cannot therefore place any weight on their identifications.

In the auroral spectrum we also find a number of weak lines which, within the limit of error, coincide with permitted lines from atomic nitrogen in the neutral and singly ionized state.

Although it is probable that lines from atomic nitrogen appear in the auroral spectrum, we cannot yet claim that their presence has been definitely proved. At any rate, they are much weaker than the lines from atomic oxygen, and this indicates that oxygen is dissociated to a much higher degree than nitrogen, and this is also in agreement with the fact that the oxygen band spectra have not been observed in the auroral spectrum while the nitrogen bands appear with dominating intensity.

Occasional occurrence of hydrogen lines, which sometimes show doppler displacement

As already mentioned, the auroral spectrograms usually show no trace of hydrogen lines. Some spectrograms obtained at Oslo in 1939, however, showed fairly strong lines coinciding with H_α and H_β of the Balmer series indicating that showers of hydrogen from the sun occacionally were operating in the auroral region (6,7,8).

The result was confirmed by spectrograms at Tromsoe (9,10) 1940-41 with a spectrograph of much greater dispersion. These spectrograms showed a sharp line exactly coinciding with the H_β -line of the comparison spectrum.

On some spectrograms taken with the same spectrograph on the same kind of plates and quite as strongly exposed, the sharp H_β -line had disappeared; but in its place appeared near to it towards shorter waves a broad line with a wave length 4856,5. The line coincides with the OII-Line 4856,5, but as the auroral line is not sharp this coincidence may be accidental. The fact that it had not been previously observed and the occurrence of hydrogen showers suggests that such showers had been in operation during the exposure and that we were observing the H-line displaced through doppler effect. If so, the average displacement of about 5 Å corresponds to a velocity towards the observer of about 300 km/sec.

This is also what is to be expected from our theory of the solar corona and the formation of the bundles of electric rays which produce aurorae and magnetic disturbances. According to this theory the bundles should consist of electrons mixed with positive ions of great specific charge preferably hydrogen nuclei (protons).

It is also possible that hydrogen in prominences may obtain sufficient velocities to reach the earth. Instances of so great velocities have been observed.

Sodium in the upper atmosphere

It has been known for a long time that a yellow line with a wave length of 5893 appears in the spectra of aurorae, night sky, and twilight.

Through observations and measurements of Bernard (11), Cabannes, Dufay, and Gauzit (12), and by Vegard and Tønsberg (13), it has been definitely proved that the yellow line is identical with the D-doublet of sodium. In the aurorae and night sky luminescence the sodium line, when it appears, is very weak. In twilight, however, it appears with an intensity of a higher order of magnitude. It is therefore possible to define an upper limit (H_u) where the intensity of the D-line in twilight fairly suddenly diminishes. This means that when shadow lines of the effective solar radiation have passed this limit the D-line disappears on spectrograms taken with an exposure of the same order of magnitude as that used to obtain the D-line from twilight.

Bernard (11) was the first to observe and study this sudden apparent disappearance. From the time of disappearance (t_d) he calculated the height of the shadow formed by the surface of the earth, and he found an upper limit of about 60 km for the twilight emission.

In 1939 we took series of twilight spectrograms both at Oslo and Tromsoe for the determination of (t_d). We took first a series from Zenith and then one in a nearly horizontal direction. In all cases the spectrograph had a lens before the slit.

Assuming that the D-line was excited by ordinary sunlight and calculating the height of the shadow limit formed by the surface of the earth at the time of disappearance, we always found that the zenith observations gave a much smaller upper limit (H_u) than those taken near the horizon.

Now the upper limit must in reality be the same in both cases. The apparent difference between the (H_u) values at zenith and near the horizon was explained by assuming that the excitation of the D-line required ultraviolet light of so short wave length that it was absorbed in the lower part of the atmosphere. This again means that the effective shadow is not formed by the surface of the earth of radius R, but by a sphere of radius ($R+H_S$) where H_S is the screening height of the atmosphere.

The true upper limit (H_u) and the screening height (H_S) were found from the condition that the zenith and the horizon observations should give the same value of H_u.

The results of our first calculations based on the Oslo observations were published in a letter to Nature, 1940 (14), and gave a screening height (H_S=55 km), and an upper limit of the twilight emission H_u=115 km. It was pointed out that the absorption of the effective ultraviolet radiation was caused by ozone, and the effective wave length should be somewhere near 2500 Å. The Tromsoe observations gave results in good agreement with those from Oslo, as will be seen from a paper published by Vegard and Tønsberg (15).

During the years 1942-43 the investigations were continued at Oslo in collaboration with G. Kvifte (16), where we adopted a more accurate method for the determination of the time of disappearance (t_d).

The results derived from a great number of independent determinations are given in the table:

Spot of obs.	H_S in km	H_u in km
Oslo 1939	58	119
Tromsoe 1939	50	109
Oslo 1942-43	43,7	105,4

The ozone concentration has its maximum at a height of about 25 km and the screening heights given in the table correspond to the altitude where the ozone concentration is practically zero.

The fact that the intensity of the D-line keeps nearly constant until it rapidly drops to a lower order of magnitude indicates that the sodium responsible for the D-emission in twilight is restricted to a fairly thin layer near the upper limit H_u. As long as the whole layer is exposed to the effective ultraviolet radiation the intensity of the D-line remains nearly constant and begins to drop rapidly when the shadow formed by the screening sphere passes the lower border of the sodium layer and vanishes when the upper limit of this layer at altitude H_u passes into the shadow. The thickness (Δh) of the layer can then be calculated from the time interval (Δt) between these two events.

The thickness has been calculated for the zenith observations taken at Oslo during the winter 1942-43. The values of h varied between 8,4 and 27 km with a mean value 16,2 km. The values varied somewhat regularly indicating a minimum in January.

The sodium layer producing the strong D-line in twilight should thus extend from H_u=105 km down to an altitude varying from about 95 to 80 km.

The great altitude found for the sodium layer and the fact that the D-line also appears in the auroral and night sky luminescence, and further the large fluctuations of the intensity of the D-line in all these luminescence phenomena, indicates that sodium from the sun, just like hydrogen, occasionally enters into the atmosphere.

This is also what we should expect from our theory of the solar corona and of the constitution of the electric ray bundles, which produce aurorae and magnetic disturbances.

Now hydrogen and sodium ions will combine with the free oxygen atoms and form water vapor and sodium oxide. The latter substance will form small solid particles which may act as condensation nuclei for the water vapor and in this way the formation of the luminous night clouds, which are situated at an altitude of about 80-85 km, may be explained.

Determination of the ionospheric temperature from aurorae at different altitudes or in a sunlit atmosphere

For the study of the physical state of the ionosphere it is most essential to determine its temperature. In the case of the ionosphere where photoelectric processes, expulsion of high speed electrons, ionization and electric fields come into play, the translatory motions of electrons, atoms, molecules, and ions do not define a temperature in the thermodynamic sense of this physical quantity. As we know from auroral investigations, the gases of the upper atmosphere are not in a static thermodynamic equilibrium, but is a dynamical system, which at a certain moment may be in a quasi-stationary state, which however undergoes rapid changes with time, due e.g. to changes in the solar effects which form the primary cause of the dynamical processes within the ionosphere.

In the ionosphere there are translatory motions which maintain the dynamical system superimposed on a truly thermic motion, which define a certain temperature. The thermic part of the energy is subject to the law of equipartition of energy and is therefore transferred to the rotational motion of the molecules.

In the case of the upper atmosphere of the earth we are in the lucky position that nitrogen in the molecular state is present throughout the ionosphere in great abundance, and that the rotational energy manifests itself through the rotational series of the nitrogen bands.

We are therefore justified in defining the ionospheric temperature by means of the energy of the molecular rotation, and this temperature can be measured from the extension of, and intensity distribution within, a nitrogen band, e.g. one belonging to the negative group.

Since the first estimates of the temperature by this method were applied in 1923 a considerable number of quantitative measurements have been carried out. Spectrograms suitable for this purpose must have a fairly large dispersion and with the spectrographs at our disposal the time of exposure was very long.

The spectrograms previously obtained for this purpose were taken in the way that the collimator was directed on the part of the aurorae showing maximum intensity.

The measurements undertaken in this way correspond to an altitude interval of 110-140 km and all of them gave temperatures far below 0° C with an average of -40° C (18).

In 1941 and 1942 (7) we were able to measure the temperature from three spectrograms corresponding to aurorae exposed to sunlight. The following temperatures were found: -26°, -40°, -57° C. Mean value -41° C.

In 1938 we obtained with the big quartz spectrograph at Tromsoe a pair of spectrograms, one corresponding to the lower, the other to the upper limit of the auroral streamers. The temperature found from the 3914 band was exactly the same (-63° C) in both cases.

The determination of temperatures from sunlit aurorae and for large altitudes will be continued, but the measurements undertaken up to the present give no indication of any essential increase of temperature with altitude or when the aurorae are exposed to sunlight.

Changes within the upper atmosphere indicated by the variability of the auroral luminescence

The great variability of the intensity distribution within the auroral spectrum is a matter of great importance. It may correspond to variations of composition and state of the matter in the auroral region and to changes in the excitation processes and therefore also to possible variations of the properties of the electric solar radiation, which is the primary cause of the luminescence. In fact, I think that the physical interpretation of the variability effects will involve a fairly complete understanding of the processes going on in the ionosphere and will add essentially to our knowledge of the relation between terrestrial and solar phenomena.

In order to make advances towards the solution of these complicated problems, we have first of all to collect observational data and to correlate them with variations of other observable phenomena.

Among the variability effects as yet discovered we may call attention to the following:

1. The red OI-doublet (6300,3 and 6364) which is usually very weak as compared with the green line may sometimes be greatly enhanced so its intensity may be many times as great as that of the green line, with the result that the whole auroral form from bottom edge to the top appears intensively red (red aurora of type A). It is very remarkable that red aurora and aurora of the usual color may appear simultaneously on the sky. On the other hand, we find that when spectrograms taken at Oslo show a strong red doublet, we will find that spectrograms taken about simultaneously at Tromsoe also show a comparatively strong red doublet. The variation of the intensity of the red doublet and the frequency of the red aurora of type A are found to follow the sunspot frequency.

2. The intensity of the red bands of the first-positive group of nitrogen are enhanced with decreasing altitude. When the aurora come down to very low altitudes the lower border turns red owing to the enhanced bands (red aurora of type B). The frequency of the red aurora of type B (which means aurora reaching down to low altitudes) is greater at sunspot minima than at sunspot maxima.

3. The intensity of the negative nitrogen bands emitted from N_2^+ ions relative to that of the green line, increases with altitude and for the same altitude it decreases towards lower latitudes. The bands are also enhanced in a sunlit atmosphere.

4. The intensity of the red OI-doublet relative to that of the green line and the negative nitrogen bands increases largely with altitude, towards lower latitudes, in a sunlit atmosphere and with solar activity.

5. The relative intensity within the vibrational bands of the negative nitrogen group varies in a characteristic way with altitude and probably also with latitude. These variability effects may possibly be due to variations in the properties of solar electric radiation. These rays consist of electrons probably mixed with positive ions of high specific charge, mostly protons.

6. Some OII-lines (from singly ionized O-atoms) are enhanced towards greater altitudes. This effect indicates that the relative concentration of ionized oxygen atoms increases upwards.

7. The intensity distribution within the auroral spectrum varies in a characteristic way with the auroral type. In order to clear up these type effects it is very essential to have spectrographs of extremely high light power so spectrograms from a certain auroral type could be taken with short exposure and coordinated with simultaneous height measurements of the same auroral type.

It would be out of place in this connection to enter into a further discussion regarding the possible physical interpretation of the numerous variability effects. A number of suggestive ideas have been advanced by various authors but a great many of the effects have not yet found their physical explanation.

The story told by the auroral luminescence regarding the state of the upper atmosphere would be very incomplete if we did not mention what it has taught us regarding the state of the ionization of the upper atmosphere and the ionospheric layers.

We have already mentioned that the presence of molecular nitrogen and atomic oxygen up to altitudes of 800-1000 km, seen in relation to the fact that the temperature is below 0° C, led to the consequence that matter partly in an ionized state must be driven to higher levels through the effect of electric fields produced through the continual action of a radiation from the sun of the type of soft X-rays.

The range of the secondary electron rays of a speed corresponding to 1000-1500 electron volts will be greater in the direction upwards than downwards, and an electric double layer will be set up with its negative side upwards. Matter left behind with a surplus of positive electricity will be subject to an upwards directed force which will partly counterbalance gravitation and carry matter towards higher altitude, and give the upper atmosphere a coronal structure. The soft X-radiation will produce two ionizing layers, one supposed to be situated at the altitude where the rate of absorption per unit length of path of the primary X-rays is a maximum, and one which may be situated at an altitude of several hundred kilometers, of the same order of magnitude as the tops of the highest auroral ray streamers. This maximum is due to the accumulation of negative electrons produced by photoelectric action of the X-rays. In between these two it was assumed that a third maximum was produced by the action of ultraviolet rays of sufficiently high frequency and photon energy to ionize oxygen and nitrogen which means a wave length below 1000 or 800 Å.

After this result was reached regarding the electrical state of the atmosphere, the ionospheric layers were more directly explored by means of reflection of electric waves. The two maxima produced by the soft X-radiation were then identified as the E layer and the F2 layer and that in between due to ultraviolet light was assumed to correspond to the F1 layer.

Regarding a more detailed discussion of the correlation between the theory and the observed properties of the ionospheric layers, we must refer to previous papers (17).

The interpretation of the coronal lines by Edlèn shows that a photon radiation corresponding to an energy of about 1500 e.v. is emitted from the sun, and this radiation has just the right absorption coefficient to explain the altitude of 100 km of the E layer and solar photon radiation in the interval $20<\lambda<1000$ Å accounts for the F1 layer.

The theory led to a number of other consequences confirmed by later observations of which we may call attention to the following. The length and height of the auroral rays should increase towards lower latitudes and in a sunlit atmosphere. These consequences are confirmed by Størmer. The fact observed by Størmer that auroral rays in a sunlit atmosphere apparently stops at the shadow limit to continue further down is explained from our theory, but cannot be explained if matter were distributed according to the barometric height formula.

According to theory, matter at great altitude where electrons and ions have a large mean free path has a tendency to accumulate towards the plane of the magnetic equator and to obtain its greatest extension in the direction of the sun, and thus the shape and composition of the upper atmosphere explains the properties of the zodiacal light.

The theory further explains the fact found by Appleton that the ion density of the F2 layer has a tendency to distribute itself symmetrically relative to the plane of the magnetic equator.

Finally, the theory of the terrestrial corona (ionosphere) also applies to the corona of the sun (18).

References

1. L. Vegard and G. Kvifte, Geof. Publ., Oslo, XVI, No. 7, 1945.
2. V. M. Slipher and L. Sommer, Naturwiss., 17, 802, 1929.
3. P. Gøtz, Naturwiss., 29, 690, 1941.
4. J. Dufay, Ann. d'Astrophys., 6, Nos. 3 and 4, 1943.
5. D. Barbier, Contrib. de l'Institut d'Astrophys., 13, No. 14, 1947.
6. L. Vegard, Nature, 144, 1089, 1939.
7. L. Vegard, Geof. Publ., XII, No. 5, 1938.
8. L. Vegard, Terr. Mag., 1939.
9. L. Vegard and E. Tønsberg, Geof. Publ., XIII, No. 5, 1941.
10. L. Vegard and E. Tønsberg, Geof. Publ., XVI, No. 2, 1944.
11. R. Bernard, C. R., 206, 448, 928, 1938, 207, 488, 1938.
12. J. Cabannes, J. Dufay and J. Gauzit, C. R., 206, 1525, 1938; Astrophys. Jour., 88, 164, 1938.
13. L. Vegard and E. Tønsberg, Geof. Publ., XIII, No. 1, 1940.
14. L. Vegard, Nature, 145, 623, 1940.
15. L. Vegard and E. Tønsberg, Geof. Publ., XIII, No. 1, 1940.
16. L. Vegard and G. Kvifte, Geof. Publ., XVI, No. 7, 1945.
17. L. Vegard, Ergebnisse d. Exakt. Naturwiss., XVII, 229, 1938.
18. L. Vegard, Geof. Publ., Oslo, XVI, No. 1, 1944.

DISCUSSION

<u>H. Alfvén</u>: In Professor Vegard's survey the basic idea of the theoretical part was that charged particles emitted from the sun directly hit the upper atmosphere of the earth where they produce aurora. Magnetic storms were also supposed to be a product of some similar mechanism. So many arguments have been given against this general view that I do not think that it could be regarded as tenable. It is very unlikely that the aurora is due to particles reaching the earth along Störmer orbits.

A more promising way of approach seems to be to assume that the cause of a magnetic storm (with its associated aurorae) is an electric field which at intervals is established in the environment of the earth. Such a field should be produced by a stream of ionized gas expelled from the sun, because its motion in the solar magnetic field causes a polarization. On this basis a theory of magnetic storms and aurorae was proposed several years ago. A recent model experiment by Malmfors shows that an electric field applied to a "terrella" produces a discharge which hits the terrella in eccentric rings around the poles, and it seems likely that the aurora is produced by a mechanism of this kind. The experiment supports the general lines of the electric field theory, although some details may need a revision.

Recent observations of the change in cosmic ray intensity during magnetic storms also indicate the existence of an electric field during a magnetic storm.

AURORA SPECTRA SHOWING BROAD HYDROGEN LINES

By Carl W. Gartlein

A two prism spectrograph of 10 cm focus and aperture F/1.65 has been used since 1939 in the National Geographic Society - Cornell University Study of Aurora. A line on the plate in the position, 4861 Å, of hydrogen, was noted in March 1940. This line was so much broader than other lines on the plate it was assumed that it could not be an atomic line. The best additional plates have now been given a careful study. From those of September 17-18, 1941, September 18-19, 1941, February 25, 1943, and March 23, 1946, we conclude that three lines which often appear are H_α(6563 Å), H_β(4861 Å), and $H\gamma$ (4340 Å) and that the H_β and $H\gamma$ are always broad.

H_α is superposed on the first positive band system of nitrogen and cannot be studied, except for detection, with the present spectrographs. Measurements on the two plates showing least band interference indicates that H_β and $H\gamma$ have a natural width of 5 Å or more wider than the line at 5003 Å. The 5003 Å line appears to be a blend of several lines of N II. Thus, with present equipment the absolute line widths cannot be determined.

Unless another identification can be found for these lines we must assume they indicate the presence of hydrogen in violent random motion during many auroras. This suggests that protons come into the upper air during auroras at velocities exceeding 200 to 500 km per second.

A time sequence patrol spectrograph, with camera lens operating at F/.8, has been operated every night since 1941. The spectrum is spread out in time so we can note when these hydrogen lines appear during the displays. They have appeared on at least forty-four nights since 1943. On fourteen of these nights the hydrogen appeared before and during sudden outbursts of the aurora. This suggests that the influx of hydrogen may initiate the larger outbursts. Since the spectrograph is aimed at only a small region of the sky, about 10° wide at an elevation of 9° in the north, it seems likely that it would not record the initiating impulse in every case if the impulse is confined to a small region. The above seems to support T. L. Eckersley's theory of differential penetration. The quieter auroras do not show the hydrogen.

Photoelectric records of aurora light have been taken regularly since 1941. These show that sudden outbursts may double the intensity of aurora light. They rise to maximum in two or three minutes and fade in 15 to 45 minutes. This occurs shortly after rays form. In many cases these outbursts occur in step with sudden changes in the earth's magnetic field. The one at 6^h 35^m GMT on March 28, 1946, coincides with the "similarity effect" disturbances pointed out by H. W. Newton, Terrestrial Magnetism, Vol. 52, No. 4.

Cornell University
Ithaca, New York

DISCUSSION:

M. Nicolet: "En relation avec l'apparition des raies de l'hydrogène dans les spectres d'aurores, il est intéressant de signaler les résultats que l'on peut tirer des observations du Prof. C. Störmer.

"Dans l'aurore du March 29, 1940, les raies de l'hydrogène n'apparaissent que dans un Arc au Sud entre $23^h\ 00^m$ et $23^h\ 25^m$. En outre, dans les 'Cloudlike Aurores' (January 3, 1940) les vitesses mesurées vont de 690 m/sec à 780 m/sec. L'altitude moyenee est de 106 km et l'épaisseur de 10 à 20 km."

L. Vegard: "I have been greatly impressed by the very beautiful auroral spectrograms and records obtained by Dr. Gartlein. Although the spectrographs used by him have considerably smaller dispersion than the largest I have been using, he must have instruments of very high quality and effective light power. It was therefore with particular interest I saw the way he had been able to follow the fairly rapid changes in the intensity of the spectral lines. I have not had the opportunity of studying any of his published papers; but both his instrumental equipment and the results obtained will be of the greatest interest in connection with the work carried out in this country along similar lines.

"The records of auroral luminescence and those of the intensity of the magnetic field indicate a time lag of the latter, which would be in accordance with the observation I have made that aurorae may appear near the station without producing noticeable changes in the magnetic field."

RECENT WORK ON THE MEASUREMENT OF ATMOSPHERIC OZONE AND ITS VERTICAL DISTRIBUTION IN INDIA

By K. R. Ramanathan and R. V. Karandikar

1. Using a Dobson's photoelectric spectrophotometer belonging to the India Meteorological Department, and with recalibrated optical wedges, observations with direct sunlight were taken at Delhi during the period November 1945 to March 1947 to determine the daily values of ozone. The monthly mean values are given in Table 1. The observations generally refer to afternoon. The main maximum ozone values occur in April to June. The minimum seems to occur in November but there is a pronounced secondary minimum in August. Curves for Bombay and Kodaikanal and for Helwan and Zikawei show similar features. The values for the winter of 1946-47 were definitely higher than those for the winter of 1945-46. It is a moot point whether this increase in ozone amount was due to increased solar activity.

Table 1--Mean monthly values of ozone amount at Delhi (28°35'N)

Month	1945		1946		1947	
	No. of observations	Mean ozone amount in cm. N.T.P.	No. of observations	Mean ozone amount in cm	No. of observations	Mean ozone amount in cm
January			28	0.170	18	0.192
February			22	0.173	26	0.197
March			28	0.183	24	0.198
April			30	0.188		
May			29	0.187		
June			28	0.189		
July			21	0.179		
August			21	0.173		
September			28	0.176		
October			21	0.179		
November	19	0.169	29	0.175		
December	27	0.170	28	0.182		

The daily ozone values at Delhi were plotted side by side with various meteorological factors. Out of these, minimum temperatures at Simla showed marked correlation with Delhi ozone values during the period October to April--except when Simla minimum temperatures were affected by föhn-effect or by rainfall.

The day-to-day changes in ozone amount were small in July-September but quite conspicuous during the period of western disturbances. In general, northerly air was found to be associated with high ozone amounts. Any association of changes of ozone amount with fronts has not yet been established. The depressing and stabilizing effect of the monsoon on the total ozone amount in the atmosphere suggests that water-vapor in the upper troposphere has a destructive action on ozone. During the monsoon, the tropopause in Northern India is almost always of Type I, beginning with a strong inversion at a height of 16-17 km.

2. Measurements of the intensity of the zenith-scattered light were taken on a number of clear days in different seasons for varying zenith-distances of the sun. The Umkehr-effect was observable without difficulty. From the curves of variation of the zenith-scattered light with the zenith-distance of the sun, the vertical distributions of ozone were calculated for the following values of total ozone: 0.155 cm., 0.175 cm., 0.200 cm., and 0.217 cm. Table 2 gives the average concentration of ozone expressed as cm at N.T.P. per km, in different atmospheric layers for different ozone amounts. The higher values of total ozone amount are associated with higher ozone-concentrations in the layers 9-18 km and 18-27 km. The center of gravity was found to be 26.5 km for 0.155 cm and 25.0 km for 0.217 cm. For the same ozone amount, the height of the center of gravity lowers as we go to higher latitudes. For example, for the ozone amount 0.217 cm, the height is 25 km at Delhi, 22.5 km at Arosa and 21 km at Tromsö. Greater precision in determining the boundaries of the layer in which the changes in ozone concentration occur would require a major improvement in method.

Table 2--Vertical distribution of ozone over Delhi (28°35'N)

Height of layer in km	Total ozone			
	0.155 cm	0.175 cm	0.200 cm	0.217 cm
Surface-9 km	0.0010 cm/km+	0.0010 cm/km+	0.0010 cm/km+	0.0010 cm/km+
9-18	0.0016 "	0.0020 "	0.0026 "	0.0030 "
18-27	0.0055 "	0.0070 "	0.0091 "	0.0104 "
27-36	0.0077 "	0.0080 "	0.0080 "	0.0080 "
36-45	0.0010 "	0.0010 "	0.0010 "	0.0012 "
45-54	0.0004 "	0.0004 "	0.0005 "	0.0005 "

+These are assumed values.

3. From the measurements of intensity of the direct radiation from the sun, the fraction of the incident radiation scattered by the large particles in the atmosphere can be deduced by subtracting the calculated attenuation due to molecular scattering from the total measured attenuation.

Daily values of $\delta' - \delta''$, where δ', δ'' are the net losses due to particle scattering at the wavelengths 3300 and 4450 A were tabulated. An unexpected new feature was the negative sign of $\delta' - \delta''$ (i.e., apparently greater loss due to scattering at 4450 Å than at 3300 Å) in the pre-monsoon period, particularly on days when there was widespread milky haze over the sky. This will be discussed in a separate paper elsewhere.

4. Arrangements are in progress for determining the vertical distribution of ozone over Poona (18°N) and Kodaikanal (10°N).

The India Meteorological Department and the Board of Scientific and Industrial Research are financing this work.

DISCUSSION:

A la suite de cette communication, le Professeur Vassy remarque que c'est l'influence de la température qui conditionne la proportion d'ozone et qui peut ainsi expliquer les particularités signalées par le Professeur Ramanathan.

RADIO STUDIES OF METEORIC IONIZATION

By C. D. Ellyett and A. C. B. Lovell

A complete survey of the subject, prepared by the junior author, will appear in the January 1950 issue of "Science Progress" (Vol. 58, No. 149, London).

THE CORRELATION OF VISUAL METEOR DATA WITH THE CHARACTER OF METEOR RADAR ECHOES

By Peter M. Millman and D. W. R. McKinley

During the summer of 1947 a combined program of visual, photographic, and radar observations of meteors was commenced at Ottawa, Canada, by the Dominion Observatory and the National Research Council, with particular emphasis being laid on the observations made during the period of annual meteor showers. Approximately 1800 visual meteors have been plotted during these showers and over 100,000 radar echoes from meteors have been recorded, using a frequency of 32.5 megacycles per second. Attention was paid to reducing the observational errors as much as possible, especially the errors in timing the occurrences of the visual meteors and the radar echoes. A number of criteria were applied to correlate a visual meteor with a radar echo, and the positions and the orientations of the trails of the selected visual shower meteors were calculated and combined with the information yielded by the radar display.

The radar echoes were recorded by photography on a two-coordinate system with range as ordinate and standard time as abscissa. On the range-time display the motion of a meteor moving with constant velocity traces out a hyperbola. In a large number of cases a moving echo was observed showing a decreasing range for approaching meteors and an increasing range for meteors which were receding from the observer. Frequently this echo was of very brief duration and its motion on the range-time display corresponded closely with the known geocentric velocity of the shower meteors. In other cases the echo exhibited a delay in appearance and has a moderate duration of several seconds. Both the delay and the duration were in general progressively greater toward the end of the meteor's path.

There was also a more enduring type of echo which remained visible for periods ranging from ten seconds up to several minutes. It was found that the long enduring radar echo obtained from a bright visual meteor coming head-on did not appear until several seconds after the meteor was seen visually, whereas the radar echo from meteors travelling normal to the line of sight appeared in coincidence with the visual meteor. The delays in appearance of the radar echo from meteor trails with intermediate orientation varied fairly smoothly between these limits. A second important feature of many enduring echoes was their complex structure, several discrete echoes at different ranges (or heights) appearing with various time delays. Such complex echoes were observed chiefly from meteors with paths forming an acute angle with the line of sight, e.g., meteors approaching the observer fairly rapidly. Since none of the selected meteors showed visual bursts of light along their paths it was felt that some other agency must be invoked to account for the multiple ranges. A third point of interest was the observation that the delay in appearance of the radar echo not only appeared to be a function of the angle of orientation of the meteor trail with respect to the observer, as noted above, but also appeared to depend on the absolute height of the echo. As a fourth point a statistical correlation was found between the length of time an echo remained visible and both the visual brightness of the meteors and their velocities through the atmosphere. The faster and brighter meteors produced echoes of longer duration.

From this data a phenomenological theory has been evolved postulating the existence of an M-region (meteor-region), slightly below the accepted E-region, in which the visual meteors are most likely to produce observable ionization effects. This region, as plotted from the long enduring echoes, is at least 15 kilometers thick and has a mean height not far from 90 kilometers above sea level. In the M-region are visualized striae, or patches, which form a fine structure such that within the striae the physical properties of the atmosphere emphasize the creation and maintenance of meteoric ionization as compared to the ionization produced in the intervening spaces. Following the passage of a bright meteor, strong echoes will appear at a number of discrete ranges, corresponding to the striae which the meteor path intersects.

An ionized cloud large enough to reflect 9-meter waves might be formed instantaneously by intense ultra violet light from the head of the meteor. This would explain an echo moving with a velocity equal to the meteor itself. In the cases where a delay in the appearance of an enduring echo is observed an explanation can be found by assuming that a compact ionization cloud expands by diffusion until large enough to be detected with the wave length used. Diffusion being more rapid at higher levels one would expect that on the average the delays would increase towards the end of the meteor's path, and this fact is confirmed by observation. A more complete discussion of this theory has been prepared and will be published shortly elsewhere. The results of other workers, using radio frequencies above and below our frequency, fit consistently into the picture.

Ottawa, Ontario, Canada
May, 1948

[Editor's note: The more complete discussion referred to above is a paper entitled "A Phenomenological Theory of Radar Echoes from Meteors" by D. W. R. McKinley and Peter M. Millman, Proceedings of the Institute of Radio Engineers, vol. 37, No. 4, pp. 364-375 (1949).]

LUMINESCENCE AND IONIZATION OF METEORS

By Hantaro Nagaoka

The complete text is published in the Proceedings of the Imperial Academy, Tokyo, Vol. XV, pp. 345-348.

EXPLORATION MÉTÉORIQUE DE LA HAUTE ATMOSPHÈRE

Par F. Link

L'interprétation correcte des phénomènes météoriques se heurte à quelques difficultés qui rendent peu certaines les déterminations absolues de la densité atmosphérique audessus de 50 km d'altitude. Deux facteurs notamment entrent en jeu: 1° la fraction η d'énergie cinétique des masses d'air traversées par le météore qui est transformée en chaleur, 2° la fraction τ de l'énergie cinétique du météore transformée en radiations visibles. Les méthodes relatives peuvent s'affranchir de la connaissance de ces facteurs, si l'on admet seulement leur constance durant le vol du météore.

Dans cet ordre d'idées, nous allons montrer de quelle façon les observations météoriques peuvent conduire à la determination de la limite supérieure du gradient de densité $d\rho : \rho dh = \beta$ où ρ est la densité à l'altitude h. Il est évident que la disparition du météore dépend de la masse d'air M_d traversée par le météore, de la masse météorique m, de sa vitesse v et de la chaleur totale de vaporisation q + h d'un gramme de la matière météorique. La relation suivante donne la disparition

$$\frac{v^2}{2}\int_0^{s_d} \eta S\rho ds = m(q + h) \tag{1}$$

ou S est la section du météore normale à la trajectoire et de l'élement de cette dernière.

L'apparition du météore a lieu quelque part dans l'intervalle $0.....s_d$. On peut admettre que le météore apparaît au plutôt dès que sa température atteint la température de fusion avec la consommation de la chaleur q par gramme. La condition d'apparition sera donc

$$\frac{\eta v^2 S}{2}\int_0^{s_a} \rho ds = qm \tag{2}$$

où nous admettons que la section S ne varie pas sensiblement avant l'apparition. Dans les formules ci-dessus les intégrales

$$M_a = \int_0^{s_a} \rho ds \qquad M_d = \int_0^{s_d} \rho ds \tag{3}$$

les masse d'air d'apparition et de disparition.

Nous pouvons calculer leur rapport $M_d:M_a$ comme l'a fait, pour la première fois, Öpik (1). Ce rapport dépend de la façon dont varie la section S pendant la dissipation du météore. Le mode admis par Öpik et que nous avons également admis dans notre premier travail (2) est caractéristique au corps cylindrique droit qui se déplace suivant la direction de son axe. Cela conduit au rapport des masses d'air

$$(4) \qquad \frac{M_d}{M_a} = \frac{q + h}{q} = k$$

Si nous admettons, en différence avec Öpik, une forme sphérique pendant la dissipation on obtient

$$(5) \qquad \frac{M_d}{M_a} = 3k$$

Enfin une sphère qui se dissipe sans changement d'orientation et sans liquefaction totale donne en moyenne

$$(6) \qquad \frac{M_d}{M_a} = \frac{3}{4} k$$

Les formules (5) et (6) fixent très approximativement les limites du rapport des masses d'air sous l'influence de la forme du noyau météorique. D'autre part la valeur maximum de k s'obtient dans le cas où le météore apparaît à la température de fusion et disparait a la fin de vaporisation. Les constantes thermiques connues des matériaux météoriques (3) conduisent à la valeur de $k = 7.8$ pour les fers et $k = 5.8$ pour les pierres météoriques. Il en suit que le rapport des masses d'air, compte tenu de la forme et de la composition, ne peut dépasser la valeur $3 \times 7.8 = 23.4$ ou 25 en chiffres ronds.

Dans l'atmosphère où la densité varie suivant la loi

$$(7) \qquad \rho = \rho_o e^{-\beta(h - h_o)}$$

le rapport des masses d'air, tant que la distance zénithale est inférieure à 80°, sera donné par

$$(8) \qquad \log \frac{M_d}{M_a} = 0.43\, \beta\, (H_a - H_d)$$

ou H_a et H_d sont les altitudes d'apparition et de disparition.

Une statistique (4) concernant 1400 météores plus faibles que 0.9^m montre que dans les 9/10 des cas environ la différence $H_a - H_d$ est comprise dans l'intervalle de 5 à 45 km. Si alors la différence maximum $H_a - H_d = 45$ km correspond à la valeur limite de $k = 25$, il en résulte pour

$$\beta < 0.72 \times 10^{-6} \text{ cm}^{-1}$$

C'est la limite supérieure du gradient de densité dans les couches entre 80 et 110 km où l'on observe la plupart des météores. Dans le même intervalle les mesures crépusculaires donnent $\beta = 0.56 \times 10^{-6}$ (5) et les déterminations absolues de densité par Whipple à l'aide des metéores (6) conduisent à $\beta = 1.4 \times 10^{-6}$ - une valeur qui est franchement en dehors des limites cidessus. Pour expliquer la valeur aussi élevée il faudrait admettre que la chaleur consommée jusqu'à l'apparition du météore n'est que 0.1 environ de celle qui est necessaire à sa fusion complète.

Les statistiques de $H_a - H_d$ indiquent en plus très nettement la diminution du gradient β avec l'altitude croissante. Si l'on trace (Fig. 1) les courbes de

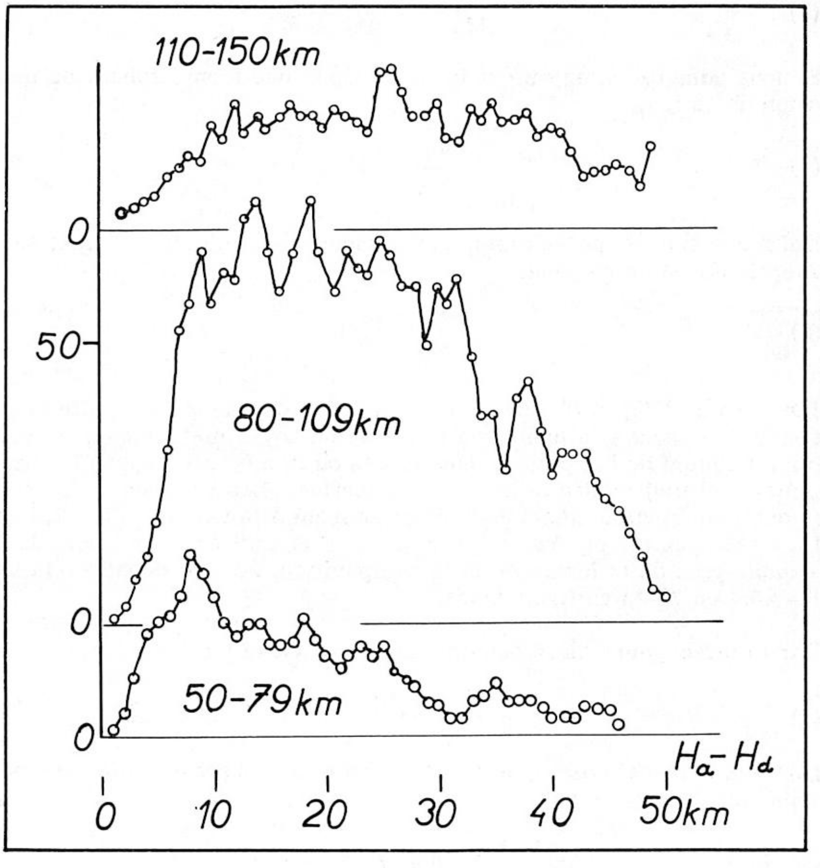


Figure 1

fréquence de $H_a - H_d$ en fonction de cette valeur dans les intervalles de 50-79 km, 80-109 km et 110-150 km de l'altitude moyenne, on trouve que les maxima des courbes se déplacent vers les valeurs plus élevées quand l'altitude moyenne croît. Cela peut être interprété d'après la formule (8) par la diminution du gradient avec l'altitude.

Il nous semble que les météores, depuis Lindemann et Dobson jusqu'à nos jours, ont largement payé leur tribut à la géophysique dans l'exploration de la haute atmosphère. Les astronomes attendent maintenant au retour les données exactes sur la densité de la haute atmosphère qui pourront être determinées dans le proche avenir par les ascensions directes et qui serviront dans la classification thermique des météores. C'est en somme un problème inverse à celui que nous venons de traiter.

Il faut signaler d'outre part que les observations par le procédé radar peuvent donner les altitudes des météores à n'importe quelle heure de la journée et permettent aussi d'étudier les variations diurnes de la haute atmosphère sur les bases que nous avons expliquées.

Bibliographie

1. E. Öpik, Publ. Obs. Tartu, v. 29, No. 5 (1937).
2. F. Link, C.R. v. 221, p. 326 (1945); Publ. Obs. Prague, v. 18 (1947).
3. F. Link - O. Petrácek, Constantes thermiques des météorites, Bull. Math. Phys. Tchécosl. , v. 72, p. 147 (1947).
4. F. Link - V. Bumba, Études météoriques, sous presse.
5. F. Link, C.R., v. 222, p. 333 (1946).
6. F. Whipple, Rev. Mod. Phys., v. 15, p. 246 (1943).

MEASUREMENT OF THE GEOMAGNETIC FIELD IN THE IONOSPHERE

By L. V. Berkner and E. H. Vestine

In the study of geomagnetic variations there has long been a need for a method of direct exploration and determination of the electrical currents which flow in the outer atmosphere. The Department of Terrestrial Magnetism has, therefore, initiated a research into possible radio methods for measurement of the earth's magnetic field at great heights. Closely allied to this research is the measurement of the earth's field at high altitudes using rockets. The two methods are complementary, for, while the first method may be used to follow the variation with respect to time at a selected level, the second method can provide a relatively instantaneous cross-section with respect to height, and one method can be used to check the other.

Radio methods--Three radio methods of measurement of the earth's magnetic field at high altitudes have been proposed. All depend upon the gyration of electrons under the influence of the earth's magnetic field.

(1) Measurement of separation of critical frequencies of ordinary and extraordinary components--This method can be used only in the vicinity of the geomagnetic equator because of the "sidewise skidding" of radio waves at levels of low ion-gradient in latitudes where the inclination of the earth's field is appreciable.

(2) Direct measurement of the gyro-frequency--This experiment depends on an effect of cross modulation between two radio frequencies in the ionosphere which was predicted in 1936 by Professor V. A. Bailey. The experiment has subsequently been tried by M. Cutolo with somewhat ambiguous results.

(3) Measurement of separation in wave frequency of ordinary and extraordinary rays reflected from the same level in regions of high ion-gradient--This experiment involves ready separation of the two rays at any wave frequency, using a substantial refinement of the technique introduced by Ratcliffe and White.

All three methods involve rather precise determinations of height.

Research on the third method is now under way at the Derwood Experimental Laboratory of the Department of Terrestrial Magnetism. Polarized receiving systems capable of quick frequency change are being developed as a first step in the effectuation of this technique. Designs are planned for precise measurement of frequency separation of echoes from the two wave components at any selected height, and improved methods of height measurement are being investigated.

Rocket measurements--Closely related and complementary to the radio methods described above are direct measurements of the geomagnetic field at great heights using rockets.

In cooperation with the Applied Physics Laboratory and Naval Ordnance Laboratory, the earth's field was measured aboard the "Aerobee" rocket. A preliminary test flight at White Sands, New Mexico, on April 13, 1948, was completely successful, with continuous telemetered signals obtained on both ascent and descent. The diminution in field with height was about 20 milligauss per 100 km, in good agreement with expectation from theory; a detailed check will be possible when more accurate information on the trajectory is available.

In subsequent experiments, it is hoped to determine the heights of electric current-systems of the atmosphere responsible for the various geomagnetic variations.

Department of Terrestrial Magnetism
Carnegie Institution of Washington
Washington, D.C., U.S.A.

UPPER ATMOSPHERE RESEARCH WITH V-2 ROCKETS

By H. E. Newell

The complete text is published as Naval Research Laboratory (Washington, D. C.) Report R-3294 of June 1948.

ROCKET MEASUREMENTS OF THE GEOMAGNETIC FIELD AND HEIGHTS OF ELECTRIC CURRENT-SYSTEMS IN THE ATMOSPHERE*

By E. H. Vestine

This project of the Applied Physics Laboratory of Johns Hopkins University, undertaken with the cooperation of the Naval Ordnance Laboratory and the Department of Terrestrial Magnetism, has shown some progress which will be briefly reported here. The work, at present only in its pioneering phase, is of special interest in that the use of new techniques permits the substitution of direct measurement of the properties of the geomagnetic field at great heights for the inferences from radio data and surface values of magnetic field available in the past.

* This report summarizes the work of a number of co-workers of the Applied Physics Laboratory of Johns Hopkins University, the Naval Ordnance Laboratory, and the Department of Terrestrial Magnetism.

At the present time, the project is regarded as comprising two parts:

(a) Measurement of the change of the Earth's main magnetic field with height and detection of a possible component of external origin to Earth.

(b) Detection of the heights of electric current-systems in the atmosphere by measurement of the discontinuity in horizontal component across the current-layers.

Under (a) the initial flight made April 12, 1948, at White Sands, New Mexico, in a rocket known as the "Aerobee", seems to have been completely successful. A device mounted in the nose of the rocket provided continuous telemetered records of total magnetic intensity from ground level to the top of trajectory of flight, with check results on descent to Earth. Initial examination of results indicates the geomagnetic field decreased with height in good accordance with expectations based on spherical harmonic analysis of the main field. A more precise evaluation of results of the flight will be possible later, when the computations of the actual trajectory have been completed. The sensitivities used were inadequate to detect the height of the current-system responsible for the solar daily magnetic variation.

It is expected that the second phase of the experiment will undertake to fire a rocket through the intensified storm-type current-system present during maximum intensity of a magnetic bay. Since the discontinuity in the horizontal component of field across the current-layer at the auroral zone may then approach 5000 gammas, there is good reason to hope this phase of the experiment will likewise be successful. Plans also contemplate similar experiments for detecting the heights of the current-systems responsible for the solar and lunar daily magnetic variations.

Department of Terrestrial Magnetism
Carnegie Institution of Washington
Washington, D.C., U. S. A.

THE SCATTERING OF TEN CENTIMETER RADIO WAVES BY RAIN

By R. C. Langille

The complete text will be published in the Journal of Geophysical Research, vol. 55, March 1950.

SONDAGES OPTIQUES DE LA HAUTE ATMOSPHÈRE A L'AIDE DES ÉCLIPSES DE LUNE

Par F. Link

Les éclipses de Lune nous donnent une excellente occasion d'observer l'ombre de l'atmosphère terrestre projetée sur la Lune. Si le Soleil était une source ponctuelle de lumière, l'ombre de l'atmosphère serait une image détaillée de sa structure. L'étendue angulaire du Soleil rend cette image un peu floue mais n'empêche pas de tirer quelques conclusions intéressantes relatives à la haute atmosphère. [Voir un mémoire plus detaillé dans les Ann. de Géoph., vol. 4, p. 47 (1948).]

Les observations donnent la densité optique de l'ombre en fonction de la distance au centre. On établit une théorie photométrique [1] qui donne, à la base de nos connaissances actuelles de l'atmosphère, les densités calculées de l'ombre. Les différences entre la densité observée et calculée peuvent alors être attribuées aux propriétés inconnues de l'atmosphère qui n'ont pu être prises en considération. Dans le calcul on adopte une atmosphère idéale diffusant suivant la loi de Rayleigh-Cabannes [2]. La structure, c'est-à-dire la densité de l'air en fonction de l'altitude, sera donnée par les sondages aérologiques et accoustiques qui déterminent cette fonction jusqu'à l'altitude de 40 à 50 km environ.

La densité optique de l'ombre se compose des deux parties principales. La première due à la diffusion moléculaire est fortement selective. La seconde sensiblement neutre est due à la réfraction dans l'atmosphère qui agit en quelque sorte comme une lentille divergente et diminue l'éclairement dans l'ombre. Dans les parties centrales de l'ombre, c'est la première composante qui est prédominante, tandisque vers le bord la réfraction est presque la seule cause connue de l'affaiblissement de la lumière. Ces différences expliquent les variations de coloration de l'ombre qui est rougeâtre au centre et grise ou verdâtre par contraste vers le bord.

La comparaison avec les observations révèle de fortes différences positives O-C dans le sens que l'ombre est plus dense que ne l'indique la théorie. Une explication immédiate par l'impureté de la basse atmosphère ne rend pas suffisamment compte de l'allure des différences O-C. Dans ces comparaisons l'introduction de la <u>masse d'air moyenne</u> M_0 est d'une grande utilité. Sous ce terme on entend la masse d'air traversée par les rayons solaires qui est responsable de la composante due à la diffusion moléculaire. Elle permet alors par une modification du coefficient d'absorption atmosphérique de diminuer ou d'augmenter les différences O-C. Si l'on représente les valeurs de O-C en fonction de la masse d'air moyenne M_0, on obtient une courbe dont l'interprétation conduit aux conclusions suivantes:

La partie rectiligne entre les masses 15 et 25 correspond aux altitudes des rayons entre 18 et 3 km environ. La pente de la courbe indique la necessité d'une augmentation du coefficient d'absorption par rapport à sa valeur théorique. Pour les masses d'air plus faibles entre 10 et 15 ou bien dans l'intervalle d'altitudes 8 et 24 km environ les différences O-C deviennent sensiblement constantes. Aucune modification du coefficient d'absorption ne peut faire disparaître cette différence. Il s'agit plutôt d'une absorption constante ou peu variable avec l'altitude des rayons solaires. Cette propriété présentant plus ou moins la couche absorbante élevée mince ou épaisse tant que l'altitude des rayons solaires est faible par rapport au niveau supérieur de la couche. La couche d'ozone explique en grande partie l'allure de cette partie de la courbe. Aux masses d'air plus faibles encore dès que les rayons solaires dépassent 24 km environ les différences O-C commencent a décroitre rapidement en signe que les rayons solaires s'approchent de la limite supérieure de la couche d'ozone. Nous avons ainsi une preuve de son altitude relativement basse. L'allure de cette partie de la courbe dépend de l'angle de position dans l'ombre ou, ce qui revient au même, de la latitude du lieu au-dessus duquel passent les rayons solaires. Il se montre alors d'une façon générale qu'aux basses latitudes les différences O-C sont plus faibles et leur chute commence à la masse d'air plus faible qu'au latitudes élevées. Autrement dit la quantité de l'ozone contenue dans l'atmosphère est plus faible à l'équateur qu'aux pôles et que son altitude croit vers l'équateur. Ceci est en accord avec les determinations directes de l'ozone par la méthode spectrale.

Les différences O-C ne peuvent être entièrement expliquées par l'ozone. En extrapolant vers $M_O = 0$ on trouve en général une valeur positive de O-C et les mesures dans le bleu où l'ozone n'absorbe pratiquement pas montrent aussi des valeurs positives de O-C. Il s'agit alors probablement d'une absorption supplémentaire dont le caractère repond à une couche élevée de 100 km environ. L'existence d'une telle couche demande encore à être étudiée plus en détail. Il n'est pas impossible que nous sommes ici en présence d'une pollution atmosphérique étendue entre le sol et le niveau de 100 km - une pollution due aux poussières metéoriques.

Les études de la pénombre ne paraissent pas être à première vue susceptibles de donner quelques indications sur la haute atmosphère. Toutefois nous avons pu montrer que lors de l'éclipse du 19 novembre 1945 les isophotes de la pénombre intérieure étaient sensiblement aplaties dans le même sens que la Terre [3]. Cet aplatissement était plus prononcé sur le coté vespéral que sur le coté matinal de l'ombre. L'origine de ce phénomène doit être cherchée dans la haute atmosphère.

Bibliographie

[1] F. Link, Bull. Astr. 8, No. 2 (1933).
[2] J. Cabannes, Diffusion moléculaire de la lumière, p. 167, Paris (1929).
[3] F. Link, C.R. 223, p. 718 (1946).

SUR LA POSSIBILITÉ DES SONDAGES OPTIQUES DE LA HAUTE ATMOSPHÈRE A L'AIDE DES PHÉNOMÈNES CRÉPUSCULAIRES

Par F. Link

Une opinion défavorable est répandue parmi les géophysiciens en ce qui concerne la possibilité des sondages optiques de la haute atmosphère à l'aide des phénomènes crépusculaires. Depuis la présentation de notre note à l'Assemblée générale de l'UGGI à Edinbourg en 1936 [1] des objections de la part de Hulburt [2] et de Grandmontagne [3] ont été levées, basées toutes les deux sur l'importance de la diffusion secondaire qui, d'après ces auteurs, rend illusoires les sondages crépusculaires. Or il n'en est rien, comme nous allons prouver par les mêmes chiffres destinés primitivement à refuter la méthode crépusculaire.

La diffusion secondaire prend naissance sur la partie basse de la verticale d'observation où la densité de l'air est bien connue et l'éclairement par le ciel crépusculaire peut être mesuré ou calculé. La diffusion primaire peut être calculée à partir des densités de la haute atmosphère généralement mal connues d'avance et l'éclairement solaire directe, relativement bien connu.

Hulburt détermine la brillance secondaire en mesurant au niveau du sol la brillance du ciel crépusculaire à l'horizon et en combinant ces valeurs avec les densités connue de l'air jusqu'à 30 km. Ce procedé, quoique grossier, peut donner l'ordre de grandeur da la brillance secondaire. Pour déterminer la brillance primaire Hulburt se montre trop confiant aux extrapolations de la basse atmosphère jusqu'à l'altitude de 140 km. De cette façon il trouve des densités et par suite aussi des brillances qui sont systématiquement de 10 à 20 fois plus faibles au moins par rapport aux valeurs généralement admises. Il n'est pas alors étonnant que sa brillance primaire devient vite negligeable par rapport à la brillance secondaire dès que les rayons dépassent l'altitude de 80 km environ.

Le procédé correcte consiste à comparer la brillance secondaire déterminée, soit par la méthode empirique de Hulburt, soit par un calcul rigoureux comme nous avons fait nous-mêmes [4] avec la brillance mesurée, qui est la somme de la brillance primaire et secondaire. De cette façon on evite toute hypothèse à priori sur les densités de la haute atmosphère. Dans le tableau suivant sont donnés: U la dépression solaire, H l'altitude de la limite de l'ombre géométrique au zénith, i_z la brillance mesurée et i_m la brillance secondaire d'après Hulburt [2] pour la lumière blanche et d'après Link pour la lumière verte et pour U = 10° [4].

Tableau I

U		H	Hulburt			Link		
			i_z	i_m	$i_m:i_z$	i_z	i_m	$i_m:i_z$
7	52	60	0.339	0.120	0.36			
9	36	80	0.0676	0.0630	0.93			
10	09	100	0.0398	0.0260	0.65	2.63	0.75	0.28
11	08	120	0.0158	0.0071	0.45			
12	02	140	0.0076	0.0049	0.64			
				moyenne	0.61			

Vers 100 km d'altitude la brillance secondaire fait d'après Hulburt 65 per cent ou d'après nous 28 per cent de la brillance mesurée. Les valeurs de Hulburt, étant calculées pour la lumière blanche et d'une façon approchée, sont probablement moins précises que les nôtres qui sont basées sur un calcul rigoureux. En tous cas, en lumière verte (5300 Å) et à 100 km d'altitude, la diffusion secondaire gêne beaucoup moins que ne le pense Hulburt et sa déclaration que.....les mesures crépusculaires à partir de 60 km ne peuvent donner aucune indication sur la densité de l'air.....nous paraît exagerée.

Il y a d'ailleurs une méthode fort simple pour réduire l'importance de la diffusion secondaire: c'est de travailler dans l'infrarouge. Vers 8000 Å la diffusion moléculaire se réduit à 1/5 de sa valeur vers 5300 Å, le rapport $i_m : i_z$ devient alors inférieur à 0.1 et la brillance mesurée en irfrarouge représente bien la densité de l'air en haute altitude.

La brillance du ciel au zénith est donnée par l'intégrale

$$b = F(U,\lambda)\int_H^\infty \rho\, E\, dh$$

ou E est l'éclairement solaire directe et ρ la densité de l'air à l'altitude h. L'éclairement E est approximativement connu par nos Tables [5] et la densité de l'air peut être déterminée en première approximation à partir de la pente de la courbe log b = f(U) comme nous l'avons montré en 1935 [6]. On peut donc évaluer l'intégrale de la brillance et par des comparaisons avec les observations on arrive à determiner les corrections de E et ρ adoptées. Nous avons effectué une série d'observations photoélectriques vers 8000 Å qui nous a donné 27 courbes individuelles log b = f(U). Nous les avons réunies en une courbe moyenne qui nous a servi pour déterminer la densité en fonction de l'altitude. Les résultats sont contenus dans le tableau suivant:

Tableau II [7]

h(km)	50	60	70	80	90	100	120	140	160	180
- log ρ	5.93	6.49	7.06	7.43	7.69	7.93	8.40	8.84	9.26	9.60

Ces chiffres représentent bien nos mesures sauf au voisinage de U = 11° où une fluctuation fait soupçonner une discontinuité - la constation faite déjà par Bruner [8].

A partir de U = 9° environ il faut tenir compte de la brillance du ciel nocturne due à d'autres causes que la diffusion moléculaire. Faute de mieux nous admettons que celle-ci pendant le crépuscule est égale à sa valeur au début de la nuit. On la retranche de la brillance observée pour obtenir la brillance due à la diffusion. La necessité de cette correction parait avoir échappé à Grandmontagne [3]. Il trouve que les courbes brutes log b = f(U) en différentes longueurs d'onde sont parallèles jusqu'à U = 9° environ, cela étant en accord avec ma théorie [6], et que plus tard le parallélisme ne se conserve plus. Grandmontagne attribue cette divergence à l'influence croissante de la diffusion secondaire. Mais si nous corrigeons les brillances brutes, comme il vient d'être expliqué, on obtient des courbes sensiblement parallèles jusqu'à U = 12° ou H = 140 km (Fig. 1). Plus loin la brillance du ciel nocturne en infrarouge devient trop grande et les sondages par les rayons infrarouges deviennent inéfficaces.

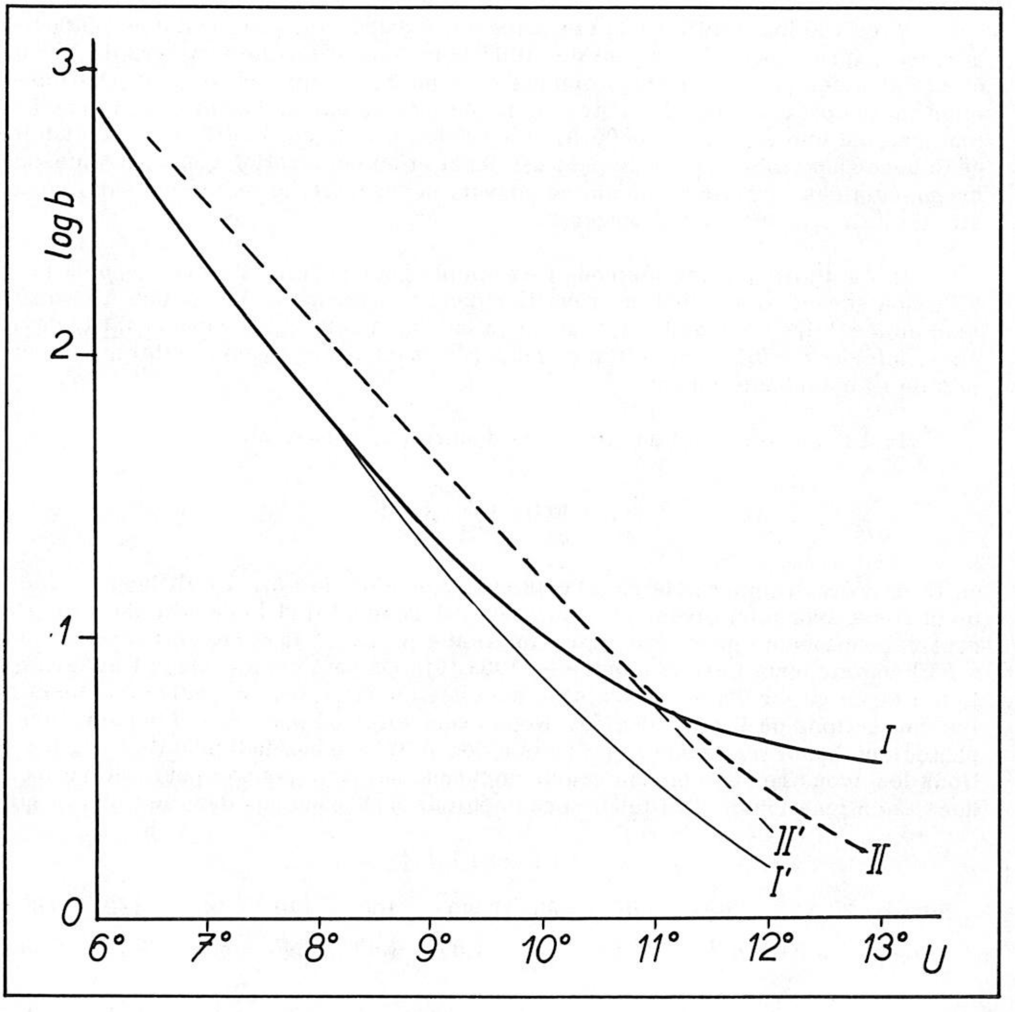


Figure 1

Bibliographie

[1] F. Link, Procès-verbaux de l'Ass. de Méterol. II, Edinbourg, p. 231 (1936).
[2] E. O. Hulburt, Journ. Opt. Soc. Amer. 28, p. 227 (1938).
[3] R. Grandmontagne, Ann. de Phys. 16, p. 253 (1941).
[4] F. Link, Met. Zeitschr. 59, p. 7 (1942).
[5] F. Link, Mitt. u. Beob. Tchech. Astr. Ges. Prag No. 6 (1942).
[6] F. Link, Journ. des Observ., 17, p. 161 (1934); C.R. 200, p. 78 (1935).
[7] F. Link, C.R. 222, p. 333 (1946).
[8] W. Bruner, Publ. Sternw., Zürich 6, p. 81 (1935).

SUDDEN FADE-OUT OF HIGH FREQUENCY ELECTRIC WAVES CAUSED BY ALPHA PARTICLES FORMED IN THE UPPERMOST ATMOSPHERE

By Hantaro Nagaoka

The complete text is published in the Proceedings of the Imperial Academy, Tokyo, Vol. XVIII, pp. 635-643.

A SUGGESTION FOR THE ELECTRIC CONDUCTIVITY OF THE UPPER ATMOSPHERE FROM AN ANALYSIS OF THE DIURNAL VARIATIONS OF TERRESTRIAL MAGNETISM

By M. Hasegawa

The results of analysis of the magnetic S field, making use of the materials of 19 observatories in the north polar region, were communicated by the writer to the Washington Meeting of the Union. Some of them are quoted here: (1) the ring electric current band near the maximum aurora zone has a considerable breadth, its outside boundary being distinct; (2) the dimension of the ring varies with the season of the year and the magnetic activity of the day. These facts must have some close bearings to the electrical states of the upper atmosphere. In this report we may discuss the electrical conductivity.

Taking for granted that the geomagnetic S field is originally caused by electric current in any layer in the upper atmosphere, the horizontal intensity of the field, for example, the X-component of the force, is approximately represented by the product of the electric potential gradient E in the perpendicular directions and the conductivity K of the layer, i.e., using suitable units,

$$X(t) = E(t) \cdot K(t)$$

where t is the local time.

Substituting, for X, E and K in the above formula, the expressions of the series of harmonic components, we have

$$A_0 + A_1 \sin(t + \epsilon_1) + A_2 \sin(2t + \epsilon_2) + A_3 \sin(3t + \epsilon_3) + \dots$$
$$= [\alpha_1 \sin(t + \theta_1) + \alpha_2 \sin(2t + \theta_2) + \dots]$$
$$[1 + \beta_1 \cos(t + \delta_1) + \beta_2 \cos(2t + \delta_2) + \dots],$$

where β cannot be much larger than 1. The values of A and ϵ are obtained by means of the harmonic analysis of X-component from the data of observations. Comparing the coefficients of both sides of the above equation, A and ϵ can be expressed as functions of α, θ, β and δ. But the functional forms are in general not simple, except the following special cases.

Case	α_1 α_2	β_1 β_2	A_1	ϵ_1	A_2	ϵ_2	A_3	ϵ_3
i	α_1 0	β_1 0	α_1	θ_1	$1/2\alpha_1 \beta_1$	$\theta_1 + \delta_1$	0	0
ii	0 α_2	β_1 β_2	$1/2\alpha_2 \beta_1$	$\theta_2 - \delta_1$	α_2	θ_2	$1/2\alpha_2 \beta_1$	$\theta_2 + \delta_1$

The case (i) can be applied to the stations where A_2 is a little more or less than 1/2 A_1, and A_3 is very small, and the case (ii) to those where A_1 and A_3 are equal and A_2 is great. Looking at the tables of the coefficients of the harmonic analysis it is found that the case (i) may be roughly applicable to all stations in the north polar region, mostly concerning the X-component. Fig. 2 shows the relative magnitudes of A_1, 2 A_2, and A_3 on disturbed days in summer, the stations being arranged in abscissa according to the distance from the geomagnetic pole in the elliptic oval coordinate system as shown in Fig. 1. In the case (i) the conductivity is assumed to be expressed in the form $K_0 [1 + \beta_1 \cos (t + \delta_1)]$, $- \delta_1$ indicating the time of occurrence of the maximum conductivity in the local time (say t_m). In Fig. 3 the values of t_m, calculated in this way, are arranged as described above.

A striking feature of these figures is that there is along the outside boundary of the ring current band a zone of abnormal conductivity, in which the maximum occurs near midnight, instead of about noon as in all other places on the Earth. This zone is not fixed, but expands in breadth and diameter containing the oval form in the S_D field and in winter as compared with the Sq field and in summer respectively. The southern rims of the zone in the cases of mean S_D (heavy lines) and mean Sq (light lines) in winter (full) and in summer (broken) are drawn in Fig. 4. The area of abnormal variations of electric conductivity covers the Scandinavia Peninsula and a part of the British Isles in the disturbed magnetic field in the winter. It is supposed that the range of shift of the zone may be greater on individual days and in the year of more sunspots than those as seen in this figure.

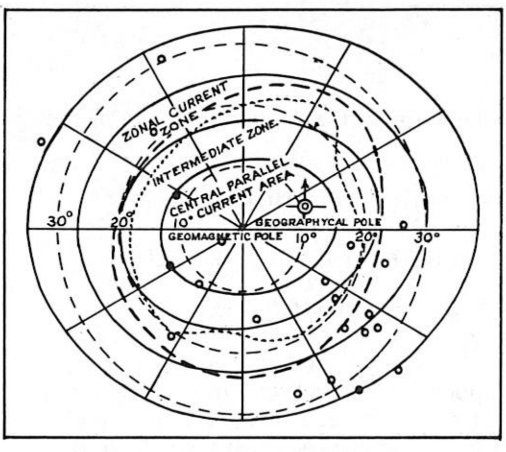


Figure 1

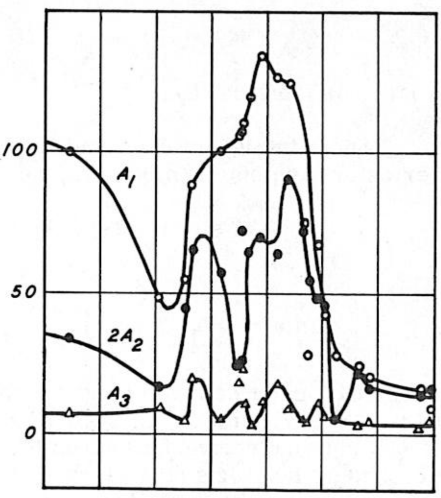


Figure 2

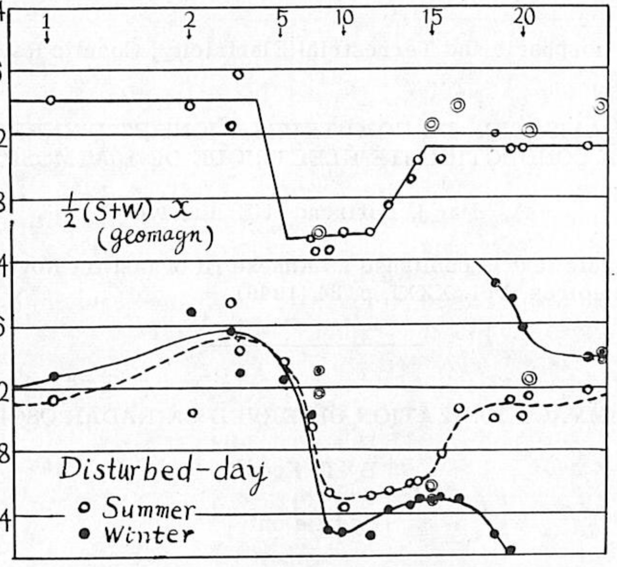


Figure 3

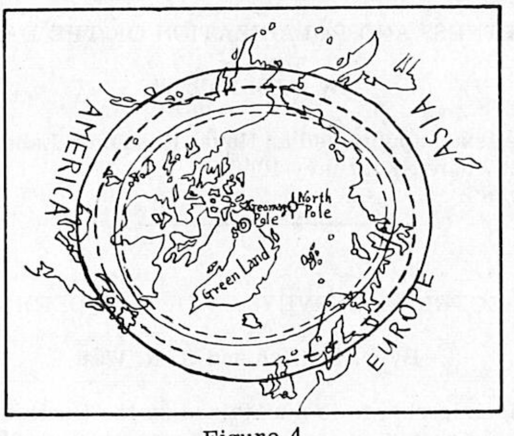


Figure 4

List of stations

1. Thule
2. Godhavn
3. Calm Bay
4. Sveagruvan
5. Scoresby Sund
6. Julian haav
7. Bjornöya
8. Fort Rae
9. Matotchkin Shar
10. Dickson Island
11. Tromsö
12. Petsamo
13. Sodankylä
14. Kandalaksha
15. Meanook
16. Lerwick
17. Sitka
18. Lovö
19. Sloutzk
20. Eskdalemuir
21. Agincourt
22. De Bilt
23. Cheltenham

Geophysical Institute
Kyoto University
Feb. 15, 1948

(F) Atmospheric and Terrestrial Electricity, Cosmic Rays, Etc.

SUR LA RÉALISATION DE COMPTEURS D'IONS ET D'ENREGISTREURS DE LA CONDUCTIBILITÉ ÉLECTRIQUE DE L'ATMOSPHÈRE

Par J. Bertrand et E. Lahaye

The complete text is published as Annexe III of Institut Royal Météorologique de Belgique Mémoires, Vol. XXXI, p. 24 (1949).

METEORIC IMPACT IONIZATION OBSERVED ON RADAR OSCILLOSCOPES

By T. Koono

[By title only]

THE BRIGHTNESS AND POLARIZATION OF THE DAYLIGHT SKY

By E. O. Hulburt

The complete text is published as Naval Research Laboratory (Washington, D. C.) Report N-3257 dated February 1948.

ELECTRICAL SURVEYS OVER THUNDERHEADS

By O. H. Gish and G. R. Wait

A negative electric charge is maintained on the Earth in all fair weather areas even though this charge is continually escaping by conduction through the atmosphere. In order to maintain this charge, negative electricity must be supplied to the Earth in some way at the rate of about 1800 amperes. C. T. R. Wilson surmised that this supply-current is generated in thunderstorms. It is scarcely feasible to make under a thunder storm reliable measurements in adequate number to ascertain whether the net current from a typical thunderstorm to Earth is of the sign and magnitude required to maintain the negative charge on the Earth. An alternative is the scheme initiated during the past summer by the Department of Terrestrial Magnetism in cooperation with the United States Army.

The measurements of electric currents passing vertically through a thunderstorm were carried out aboard a B-29 while flying entirely in the clear above the storm. Special equipment was mounted aboard the plane to measure the following elements: (1) The electric field above and that below the plane of the wing from which it is possible to differentiate between the field due to a charged wing and a charged cloud. (2) The conductivity of the air due to positive ions and that due to negative ions. (3) The electric current passing vertically through the plane through the atmosphere. From simultaneous values of the electric field and the conductivity of the air, the vertical current density through the atmosphere can be deduced and compared with that measured directly. From the results thus far obtained the following tentative conclusions are drawn: (A) The conductivity of the air above a thunderstorm is not abnormal. (B) The vertical component of electric current over the most intense thunderstorm studied was of the right sign and magnitude to maintain the fair weather current provided about 1800 such storms are in progress (on the average) at a given time.

Department of Terrestrial Magnetism
Carnegie Institution of Washington
Washington, D.C., U.S.A.

CONTRIBUTION À L'ÉTUDE DE L'INFLUENCE DE LA LUNE SUR LES COURANTS TELLURIQUES

Par A. Romañá, S.J. et J. O. Cardús, S.J.

Résumé

Les méthodes généralement suivies pour l'étude de l'influence de la Lune sur les courants telluriques ne semblent pas les plus à propos pour éliminer toute influence solaire: (a) à cause du nombre relativement petit de données employées, lequel ne permet pas une entière compensation des effets solaires; (b) parce qu'un nombre considérable des valeurs telluriques publiées étant des valeurs instantanées, les méthodes d'interpolation pour déduire des valeurs solaires les lunaires ne semblent pas toujours pouvoir leur être appliquées.

Pour éviter ces deux écoeuils on a mesuré directement sur les courbes telluriques des années 1910 à 1920, par heures et jours lunaires, les valeurs horaires moyennes. Les jours ayant été groupés par lunaisons et celles-ci par années, on a déterminé par les méthodes ordinairement suivies dans les Observatoires pour le calcul des valeurs solaires, les valeurs horaires moyennes des lunaisons, des années et de l'ensemble, de même que leurs déviations par rapport aux moyennes générales.

L'effet solaire est automatiquement éliminé, puisque les opérations nécessaires pour la détermination de chaque valeur horaire lunaire moyenne porte à l'addition de valeurs tombant dans toutes les heures solaires l'une après l'autre. L'elimination est d'autant plus parfaite que le nombre de données est plus élevé. Après avoir éliminé les jours incomplets et quelques lunaisons dont les valeurs semblaient douteuses (par ex. par fonctionnement défectueux des électrodes) on a travaillé avec un total de 3.536 jours lunaires distribués en 131 lunations.

Les résultats qu'on ne donne qu'à titre provisoire, parce qu'on est en train de revoir encore une fois les lunaisons omises dans le but de compléter le plus possible le matériel de travail, se traduisent dans la courbe à double onde semi-diurne déjà connue, mais beaucoup plus régulière: les maximums se présentent à 3^h et 18^h et les minimums à 9^h et 21^h. L'amplitude est la même pour les deux ondes et elle atteint 6.1 mV./Km. Le rapport r_2/r_1 étant beaucoup plus élevé que dans les résultats d'autres auteurs (13.7 contre 5.5 pour Egédal et 8 pour

Rooney) et les angles de phase φ_1 et φ_2 étant presque des multiples de π, tout fait croire que, si le nombre de données était encore augmenté et l'on prescindait des jours de caractère tellurique 2 (car il est évident que la perturbation responsable d'un tel caractère n'est pas d'origine lunaire), on arriverait à des courbes qui ressembleraient de plus en plus des ondes sinusoidales simples.

L'application de notre méthode à l'étude de l'effet des phases nous a porté à des courbes tout à fait similaires à celles obtenues pour le magnétisme par divers investigateurs (cf. Chapman, Geomagnetism, vol. I, pp. 245 et suiv.). Pourtant leur aspect et amplitude et surtout l'analyse de la méthode suivie nous a fait voir que le soi-disant effet de phase n'était qu'apparent et que la variation de l'aspect des courbes n'était pas dû à un effet lunaire proprement tel, mais lunisolaire. En effet, le fondement de notre méthode pour l'élimination de l'effet solaire étant l'accumulation dans une même heure lunaire des valeurs tombant sur toutes les heures solaires indifféremment, l'on voit tout de suite que cela n'arrive pas quand on additionne pour la détermination de l'effet de phase les trois jours centrés de chaque phase, puisque dans ceux-ci, le Soleil et la Lune se trouvant toujours dans la même position relative, par le fait même d'additioner les valeurs telluriques par heures lunaires, on les additionne en même temps par heures solaires, diverses certainement d'une phase à l'autre, mais les mêmes pour chaque phase. Il faut donc leur soustraire, pour voir la courbe lunaire des phases, la courbe solaire. Pour cela, comme la courbe solaire déduite des valeurs publiées dans le Bulletin de l'Observatoire de l'Ebre se trouvait être en heures solaires, on l'a déterminé de nouveau en heures lunaires. En faisant la soustraction indiquée, les courbes lunaires de chaque phase sont sensiblement les mêmes, pouvant être attribuées les différences qu'on y observe aux irrégularités dues au nombre relativement petit de données (car elles sont du même ordre que celles que l'on observe dans les courbes des années individuelles).

Un examen préliminaire des effets sur la courbe diurne de la distance et la déclinaison de la Lune nous permet d'avancer que l'amplitude de la courbe pour le périgée semble être 1.5 fois celle de l'apogée et que celle-ci change aussi avec la variation de la distance de la Lune à l'équateur. Aucune influence claire du cycle solaire se manifestant dans nos courbes, cela nous semble encore une nouvelle confirmation de l'aptitude de la méthode suivie pour l'élimination de tout effet solaire.

Ebro Observatory
July 1948

DISCUSSION:

S. Chapman was puzzled by the absence of luni-solar terms. He recommended the determination of the variation also by the method due to Chapman and Miller. There was no reason to doubt that the determination of the lunar semi-diurnal term was a good one.

[Editor's Note: Father Romañá was made a member of the Joint Committee on the Study of Lunar Variations in Meteorological, Magnetic, and Electrical Elements.]

QUELQUES RESULTATS DES OBSERVATIONS SIMULTANÉES DU CHAMP ELECTRIQUE DE LA CONDUCTIBILITÉ ET DES PHÉNOMÈNES MÉTÉOROLOGIQUES

Par W. Smosarski

The complete text is published in Bulletin de la Société des Amis des Sciences et des Lettres de Poznan, Vol. IX, pp. 143-146 (1948).

AN ABSTRACT OF GEOPHYSICAL RESEARCH OF COSMIC RAYS IN JAPAN

By Yataro Sekido

The first geophysical research of cosmic rays performed in Japan was that done by Mr. Kawano [1] of the Central Meteorological Observatory, observing the east-west effect on the summit of Mt. Fuji in 1934. The results were the same as were to be expected from those of T. H. Johnson and A. Ehmert. Researches during the following decade were almost exclusively performed at the Institute of Physical and Chemical Research (I.P.C.R.) under the direction of Dr. Nishina, as an activity of the Cosmic-Ray Sub-Committee of the Japan Society for the Promotion of Scientific Research. The first work was the observation, by means of a Compton-type cosmic-ray meter, of cosmic-ray intensities at Hakone and on Mt. Fuji in 1935, with results as expected from those of A. H. Compton, et al. Next, we observed the effect of solar eclipse on cosmic rays, during the total solar eclipse on June 19, 1936, near the summit (1260 m alt.) of Mt. Shari in Hokkaido [2], and found no effect whatever, as was to be expected. In August of the same year, the subterranean cosmic-ray intensities were measured, using a Neher-type cosmic-ray meter, in the Shimizu tunnel of the Joetsu Line [3]. Cosmic-ray burst phenomena, producing 10^7 pairs of ions simultaneously in the ionization chamber were observed at a place under ground equivalent to a water layer of about 800 m depth. Using the same instrument, we measured, in December of the same year, with assistance from the Navy, cosmic-ray intensities in high altitudes up to 7 km, with an aeroplane. The results were the same as expected from those of R. A. Millikan. Since 1935, we made continuous recordings of cosmic-ray intensities in Tokyo using a Steinke-type cosmic-ray meter [4]. From these recordings, the effect of magnetic storms on cosmic rays, the seasonal variation of cosmic-ray intensities, and also the variation of cosmic-ray intensity with the solar cycle and local time were ascertained. Also, it was found that the barometric effect on cosmic rays differed from time to time.

From April 1937 to April 1939, through courtesy of the N.Y.K., we placed the Neher-type cosmic-ray meter on the Kitano-Maru during four return voyages on the Australian service, and on the Heian-Maru for seven runs to Seattle and back, each making continuous automatic recordings. From these results, the latitude effect in these regions [5] and also the effect of magnetic storms became clear. Also they showed the variation of the barometer effect with the geographic latitude, the cause of which was explained as being in the effect of the change of temperature of upper atmosphere accompanying the pressure variations [6,7]. Further, it was ascertained that our estimation, based on this explanation, of the type of temperature change of the upper atmosphere in the tropics was in agreement with actual observations [8]. Also, correlated with this, the relation between seasonal rainfall and the type of the barometer-effect was learned [9]. Again, using the same instrument without lead shield, we observed in 1940 and 1941, the total component of cosmic rays, on the sea near Tokyo aboard the Tachibana-Maru. We found that the seasonal changes of the total component are greater than that of the hard component, and also that the radioactivity in the atmosphere changes in rainy weather.

In accordance with the schedule of the Cosmic-Ray Sub-Committee, five cosmic-ray meters of ionization-chamber type were constructed at the I.P.C.R. These were planned to be distributed at five localities ranging from Saghalien to the Palao Islands in order to make continuous observations, and we were in the process of testing them by making simultaneous observations within a thermostatic chamber in Tokyo, when we were interrupted by the war. Using the results of these, we were able, cooperated by the Central Meteorological Observatory, to ascertain, through various meteorological phenomena, that the cosmic-ray intensity on the ground is affected by the temperature of upper atmosphere [10, 11, 12, 13, 14, 15]. Also, several examples were obtained, from these observations, of the cosmic-ray variations during magnetic storms, which supported the existence of the equatorial current ring during such storms. An attempt to explain this quantitatively has been made by Dr. Kato of the Tohoku University, postulating a model for the mechanism of magnetic storm.

Cosmic-ray observations were made inside the Shimizu tunnel using counter sets, and it was discovered for the first time that these rays were present even at a depth corresponding to 3000 meters of water. Also, the intensities and nature of cosmic rays at places under ground corresponding to 1400 meters and 3000 meters of water were studied [16]. On the other hand, preparations were under way to observe cosmic rays in high altitudes by the radio-sonde method, and measurements of the total vertical component were commenced in January 1942 (up to 17 km), but were soon stopped due to the war. The results were such that they could be explained from those of Pfotzer, taking the latitude effect into account.

The activities of the Cosmic-Ray Sub-Committee were first coordinated, and later taken over, by the Cosmic-Ray Laboratory of the I.P.C.R. During the period from 1942 to 1945, efforts were mainly devoted to the meteorological application of the above-mentioned temperature effect. It was thereby attempted to make continuous presumption of the temperature of the upper atmosphere in various districts through observations at several localities of cosmic-ray intensities. As this calls for accurate cosmic-ray meters, trial constructions were commenced of a large ionization chamber of normal pressure and a counter-type cosmic-ray meter, financial support being obtained from the Bureau of Science and Technology. The construction of the ionization chamber was given up for lack of materials, but the counter-type meter was completed and observations by it commenced in July 1944 enabling us to make fairly accurate presumption of the temperature of the upper atmosphere. In March 1945 another meter of the same type was made. Meanwhile a large ionization chamber of high pressure type was constructed by Dr. Ishii, Mr. Miura, and others at the Army Meteorological Department and observations started in January 1945. However, the above three meters all ceased functioning in March due to air-raids. In parallel with these, a counter-type cosmic-ray meter was constructed by Dr. Minakawa and others at the Central Meteorological Observatory, which started observations in summer 1947. Also, at the Nishina Laboratory of the I.P.C.R., intensity observations using the Neher's electroscope were recommenced since summer 1946, and observations by one of the above-mentioned five ionization chambers were revived in summer 1947 and also the above counter-type cosmic-ray meter which was taken into parts for air-raid refuge was reconstructed and observations commenced at Itabashi, Tokyo, since August 1947. A part of the cosmic-ray group of the Nishina Laboratory has organized a cosmic-ray laboratory at the Nagoya University, and started constructing a cosmic-ray telescope with the financial support by Mr. Fukuda of Nagoya City. It is hoped that observations by a preliminary set may be commenced by spring 1948. At the Tohoku University too, preparations for the construction of a counter-type cosmic-ray meter are being made by Dr. Kato and his co-workers.

Since 1946 the above groups have joined the Special Committee for Ionospheric Researches and are carrying on analysis and discussions, either by performing cooperative observations or by comparing their respective data with those related to geomagnetism, the ionosphere, solar activities, etc. As a result, the conditions of the equatorial current ring during magnetic disturbances have become fairly clear, and various facts are thought to be useful in investigating the mechanism of magnetic storm.

References

[1] M. Kawano, Cosmic Ray Observation on Mt. Fuji, J. Meteoro. Soc. Japan, 13, 1 (1935).

[2] Y. Nishina, C. Ishii, Y. Asano, and Y. Sekido, Measurements on Cosmic Rays During the Solar Eclipse of June 19, 1936, Jap. J. Astro. Geophys., 14, 265 (1937).

[3] Y. Nishina and C. Ishii, A Cosmic Ray Burst at a Depth Equivalent to 800 M. of Water, Nature, 138, 721 (1936).

[4] C. Ishii, Y. Asano, Y. Sekido, and F. Shimamura, Intensity Variations of Cosmic Ray, Bull. Inst. Phys. Chem. Research, Tokyo, 18, 1066 (1939).

[5] Y. Sekido, Y. Asano, and T. Masuda, Cosmic Rays on the Pacific Ocean, Part I - Latitude Effect, Sci. Pap. Inst. Phys. Chem. Research, Tokyo, 40, 439 (1943).

[6] Y. Sekido, Cosmic Rays on the Pacific Ocean, Part II - On the Barometer Effect of Cosmic Rays, Sci. Pap. Inst. Phys. Chem. Research, Tokyo, 40, 456 (1943).

[7] Y. Sekido, Latitude Variation of the Barometer Effect of Cosmic Rays, J. Phys.-Math. Soc. Japan, 16, 77 (1942).

[8] Y. Sekido, Cosmic Rays and the Upper Atmosphere in Tropics, J. Phys.-Math. Soc. Japan, 16, 78 (1942).

[9] Y. Sekido, Cosmic Rays and Seasonal Rainfall, J. Phys.-Math. Soc. Japan, 16, 78 (1942).

[10] Y. Nishina, Y. Sekido, F. Shimamura, and H. Arakawa, Cosmic-Ray Intensities and Air Masses, Phys. Rev., 57, 663 (1940).

[11] Y. Nishina, Y. Sekido, F. Shimamura, and H. Arakawa, Air Mass Effect of Cosmic-Ray Intensity, Phys. Rev., 57, 1050 (1940).

[12] Y. Nishina, Y. Sekido, F. Shimamura, and H. Arakawa, Cosmic-Ray Intensities and Cyclones, Nature, 145, 703 (1940).

[13] Y. Nishina, Y. Sekido, F. Shimamura, and H. Arakawa, Cosmic-Ray Intensities in Relation to Cyclones and Anticyclones, Nature, 146, 95 (1940).

[14] Y. Nishina, Y. Sekido, F. Shimamura, and H. Arakawa, Cosmic-Ray Intensities and Typhoons, Phys. Rev., 59, 679 (1941).

[15] H. Arakawa, Seasonal and Diurnal Variations of Cosmic-Ray Intensity, Geophys. Mag. Cent. Meteo. Obs., 8, 215 (1940).

[16] Y. Nishina, Y. Sekido, Y. Miyazaki, and T. Masuda, Cosmic Rays at a Depth Equivalent to 1400 Meters of Water, Phys. Rev., 59, 401 (1941).

Nagoya University
Nagoya, Japan

ON THE REFLECTION OF RADIO WAVES FROM A METEOR

By T. Yonezawa

We have calculated theoretically the reflection coefficient of a meteor for radio waves. For mathematical simplicity the following assumptions have been made. At the time $t = 0$ a meteor shoots in a straight line and owing to its ionizing effect there leaves behind it N electrons per unit length along the line. If they have no velocity component perpendicular to the path of the meteor and spread out gradually by diffusion, the electron density at a point r cm distant from the path at the time $t = t$ is given by $(N/4\pi Dt) \exp(-r^2/4Dt)$, where D is the diffusion coefficient of an electron. Besides diffusion electrons are also lost by recombination and attachment, but we neglect these processes in order to avoid mathematical complexity. Thus the dielectric constant ϵ at the same point is

$$\epsilon = 1 - \frac{e^2N}{m\omega^2Dt} \exp(-r^2/4Dt) \tag{1}$$

where e, m, and ω are the charge on an electron in e.s.u., the mass of an electron. and the angular frequency of the radio wave used.

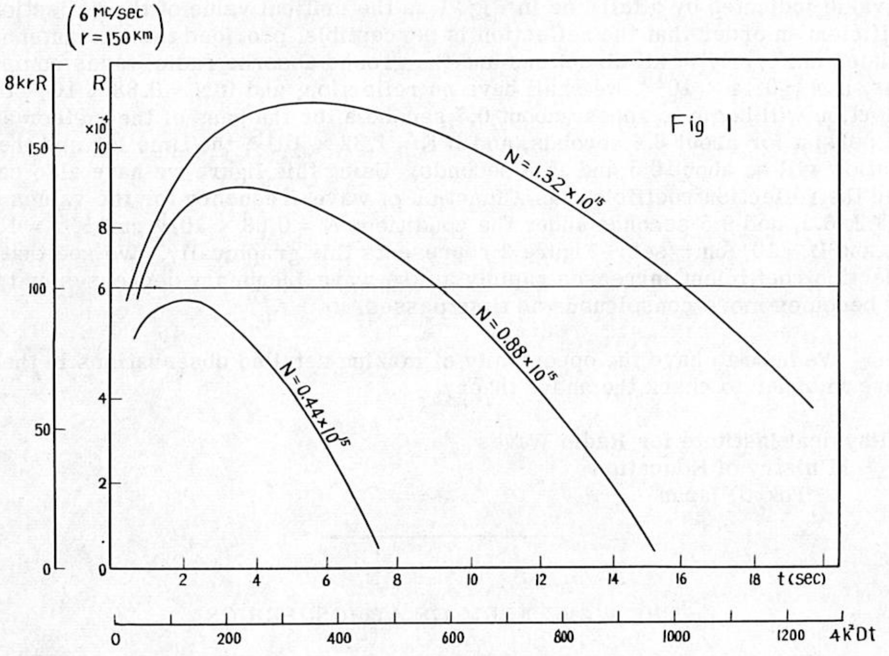
Further we assume that the radio wave is a plane wave and its electric vector is perpendicular to the path of the meteor. When such a wave is incident upon a space, where the distribution of the values of the dielectric constant is given by (1), from any direction perpendicular to the path of the meteor, one can find the asymptotic solution of the wave equation at sufficiently great distances. But the exact solution is very complex and is not convenient for numerical calculation, so we have resorted to rather bold approximation and obtained the following formula for the reflection coefficient R at a point r cm distant from the path of the meteor:

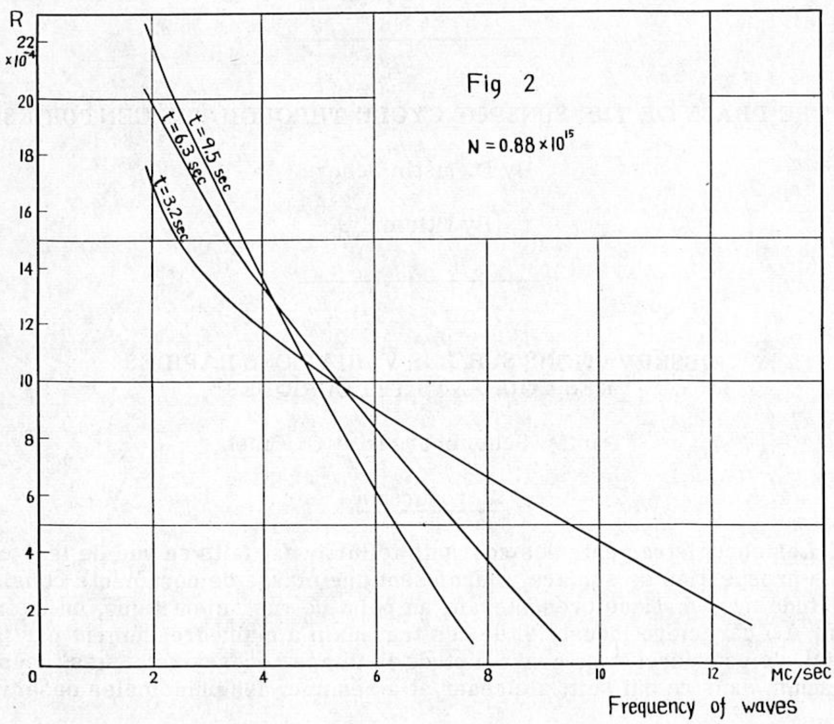
$$R = 1/[8kr\int_{x_0}^{\infty} dx/\left\{x^2\sqrt{1 + \frac{1}{4x^2} - \frac{e^2N}{m\omega^2Dt} \exp(-x^2/4k^2Dt)}\right\}] \tag{2}$$

where k is ω divided by the velocity of light in vacuo and x_0 is the positive and largest zero-point of the function $1 + (1/4x^2) - (e^2N/m\omega^2Dt) \exp(-x^2/4k^2Dt)$.

In the cases of $N = 1.32 \times 10^{15}$, 0.88×10^{15}, 0.44×10^{15} we have calculated 8krR as a function of $4k^2Dt$ by means of (2). Fig. 1 is its graphical representation, taking 8krR as ordinate and $4k^2Dt$ as abscissa. The abscissa is proportional to time and if, for instance, the wave-frequency is 6 Mc/sec and the diffusion coefficient of an electron is 10^7 cm^2/sec, we obtain the time-scale in Fig. 1. The ordinate is proportional to the reflection coefficient, and if the distance to the path of the meteor is 150 km, we have the scale of the reflection coefficient in the figure. We can see that the intensity of reflection at first increases more rapidly and reaches a maximum, and then decreases more slowly towards zero, and also that the reflection coefficient increases with N and the larger is the value of N, the later becomes the time of maximum intensity of reflection.

As an illustration we take the case that the power of the transmitter is 1 kw and the minimum perceptible electric field intensity of the receiver is 0.3 micro-


6 Mc/sec
r = 150 km
8krR
R
×10⁻⁴
Fig 1
N = 1.32 × 10¹⁵
N = 0.88 × 10¹⁵
N = 0.44 × 10¹⁵
t (sec)
4k²Dt


R
×10⁻⁴
Fig 2
N = 0.88 × 10¹⁵
t = 9.5 sec
t = 6.3 sec
t = 3.2 sec
Mc/sec
Frequency of waves

volt/cm. Then under the same conditions as the preceding paragraph we obtain the value indicated by a full line in Fig. 1 as the critical value of the reflection coefficient in order that the reflection is perceptible, provided that the antenna radiates uniformly in all directions and the ground absorbs radio waves completely. Thus, if $N = 0.44 \times 10^{15}$, we shall have no reflection, and if $N = 0.88 \times 10^{15}$ the reflection will begin to appear about 0.7 second after the pass of the meteor and will persist for about 8.4 seconds, and if $N = 1.32 \times 10^{15}$, the time lag and the duration will be about 0.5 and 15.5 seconds. Using this figure we have also calculated the reflection coefficient as a function of wave-frequency for the values of $t = 3.2$, 6.3, and 9.5 seconds under the conditions $N = 0.88 \times 10^{15}$ cm^{-1}, $r = 150$ km, and $D = 10^7$ cm^2/sec. Figure 2 represents this graphically. We see that the reflection coefficient increases rapidly as the wave-frequency decreases and that this becomes more conspicuous as time passes.

We hope to have the opportunity of making detailed observations in the future in order to check the above theory.

Physical Institute for Radio Waves
Ministry of Education
Tokyo, Japan

THE WAVE FORM OF ATMOSPHERICS

By A. Kimpara

[By title only]

THE PHASE OF THE SUNSPOT CYCLE THROUGH THE CENTURIES

By D. Justin Schove

[By title only]

OBSERVATIONS SUR LES VARIATIONS RAPIDES DES COURANTS TELLURIQUES

Par M. Schlumberger et G. Kunetz

Introduction

Les enregistrements des courants telluriques, faits en vue de leur utilisation à la prospection de surface, fournissent une masse de documents considérable, dont l'étude systématique présenterait, au point de vue scientifique, un intérêt certain. Le caractère industriel de ces travaux n'a malheureusement pas permis, jusqu'ici, de consacrer à ce genre d'étude le temps nécessaire. Aussi nous bornerons-nous, dans ce qui suit, à classer et à résumer les principales observations que permettent de faire le simple examen d'un grand nombre d'enregistrements et l'étude très sommaire de quelques-uns d'entre eux.

La prospection utilisant les courants telluriques a débuté bien avant la dernière guerre, et il a été rendu compte, ici même, des méthodes employées et des premiers résultats obtenus [Marcel Schlumberger, "The application of telluric currents to surface prospecting" (Communication au "Congrès de l'Union Géodésique et Géophysique Internationale", Washington, 1939)]. Depuis lors, d'importants progrès techniques ont été réalisés [Léon Migaux, "Une méthode nouvelle de géophysique appliquée: La Prospection par courants telluriques", Annales de Géophysique. Tome 2, fascicule 2 - juin 1946, p. 131] et la méthode a été appliquée à une échelle bien plus grande.

Emploi de la méthode tellurique

Période du Jan. 1, 1941 au Jan. 1, 1948

Pays ou région	Surfaces prospectées en Km^2	Nombre de points stationnés	Durée du travail en équipes-mois*
France	26,000	21,000	158
Afrique du Nord	3,500	6,600	25
Afrique Equatoriale Française et Madagascar	2,000	3,800	37
Angleterre	250	1,300	6
Etats-Unis	1,000	500	5
	32,750	33,200	231

*Quand plusieurs équipes indépendantes ont travaillé simultanément dans la même région on a additionné les durées de leurs travaux.

Au cours de ces 7 années, en moyenne, 3 équipes ont donc été constamment au travail, effectuant chacune environ 150 mesures par mois. Comme pendant la durée du travail d'une équipe un appareil enregistre en permanence pour servir de base de référence, la durée totale des enregistrements dépasse 50,000 heures. Certains ont d'ailleurs été effectués simultanément en des points distants de plusieurs milliers de kilomètres.

Généralités et Dispositifs de Mesure

L'étude détaillée de ces variations rapides a laissé peu de traces dans la littérature. Pourtant van Bemmelen les a déjà observées à Batavia en 1908 et les a comparées aux agitations magnétiques. C'est d'ailleurs en relation avec ces dernières, mieux étudiées, qu'elles sont quelquefois mesurées par les observateurs contemporains.

Nos enregistrements à grande vitesse de déroulement se prêtent particulièrement bien à l'étude de ces variations rapides et notamment de celles dont la période est comprise entre quelques secondes et quelques minutes. Dans ce qui suit, nous allons examiner successivement:

(a) Les variations en fonction du temps et en un point donné de la projection du champ tellurique sur une direction arbitraire. Dans ce paragraphe, un peu plus développé, nous résumerons aussi toutes nos observations qui ne font pas intervenir explicitement le caractère vectoriel du champ.

(b) Les variations, toujours en un point fixe, du vecteur champ en grandeur et en direction [Nous désignerons souvent par le terme "régime" la loi qui régit la variation du champ ou d'une de ses composantes en fonction du temps.].

(c) Les variations simultanées du vecteur champ en deux ou plusieurs points.

Pour commencer, voici quelques indications sur le dispositif de mesure:

L'appareil de mesure est un enregistreur photographique muni de deux galvanomètres permettant l'enregistrement simultané des deux composantes horizontales du champ tellurique.

Ces composantes sont mesurées entre des prises de terre dont la distance est généralement comprise entre 250 et 1000 m., suivant deux lignes rectangulaires, mais dont les directions font des angles quelconques avec le méridien.

Les prises employées sont des électrodes impolarisables, enterrées à faible profondeur, constituées par un métal baignant dans la solution saturée d'un de ses sels.

La résistance totale du circuit varie de quelques centaines à quelques milliers d'ohms.

La sensibilité est réglable. Au maximum de sensibilité à une différence de potentiel de 1 mV entre les extrémités des lignes correspond sur l'enregistrement une élongation de plusieurs dizaines de centimètres.

Enfin, la vitesse de déroulement varie de 0.5 à 4 centimètres à la minute.

Cette méthode diffère sur plusieurs points essentiels de celle habituellement employée dans les observatoires spécialisés: (a) les lignes sont plus courtes; (b) les prises sont plus simples; (c) la résistance des circuits est beaucoup plus faible; (d) la sensibilité est plus grande; (e) et, surtout, la vitesse de déroulement est beaucoup plus élevée.

L'étude des variations rapides, mises en évidence par cette vitesse d'enregistrement, peut être faite, malgré la sensibilité accrue, avec des moyens plus simples, car la stabilité des résistances et des potentiels de contact a dans ce cas beaucoup moins d'importance que dans l'étude des variations lentes.

De plus, le fait que nos observations soient fondées sur des enregistrements faits avec des milliers de couples d'électrodes et de lignes différentes, installées dans des conditions très variables, confère à leurs indications concordantes un caractère statistique excluant toute erreur systématique qui pourrait être due à des conditions locales particulières.

Variation d'une Projection du Champ

Nos enregistrements, compte tenu de la vitesse de déroulement et de l'inertie des galvanomètres, se prêtent particulièrement à l'étude des phénomènes dont la période est comprise entre 3-4 secondes et une dizaine de minutes. En ce qui concerne les intensités, on peut mesurer, dans des conditions favorables, des variations inférieures à une dizaine de microvolts.

Période des variations - Les variations du champ se présentent comme la superposition d'un grand nombre de phénomènes de périodes différentes et plus ou moins stables.

L'examen sommaire des documents à ce point de vue, à défaut de leur analyse systématique, conduit à des constatations intéressantes:

Dans la superposition des divers phénomènes périodiques il arrive souvent qu'un phénomène particulier devienne prépondérant et qu'il impose sa période, pendant plusieurs heures de suite, à l'ensemble des variations. Nous allons énumérer, en les caractérisant brièvement, quelques-uns des régimes les plus typiques.

Oscillations normales (Fig. 1b) - L'expérience montre que le phénomène de beaucoup le plus régulier a l'allure d'oscillations sinusoidales dont la période peut varier entre 15 et 30 secondes, mais qui reste, au cours d'un même train d'ondes, stable à quelques secondes près.

Pour caractériser la stabilité de ce régime dans un cas particulier, nous avons déterminé les périodes moyennes de 84 sections composées chacune de 10 oscillations consécutives, sur un enregistrement de 5 h.30 (de 7 h.30 à 13 h. GMT, le 4 Novembre 1943) pris dans sa totalité (bien que comportant plusieurs passages non-oscillatoires). On trouve une période moyenne de 24 secondes avec un écart moyen de 3 secondes. - La stabilité est bien plus grande quand on examine des intervalles de temps plus courts: ainsi sur 8 intervalles de 5 minutes chacun (du 16 Novembre 1943) la période moyenne est de 20 secondes avec un écart moyen de 1 seconde seulement.

Au lieu de considérer des périodes moyennes, on peut mesurer toutes les périodes individuelles d'un même train d'ondes. On trouve ainsi des dispersions du même ordre que ci-dessus [La dispersion réelle est évidemment beaucoup plus faible (on s'adresse à un phénomène plus pur) puisque dans le cas précédent la dispersion était calculée sur des chiffres qui étaient eux-mêmes des moyennes.]: sur un train d'ondes de dix oscillations (3 Novembre 1943) la moyenne de la période est de 19 secondes $\pm$ 1 seconde; sur un autre de 11 oscillations (16 Novembre 1943) on trouve 17 secondes, 5 $\pm$ 1 seconde.

Oscillations serrées (Fig. 1a) - La période des oscillations est quelquefois beaucoup plus petite, pouvant descendre jusqu'à 6 secondes. Ce régime, également très caractéristique, se rencontre beaucoup moins souvent.

Pulsations (Fig. 1d) - Nous avons appelé ainsi un phénomène assez fréquent mais moins caractéristique que les précédents, de période, voisine de 1 minute. Outre sa période plus longue, ce phénomène se distingue du régime oscillatoire par sa régularité beaucoup moins grande: la période est moins stable, l'amplitude varie rapidement d'une oscillation à l'autre, le dessin de ces dernières est irrégulier. On ne trouve jamais les trains d'ondes, caractéristique du régime oscillatoire.

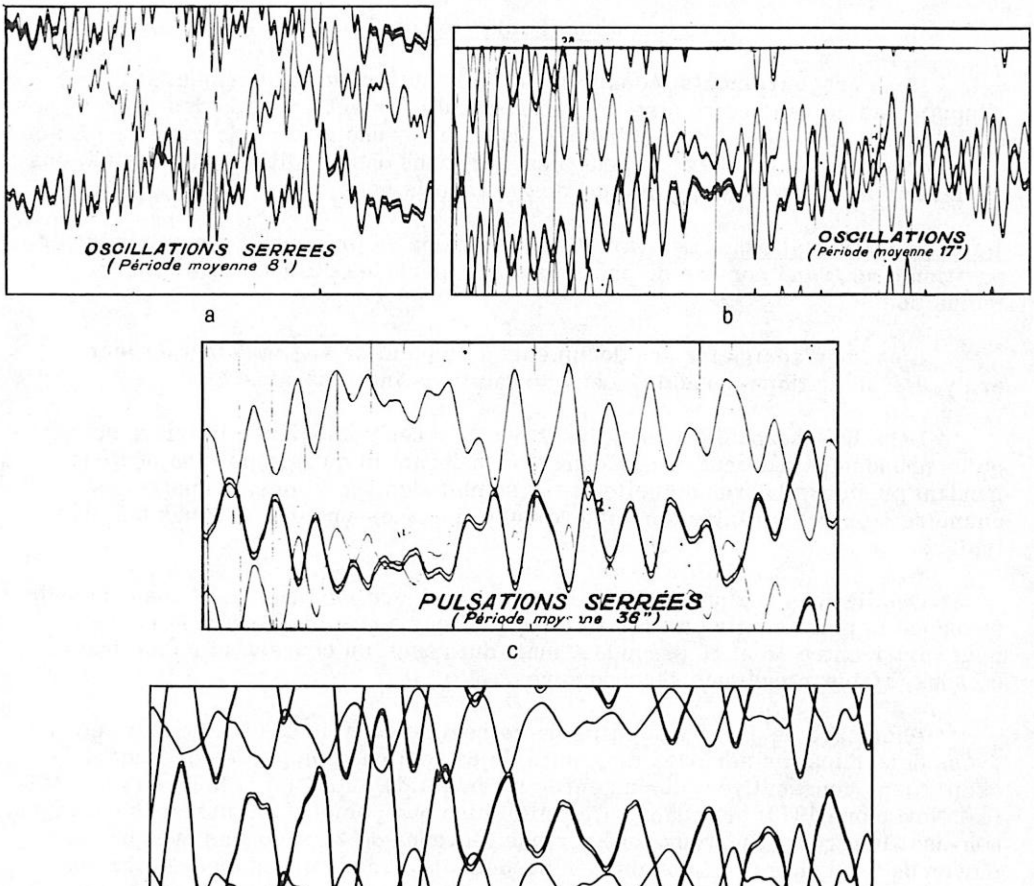

OSCILLATIONS SERREES
(Période moyenne 8")
a
OSCILLATIONS
(Période moyenne 17")
b
PULSATIONS SERRÉES
c
PULSATIONS
(Période moyenne 60")
d
GRANDS MOUVEMENTS
(Période moyenne 3')
1 mV.
1 minute
e

Fig. 1

Pulsations serrées (Fig. 1c) - Elles constituent la transition entre le régime oscillatoire et les pulsations avec des périodes allant de 30 secondes à 1 minute. Elles participent des deux régimes mais, par leur irrégularité, se rapprochent davantage des pulsations.

Pour les périodes supérieures à 1 ou 2 minutes les régimes réguliers sont plus rares. Ceci provient sans doute, en partie, de ce qu'ils sont masqués par des phénomènes à périodes plus courtes. On ne les met en évidence que si leur intensité est particulièrement grande. Nous les réunissons sous la dénomination de

Grands mouvements (Fig. 1e) - Leur période varie de quelques minutes, à quelques dizaines de minutes. Il existe des variations dont la période est encore plus longue, mais, comme nous l'avons déjà dit, nos enregistrements se prêtent mal à leur observation.

On rencontre aussi la superposition nette de deux des régimes précités: celle des grands mouvements et des oscillations est particulièrement caractéristique.

Ces régimes relativement purs sont l'exception: le plus souvent des phénomènes de période et d'amplitude variables se trouvent mêlés de telle sorte que leur identification par des procédés rapides devient impossible. Nous appelons leur superposition un régime "moyen". Celui-ci peut naturellement se rapprocher plus ou moins d'un des régimes purs énumérés ci-dessus.

Intensité - L'amplitude des variations est fonction non seulement du moment mais encore du lieu d'observation. Nous bornerons donc à donner quelques ordres de grandeur.

En considérant l'amplitude moyenne des variations rapides pendant des intervalles de quelques heures, on constate que, sur des lignes de l'ordre de 1000 m., elle est rarement inférieure à ce que nos appareils permettent de mesurer. Les valeurs les plus faibles ont été trouvées jusqu'ici en Afrique du Nord où, certains jours, l'amplitude des deux composantes est restée constamment inférieure à une vingtaine de microvolts par Km. En France, même dans les régions et les jours les plus calmes, cette amplitude a presque toujours atteint une centaine de microvolts par Km [Ces chiffres concernent les variations dont la période ne dépasse pas quelques minutes. Les ondulations plus larges ont, même les jours de faible activité, souvent une amplitude plus importante.]. Ces valeurs correspondent à des variations de courant de l'ordre de 10^{-2} microampères par m2, en tenant compte de la conductibilité moyenne des terrains à l'aplomb des stations de mesure.

Les valeurs habituelles des amplitudes des variations rapides du champ sont, en gros, cinq fois supérieures aux chiffres donnés ci-dessus, ce qui donne, pour les régions de champ tellurique minimum étudiées en France, environ 0.5 mV par Km.

Au cours des orages telluriques (qui accompagnent toujours les orages magnétiques) l'intensité moyenne peut être encore 50 ou même 100 fois supérieure - comme c'était le cas notamment lors de l'orage tellurique et magnétique du 18 Septembre 1942 - sans parler de variations isolées qui peuvent être bien plus grandes.

Comme l'intensité du champ est en rapport avec les résistivités des terrains à l'aplomb du point de mesure, les rapports entre les amplitudes moyennes au même moment peuvent atteindre des valeurs très élevées, atteignant parfois 1000, entre points distants seulement de quelques Km.

Quant à la relation entre périodes et intensités, on peut remarquer que les régimes oscillatoires et, à un moindre degré, celui des pulsations, présentent toujours une amplitude nettement supérieure à celle des régimes "moyens". Ainsi les jours particulièrement calmes ne comportent jamais d'oscillations. On est ainsi tenté d'admettre qu'oscillations et pulsations se superposent, quand elles existent, à un fond permanent de variations non-périodiques et de faible amplitude.

<u>Relation avec d'autres phénomènes</u> - L'étude de ces relations n'a pu qu'être amorcée jusqu'ici.

L'influence, sur l'agitation tellurique, des heures du jour ou de la nuit est difficile à étudier, car nos enregistrements ne sont faits généralement que de jour, le plus souvent entre 8h. et 18h. Quelques enregistrements continus de 24h. et plus permettent de compléter leurs indications. Les conclusions d'ensemble sont les suivantes:

1. L'activité des variations rapides est plus grande le jour que la nuit.

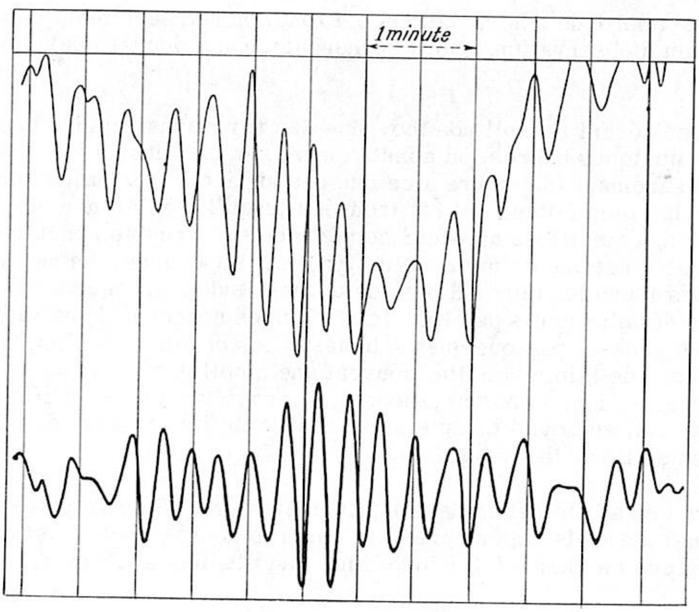
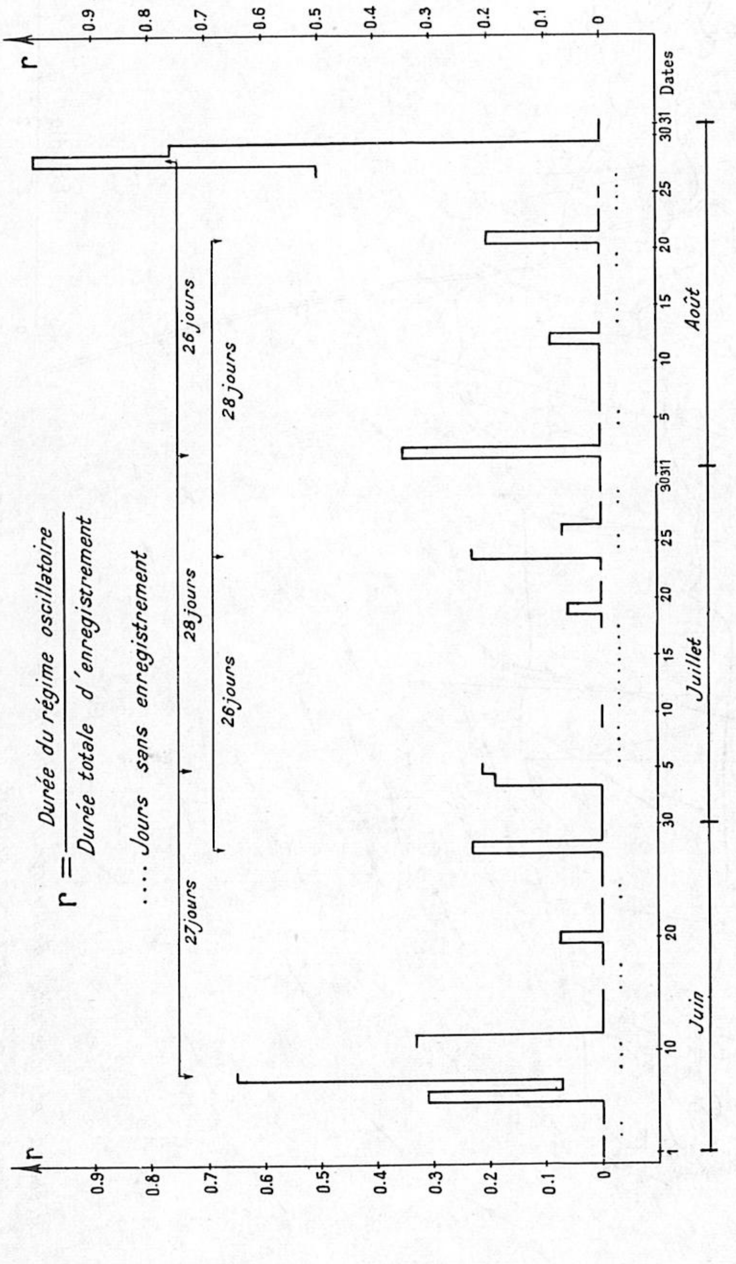


Fig. 2



Fréquence du régime oscillatoire dans le sud de la France pendant l'été 1945

Fig.3

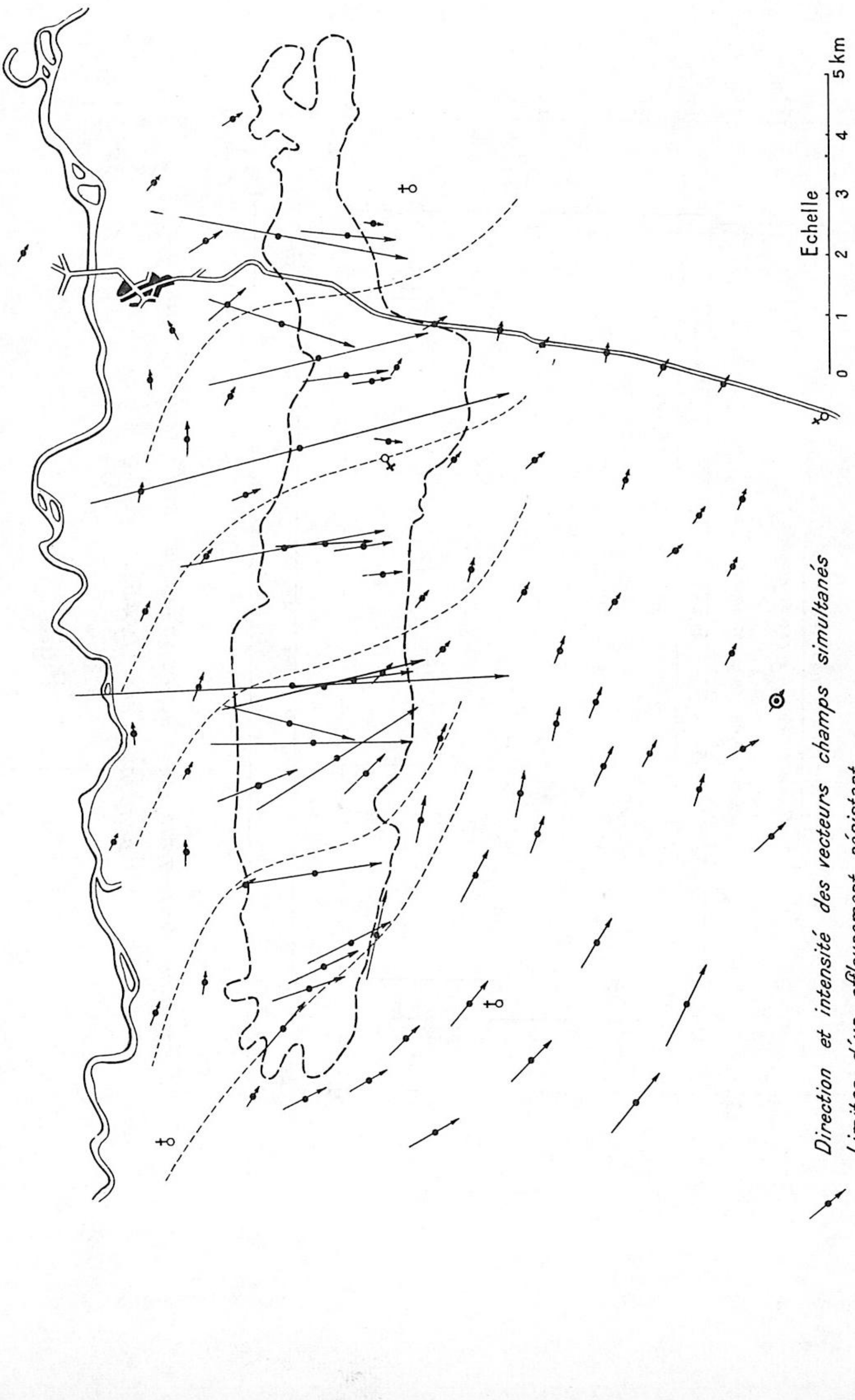

Echelle
0 1 2 3 4 5 km
Direction et intensité des vecteurs champs simultanés
Limites d'un affleurement résistant
Schéma des lignes de courant

Fig. 4

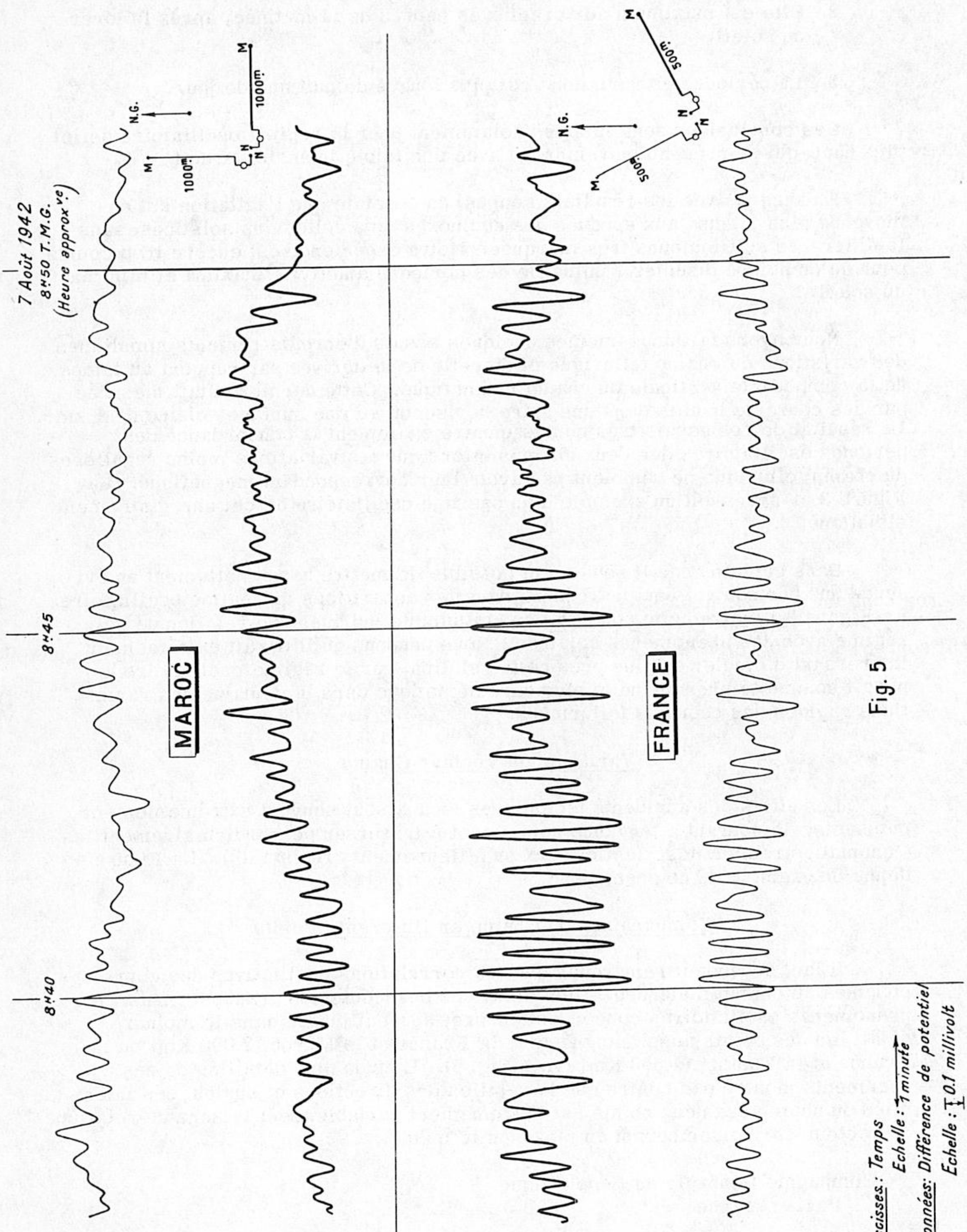

7 Août 1942
8h50 T.M.G.
(Heure approx.ve)
8h45
8h40
MAROC
FRANCE
N.G.
1000m
500m
M
N
Abscisses: Temps
Echelle: 1 minute
Ordonnées: Différence de potentiel
Echelle: 0.1 millivolt

Fig. 5

2. Elle est maximum aux premières heures de la matinée, après le lever du soleil.

3. La période des variations est plus longue de nuit que de jour.

Ces conclusions sont valables notamment pour le régime oscillatoire défini plus haut, qui se présente rarement et avec une faible intensité la nuit.

En accord avec les résultats connus, on constate que l'agitation est en moyenne plus intense aux époques des équinoxes qu'à celles des solstices, sans que la différence soit toujours très marquée. Notre expérience est encore trop courte pour qu'on puisse discuter l'influence des périodes d'activité maxima et minima du soleil.

Nous avons fait nous-mêmes quelques essais d'enregistrements simultanés des variations du champ tellurique et de celle de la dérivée par rapport au temps de la composante verticale du champ magnétique. Cette dernière était mesurée par des courants induits dans une spire horizontale d'une surface voisine de 1 km^2. Le résultat de ces essais très courts montre également la concordance des périodes oscillatoires des deux champs, alors que les variations moins régulières du champ tellurique ne semblent pas avoir leur correspondant magnétique. La Figure 2 ci-après est un exemple d'un passage oscillatoire de cet enregistrement simultané.

Dans certains cas il nous a été possible de mettre assez nettement en évidence une période voisine de 27 jours dans les apparitions du régime oscillatoire. La Figure 3 illustre cette constatation qui semble indiquer une relation de ce régime avec des phénomènes solaires. Nous pensons qu'il serait extrêmement intéressant d'étudier de plus près cette relation, car le régime oscillatoire apparaît comme le phénomène le plus caractéristique dans le domaine des variations rapides des courants telluriques.

Variation du Vecteur Champ

Les effets des accidents tectoniques locaux sont souvent extrêmemement puissants: le courant a tendance notamment à traverser perpendiculairement les "anomalies résistantes" (anticlinaux ou affleurements résistants). La Figure 4 donne un exemple de ce phénomène.

Comparaison du Champ en Differents Points

Il faut cependant remarquer que les corrélations qualitatives des composantes du champ s'étendent à des distances beaucoup plus grandes. Ainsi, les phénomènes oscillatoires concordent encore, souvent jusque dans le moindre détail, en des points aussi éloignés que la France et le Maroc (2,000 Km) ou la France et la Tunisie (1,500 Km) (voir Fig. 5). L'étude plus détaillée de ces documents montre par contre que la relation des directions et surtout des intensités du champ aux deux points est extrêmement variable, seul le sens de rotation du vecteur champ demeurant en moyenne le même.

Compagnie Générale de Géophysique
Paris, France

SUMMARY OF COSMIC-RAY INVESTIGATIONS

By S. E. Forbush

By 1938 the Carnegie Institution of Washington, through its Committee on Coordination of Cosmic-Ray Investigations, had in operation several cosmic-ray meters. These continuously recording ionization chambers [1] were located at Godhavn (Greenland), Cheltenham (Maryland, U. S.), Teoloyucan (Mexico), Huancayo (Peru), and Christchurch (New Zealand).

Among the first results of this program was the discovery of world-wide changes in cosmic-ray intensity during magnetic storms [2]. It was subsequently found [3] that most of the major changes, apart from seasonal variations, were world-wide and were associated with terrestrial magnetic activity [4,5].

On February 28 and March 7, 1942, two unusual, sudden increases in cosmic-ray intensity occurred simultaneously at Godhavn, Cheltenham, and Christchurch. At Huancayo (geomagnetic latitude 0°.6 S) no significant increases occurred on the above dates [6]. The implications of these two sudden increases were overlooked until a similar but much larger sudden increase was observed at Cheltenham [7] and Godhavn on July 25, 1946. Again the increase did not occur at Huancayo. All three of these increases were found to follow, within an hour or less, the onset of an observed chromospheric eruption (solar flare) or the onset of a radio fadeout on the daylight side of the Earth, definitely indicating a solar flare.

During the increase of July 25, 1946, the magnetograms from several magnetic observatories in different parts of the world indicated no world-wide magnetic disturbance although a world-wide magnetic storm began about 26 hours after the beginning of the cosmic-ray increase. Thus the evidence indicated some solar phenomenon, and not storm changes in the Earth's magnetic field, was responsible for the increases.

In a preliminary communication entitled "On the mechanism of sudden increases of cosmic-ray intensity associated with solar flares" [8], it is indicated that the time variation of the magnetic field of the sunspot groups in which the flares occurred is capable of accelerating charged particles to sufficient energy to explain the observed increases, at the latitudes where these occurred. This calculation is based essentially on the mechanism proposed by W. F. G. Swann [9].

However, if these charged particles leave the Sun from the neighborhood of the solar flare, then, on account of the Sun's general magnetic field, they could not escape unless some special means is provided. This means appears to be provided by the dipole moments M_{SS} of the sunspot groups involved, which provide a tunnel [10] through the otherwise forbidden regions of Störmer arising from the Sun's permanent magnetic moment, M_S. The existence of the tunnel depends not only on M_S, but rather critically on the orientation of M_S relative to M_{SS}.

A tunnel is found on July 25, 1946, which, together with the fact that the M_{SS} involved was nearly 15 per cent greater than on July 24, indicates that the proposed mechanism is a promising one.

Examination of the facts for a long lasting solar flare on February 6, 1946, showed that no tunnel existed though this spot group had the largest area (and a larger M_{SS}) yet recorded. No cosmic-ray increases were observed on that date.

For the increases of February 28 and March 7, 1942, the existence of tunnels is yet in some doubt owing to difficulties in determining the direction of M_{SS}.

Further work must yet be done to insure that the tunnel is really open for the particle energies in question and to determine whether the particles can reach the Earth if the tunnel is open. Both problems will require the use of modern high-speed electronic computers for computations of trajectories in the combined fields of M_S and M_{SS}, and finally in the Earth's field. The proposed mechanism has the important merit of explaining why sudden increases of cosmic-ray intensity are not more often observed during solar flares.

References

[1] A. H. Compton, E. O. Wollan, and R. D. Bennett, Rev. Sci. Instr., vol. 5, 415-422 (1934).
[2] S. E. Forbush, Terr. Mag., vol. 43, 203-218 (1938).
[3] S. E. Forbush, Phys. Rev., vol. 54, 975-988 (1938).
[4] S. E. Forbush, Rev. Mod. Phys., vol. 11, 168-172 (1939).
[5] S. E. Forbush, Internat. Assoc. Terr. Mag. Elec., 1-10, Wash. Assembly, 1939.
[6] S. E. Forbush and I. Lange, Terr. Mag., vol. 47, 331-334 (1942).
[7] S. E. Forbush, Phys. Rev., vol. 70, 771-772 (1946).
[8] S. E. Forbush, P. S. Gill, and M. S. Vallarta (to be presented at the Millikan Cosmic-Ray Symposium, California Institute of Technology, June 21-23, 1948).
[9] W. F. G. Swann, Phys. Rev., vol. 43, 217-220 (1933).
[10] M. S. Vallarta and O. Godart, Rev. Mod. Phys., vol. 11, 180-189 (1939).

Department of Terrestrial Magnetism
Carnegie Institution of Washington
Washington, D.C., U.S.A.

DISCUSSION:

E. Marsden asked whether coincidences on horizontal and vertical counters had been used. Answer: Blackett had used them in the storm of July.

D. F. Martyn asked whether mean free path of ions in solar envelope was adequate to permit these voltages to be generated. Answer: Yes.

Alexandre Dauvillier: Les effets observés par S. E. Forbush en diverses parties du monde, ceux obtenus par Ehmert en Allemagne, et d'autres; les importantes observations de Babcock sur les étoiles à champ magnétique variable, justifient l'opinion émise par Swann en 1933, selon laquelle les rayons cosmiques sont émis lors des variations des champs magnétiques des taches solaires. Nous avons, nous même en 1931 sur la base de la Théorie Aurorale des Rayons Secondaires, attribué une partie du rayonnement cosmique au Soleil.

Ces importants résultats doivent être rapprochés de ceux de Grotrian et Edlén, relatifs à l'identification des raies de la couronne solaire interne, car ce sont les particules stellaires les plus externes qui seront accélérées durant les variations des champs magnetiques stellaires - les etoiles se comportant comme des "accélérateurs cosmiques" de particules chargeés. Ces particules sont des atoms de fer, de nickel et de calcium, fortement ionisés. Or, les, "etoiles" nucléaires présentées par certaines émulsions photographiques, exposeés à très haute altitude, montient, précisément, l'impact de particules primaires positive lourdes, donées d'une grande énergie.

L'ensemble de tous ces résultats montre que c'est bien dans le magnetisme cosmique qu'il faut rechercher l'origine du rayonnement cosmique. Le problème fondamental devient celui du mécanisme de la production de ces champs magnétiques stellaires.

THE USE OF ROCKETS IN UPPER ATMOSPHERIC RESEARCH

By James A. Van Allen

Introduction

Only by means of powerful rockets developed during the recent war has it at last become possible to transport experimental equipment above about 37 km. Yet the study of the upper reaches of the atmosphere has long engaged scientific attention. Observations of auroral displays and of "shooting stars" have been recorded in the earliest written literature.

In more recent years a large body of observed data and deductions on the physics of the upper atmosphere has been acquired by the application of ingenious indirect methods.

Ionized layers of the atmosphere have been discovered and extensively studied. The anomalous refraction of explosion waves has been found; interpretation of these findings has yielded a curve of atmospheric temperature versus altitude. Measurements have been made of the height of appearance and disappearance of meteor trails, of the velocity and rate of loss of velocity of the meteors themselves. The spectra of auroral flares and of the light of the night sky have been brought under study. A great deal has been learned about the amount of ozone in the atmosphere.

All of these investigations have been made possible by what may be termed the general transparency of the atmosphere. Thus, the atmosphere is reasonably transparent to sound, to a considerable range of radio frequencies, to many regions of the spectrum.

Yet no such transparency exists with respect to cosmic rays, for example.

The Role of Rockets

Rockets now make it possible to place one's apparatus in direct contact with many of the grand phenomena of the upper atmosphere. It may be hoped that many missing links in the physics of the upper atmosphere may be progressively filled in. The opportunity for new discoveries is a very attractive one.

It should not be concluded that measurements from rockets are easily done.

The types of measurement possible from a sounding rocket are greatly restricted by various practical considerations. The most important of these is the very brief time which a rocket of present type spends in any specified altitude range--a vertically-fired V-2 spends only five minutes above 35 km. Another severe difficulty arises in performing an experiment in which it is necessary to maintain a fixed orientation of the apparatus.

Limitations as to electrical power, weight, shape, and size; requirements of ruggedness, automatic calibration, and reliability; the necessity for radio transmission or recovery of data--all these considerations place further demands on the experimentalist.

High-altitude rockets are being used as vehicles for investigations in the following general categories:

A. Geophysics of the upper atmosphere itself.

B. Investigations in which it is desired to surmount the appreciable atmosphere.

C. Exploratory engineering as a basis for further rocket developments.

Under category A may be mentioned a few examples: sampling of the atmosphere to determine gaseous composition at high altitudes; in situ determination of pressure, temperature, and density versus altitude; measurements of the index of refraction for radio waves of various frequencies within, and especially between the layers of the ionosphere; measurement of the altitude distribution of ozone and other gases; magnetic field measurements with particular reference to the location and magnitude of anomalies at high altitudes.

Study of the properties of primary cosmic rays, before moderation by the atmosphere, falls in category B; as do likewise studies of the ultraviolet spectra of the sun and stars.

Category C is self-evident and is not dealt with in this paper.

Use of the German V-2 in the United States

As early as October 1945, an American sounding rocket, known by the code name WAC Corporal, had reached an altitude of 72 km. Yet, its useful instrument payload (about 10 kg) and volume were so small as to make it of only slight value in upper atmospheric investigations.

Late in the European war, the U. S. Army captured a considerable number of unassembled V-2's in Peenemunde. These parts were eventually sent to the Army Ordnance Department in the United States, which had meanwhile made plans for military appraisal by actual assembly, testing, firing and tracking a number of them. In January 1946, the Ordnance Department made generally known its intention, and invited interested scientific groups to utilize the payload available. This enlightened invitation brought forward an enthusiastic response.

On 16 April 1946, the first V-2 was launched at the White Sands Proving Ground near Las Cruces, New Mexico. The flight was unfortunately a failure; nonetheless, this missile carried, among other equipment, a single Geiger counter prepared by the Applied Physics Laboratory for recording cosmic-ray intensity. This firing date may, therefore, be considered to have opened a period of very fruitful application of the wartime V-2 to a significant peacetime role.

Up to 1 July 1948, thirty-one V-2's have been fired from White Sands with upper atmospheric equipment as the primary payload. Twenty-one have been successful flights. Summit altitudes of successful rounds have ranged from 100 to 184 km, with 135 km being the average. In contrast to the German military use, the V-2's at White Sands are fired on a near-vertical trajectory in order to achieve maximum altitude.

Six research agencies have had primary responsibility for the experimental equipment in these flights--the Naval Research Laboratory, the General Electric Company, the Air Materiel Command, the Signal Corps Engineering Laboratories, Princeton University, and the Applied Physics Laboratory of the Johns Hopkins University. A large number of other industrial, government, and university groups and persons have been associated with this work.

Practical Aspects of Rocket Measurements

The problem of capturing the data which apparatus yields in flight has been solved by two principal methods:

A. By radio, from a suitable multi-channel transmitter in the rocket to a system of receiving and recording stations on the ground.

B. By physical recovery of records produced within the rocket during its flight.

Method A has been attended by very good success for the transmission of data which can be reduced conveniently to an electrical voltage.

Physical recovery techniques are now well worked out. Photographic film and similar type records are commonly recovered in good condition. Occasionally V-2's break up spontaneously upon return into the atmosphere. In such cases, many parts of the rocket are found in reasonably intact condition, though scattered over a wide area. But when they do not, the impact velocity is approximately 1300 m/sec. and recovery of specific pieces of even very substantial equipment is usually quite hopeless.

A procedure has, therefore, been developed of blowing-off the forward portion of the missile by means of an explosive charge. This charge is detonated by radio command at an altitude of about 50 km on the descending leg of the trajectory. The separate portions of the missile then fall as objects of poor aerodynamic shape. Moderate impact velocities of the order of 100-200 m/sec result. Ordinary photographic film in heavy steel or dural casettes can be reliably recovered in good condition. The principal practical problem is the location of the impact wreckage in a large desert area. Radar tracking data and artillery spotting planes aid the ground search parties greatly in the search for impact.

Parachuting of selected small portions of the missile has been attended by some success and will undoubtedly assume a more important role in future work.

Brief Resumé of Results to Date

All research groups using the V-2's have expended considerable effort during the pioneering stages of this work in the development of techniques.

A number of significant physical measurements has already rewarded their efforts.

The Naval Research Laboratory group has a quantity of data on the nature of the reactions of primary cosmic rays in traversing blocks of material in Geiger telescopes. Measurements on atmospheric temperature and pressure to about 120 km have been made and analyzed. A preliminary distribution curve of ozone versus altitude has been found. Important extensions to the solar spectrum have been made. They have recorded data on the index of refraction for certain frequencies of radio waves in the E-layer of the ionosphere. Recently they have succeeded in operating a Wilson cloud chamber in flight.

The General Electric flights have been principally designed to obtain exploratory engineering information.

The Johns Hopkins group has obtained measurements of the cosmic-ray intensity above the atmosphere and has conducted a series of successful flights of Geiger counter telescopes and pulse ionization chambers in various physical arrangements for learning the nature of the "primary cosmic-ray event". Ultraviolet spectra of the sun to 2300 Å have been recovered and analyzed. The feasibility of high altitude aerial reconnaissance from rockets has been demonstrated.

The Princeton University and Air Materiel Command groups have been plagued by a number of missile failures. However, the AMC and its associated universities have made significant contributions to parachute recovery; have obtained data on ambient pressure and temperature in the upper atmosphere; have obtained ionospheric data in the lower portion of the E-layer; and have secured information on sky brightness.

A program of high-altitude measurements of meteorological nature is being conducted by the Signal Corps in conjunction with the University of Michigan. Several samples of air at about 60 km altitude have been successfully captured and recovered; gas analysis of these samples is under way. Smoke puffs and smoke trails have been produced at high altitudes for learning wind velocities. Explosions have been produced for sound propagation experiments; and measurements of pressure and temperature have been made.

The Aerobee - A New American Sounding Rocket

Early in 1946 it was realized that the captured German V-2's would provide at best a series of high-altitude flights of limited extent. Furthermore, the V-2's are extremely complicated and expensive. So that it did not seem likely that they could reasonably be duplicated in the United States for the sole purpose of a sounding rocket.

Realizing these things, the Johns Hopkins Laboratory undertook the sponsorship of a small, relatively inexpensive rocket for use as a vehicle for upper atmospheric equipment. The development was accepted by the Aerojet Engineering Corporation and the Douglas Aircraft Corporation with the support of the Navy Bureau of Ordnance and the Office of Naval Research.

The design of the WAC Corporal, mentioned above, was used as a guide. But the new rocket was intended to transport considerably more useful payload. The original specification was that it should transport 68 kg of payload in a volume of 0.1 cubic meter to at least 80 km altitude.

This rocket, subsequently named the Aerobee, is now a proved missile with performance considerably in excess of the original specification.

The Aerobee is an extremely simple missile. There are no movable surfaces or internal controls. It possesses only arrow-stability. Propulsion is in two stages. A booster brings the velocity to about 300 m/sec, then falls away. The sustaining jet motor produces a final velocity of about 1300 m/sec at an altitude of about 30 km. Summit altitudes of about 115 km have been attained with a payload of 70 kg.

Two flights have thus far been made with upper atmospheric data as the primary objective. In the first of these, a system of Geiger counter telescopes was used for measuring, as the rocket rolled, the azimuthal asymmetry and absolute intensity of primary cosmic rays above the atmosphere. Excellent data were obtained for 320 seconds of flight.

The second flight contained a cooperative experiment of the Department of Terrestrial Magnetism, the Naval Ordnance Laboratory, and the Johns Hopkins Laboratory. In it, the total strength of the earth's magnetic field was successfully measured from ground level to about 110 km altitude.

The field operations involved in handling the Aerobee are greatly simplified over those required for the V-2. The missile itself is simple, relatively inexpensive, and readily reproduced in quantity. It may be anticipated that wide research application of this type of rocket will develop.

Future of the Rocket Technique in Upper Atmospheric Investigations

The V-2's have served a vital role in the pioneering work in this field.

But in spite of the great effort expended by various laboratories during the past two and a half years in the conduct of rocket-borne experiments, it may be accurately said that only a good beginning has been made. All participating laboratories have under plan investigations which will require many years for satisfactory accomplishment.

In particular, it may be mentioned that all high-altitude rocket flights made thus far in the United States have been over one specific geographical area--namely, the White Sands Proving Ground in New Mexico. No world-wide surveys of any sort have been undertaken.

Even at White Sands very little information on seasonal or diurnal effects has been obtained.

No really satisfactory knowledge of the pressure and temperature distribution in the atmosphere, of the earth's magnetic field at high altitude, of the distribution and nature of cosmic-ray primaries, of high-altitude winds, of the distribution of ozone in the atmosphere, as examples, can be presumed on the basis of single pioneering measurements, no matter how successful, at any one location.

It may, therefore, be expected that repeated flights with identical instruments at different geographical locations, at different seasons, at different times of the year, under different meteorological conditions, and during solar, ionospheric and magnetic disturbances will characterize future work in the physics of the upper atmosphere.

For such extensive flight programs, rockets of the Aerobee type will undoubtedly play a major role.

Then there is always the prospect of pioneering measurements at even higher altitudes.

Acknowledgment

The author is especially indebted to Dr. Merle A. Tuve from whose initiative and foresight has stemmed the upper atmosphere program of the Applied Physics Laboratory of the Johns Hopkins University.

Applied Physics Laboratory
Johns Hopkins University
Silver Spring, Maryland, U.S.A.

L'EQUILIBRE IONIQUE DE LA BASSE ATMOSPHÈRE

By J. Bricard

The complete text has been published in the Journal of Geophysical Research, Vol. 54, pp. 39-52 (1949).

PART VI

RESOLUTIONS AND COMMITTEES

A.--RESOLUTIONS OF THE ASSOCIATION

(1) New Magnetic Observatories: The International Association of Terrestrial Magnetism and Electricity recommends that when new magnetic observatories are being planned, every care should be taken to choose sites free from pronounced local magnetic anomalies and also sites likely to remain long undisturbed electromagnetically by artificial causes; in the absence of special provision by insulated returns, the distance from railways which are, or are likely to become electrified, should in general be not less than 30 km.

(2) International Institution for Geomagnetism: The International Association of Terrestrial Magnetism and Electricity recommends the establishment by an appropriate organization under the auspices of UNO of an international institution for geomagnetism. The institution should collect, preserve and study geomagnetic data from observatories and surveys, and should apply these data for practical purposes by the construction of magnetic charts and otherwise. It should be equipped with laboratories for geomagnetic research and for the development and effective standardization of new instruments and methods of observation.

(3) R.R.S. Research: The International Association of Terrestrial Magnetism and Electricity welcomes the statement made at its Oslo Assembly on behalf of the Board of Admiralty regarding its recognition of the high international importance of the work that the Royal Research Ship Research was designed to undertake, and expresses the hope that such work can now be begun, even if at the outset it is necessary to operate the vessel under sail.

(4) Surface Magnetic Surveys: The International Association of Terrestrial Magnetism and Electricity considers that while prospects of the early realization of airborne magnetic surveys over land and ocean areas show some promise, surface magnetic surveys over land and sea areas remain of paramount importance as (1) control observations for airborne surveys, and (2) as means of continuing the series of secular variation observations so necessary to the proper maintenance of world-wide magnetic surveys. Hence, such surface observations must be continued as in the past.

(5) Giant Pulsations: The International Association of Terrestrial Magnetism and Electricity urges the importance to studies of giant pulsations of operating continuous quick-run magnetographs at Tromsö, Abisko, and Sodankylä.

(6) Magnetic Station at Spitsbergen: The International Association of Terrestrial Magnetism and Electricity urges the importance of a magnetic recording station at Spitsbergen, in view of the great interest attached to magnetism and auroral observations to the north of the aurorae.

(7) Geomagnetic Control of F_2-Layer Densities: The International Association of Terrestrial Magnetism and Electricity endorses resolution No. 14 adopted at the Brussels meeting of the Mixed Commission on the Ionosphere of the International Council of Scientific Unions, namely "That, in view of the remarkable geomagnetic control of F_2 layer density and the known abnormal variation of the daily magnetic force in regions where the geomagnetic and geographical equators are widely separated, efforts should be made to achieve operation, for one or two years, of a chain of ionospheric and magnetic stations across these equators near the longitude of Huancayo or in East Africa and, if possible, another chain near a place at which these equators coincide."

(8) Times of Sudden Commencements and Other Unusual Phenomena: The International Association of Terrestrial Magnetism and Electricity would recommend to all magnetic observatories that their publications should include a list of times of sudden commencements of magnetic disturbances, and as far as practicable, crochets, pulsations, giant pulsations, and of similar changes and other remarkable phenomena not followed by magnetic disturbance, together with the amount and movement in each magnetic element recorded.

[RESOLUTIONS REFERRED TO THE UNION]

(9) Geomagnetic Observatory in Northern Sweden: The International Union of Geodesy and Geophysics recommends the foundation of a new geophysical observatory in northern Sweden, to replace the already existing observatory at Abisko, whose magnetic registrations are now disturbed by electric currents, and hopes that the two observatories will work concurrently during a period of about two years in order to connect the two series of records.

(10) Geophysical Observatory in Southern Finland: The International Union of Geodesy and Geophysics recommends the foundation of a new geophysical observatory in the southern part of Finland, preferably between the existing observatories of Lovö (Sweden) and Sloutzk (Russia); this would make a very valuable addition to the network of geophysical observatories in northern Europe.

(11) Geomagnetic Observatory and Laboratory to Replace Cheltenham: The International Union of Geodesy and Geophysics welcomes the proposed substitution of a new and extended geomagnetic observatory and laboratory for the existing observatory of Cheltenham, Maryland, U.S.A.

(12) Magnetic Observatory in Italy: The International Union of Geodesy and Geophysics welcomes the proposed institution of a new magnetic observatory in Italy.

(13) Magnetic Observatory in Southern India: The International Union of Geodesy and Geophysics welcomes the proposed institution of a new magnetic observatory in Southern India, near the magnetic equator.

(14) Geophysical Observatories in the Belgian Congo: The International Union of Geodesy and Geophysics welcomes the proposed institution of one or more new geophysical observatories in the Belgian Congo.

(15) Geophysical Observatories in French Colonial Possessions: The International Union of Geodesy and Geophysics welcomes the proposed institution of new geophysical observatories in the French colonial possessions.

(16) A Center of Geophysical Studies in Belgium: The International Union of Geodesy and Geophysics welcomes the decision to establish a center of geophysical studies in Belgium.

(17) Geophysical Observatory in Spain: The International Union of Geodesy and Geophysics welcomes the proposed institution of a geophysical observatory in Spain.

(18) Additional Non-Magnetic Vessels: The International Union of Geodesy and Geophysics recommends that hydrographic services should consider the possibility of constructing non-magnetic vessels for cooperation with Great Britain in resuming the ocean magnetic survey which is now so urgently desirable.

B.--EXECUTIVE COMMITTEE

President: Prof. S. Chapman, California Institute of Technology, Pasadena, California (until April 1, 1951; 2 Queen's Lane, Oxford, England (after April 1, 1951).

Vice-Presidents: Prof. J. Coulomb, 191 Rue Saint-Jacques, Paris, 5e, France.
Dr. B. F. J. Schonland, P. O. Box 395, Pretoria, Transvaal, Union of South Africa.

Secretary and Director of the Central Bureau: Dr. J. W. Joyce, 6641 - 32nd Street, N.W., Washington 15, D. C., U. S. A.

Members: Dr. S. K. Banerji
Mr. L. V. Berkner
Dr. Jno. A. Fleming
Mr. V. Laursen
Mr. O. Lützow-Holm
Dr. D. F. Martyn

C.--COMMITTEES

1. Committee on selection of sites of new observatories for terrestrial magnetism and electricity:

Dr. J. A. Fleming, Chairman
1530 P Street, N.W., Washington 5, D. C., U. S. A.
Prof. S. Chapman
Prof. J. Coulomb
Mr. V. Laursen

2. Committee on Aurora:

Prof. C. Störmer, Chairman
Institute of Theoretical Astrophysics, Blindern, v. Aker, Norway
Dr. B. W. Currie
Dr. J. Dufay
Dr. F. W. P. Götz
Dr. J. Paton
Dr. E. Sucksdorff

3. Committee on magnetic secular-variation stations:

Dr. E. H. Vestine, Chairman
5241 Broad Branch Road, N.W., Washington 15, D. C., U. S. A.
Mr. J. Egedal
Dr. J. A. Fleming
Mlle. S. Kalinowska
Mr. T. H. O'Beirne
Dr. N. V. Pushkov
Dr. J. M. Rayner

4. Committee on magnetic charts:

Dr. E. H. Vestine, Chairman
5241 Broad Branch Road, N.W., Washington 15, D. C., U. S. A.
Dr. N. Ambolt
Mr. R. G. Madill
Capt. E. B. Roberts
Sir Harold Spencer Jones

5. Committee on registration of giant pulsations:

Mr. J. Olsen, Chairman
Det Danske Meteorologiske Institut, Toldbodvej 15 st., København K, Denmark
Mr. F. T. Davies
Dr. L. Harang
Dr. E. Sucksdorff

6. Committee on methods of observatory publication:

Dr. J. Bartels, Chairman
Herzberger Landstr. 180, (20B) Göttingen, British Zone, Germany
Dr. J. A. Fleming
Capt. E. B. Roberts
Mr. E. Selzer
Dr. B. Trumpy

7. Committee to promote international comparisons of magnetic standards:

Mr. V. Laursen, Chairman
Det Danske Meteorologiske Institut, Charlottenlund, Denmark
Dr. N. Ambolt
Prof. J. Keränen
Dr. L. Koenigsfeld
Mr. R. G. Madill
Prof. E. Thellier

8. Committee on observational technique:

Mr. H. E. McComb, Chairman
U. S. Coast and Geodetic Survey, Washington 25, D. C., U. S. A.
Mr. S. Åslund
Mr. E. A. Chamberlain
Mr. O. Lützow-Holm
Mr. J. Olsen
Prof. E. Thellier

9. Committee on characterization of magnetic disturbances:

Dr. J. Bartels, Chairman
Herzberger Landstr. 180, (20B) Göttingen, British Zone, Germany
Mr. J. Egedal
Mr. H. F. Johnston
Dr. E. Lahaye
Sir Harold Spencer Jones
Dr. E. Sucksdorff
Dr. J. Veldkamp

10. Committee on centralization and standardization of records:

Sir Harold Spencer Jones, Chairman
The Astronomer Royal, Royal Observatory, Greenwich, London, S.E. 10, England
Dr. N. Ambolt
Mr. O. Lützow-Holm
Dr. N. V. Pushkov
Capt. E. B. Roberts
Dr. E. H. Vestine

11. Committee to promote daily observations of horizontal force between and near the geographic and magnetic equators:

Mr. J. Egedal, Chairman
Det Danske Meteorologiske Institut, Toldbodvej 15 st., København K, Denmark
Dr. S. K. Banerji
Dr. P. H. Berlage
Prof. J. Coulomb
Mr. A. A. Giesecke, Jr.
Mr. P. Herrinck
Mr. O. Lützow-Holm
Dr. M. R. Madwar
Dr. D. F. Martyn
Mr. A. G. McNish
Rev. Antonio Romañá, S. J.

12. Committee on magnetic airborne surveys:

Dr. J. W. Joyce, Chairman
6641 - 32nd Street, N.W., Washington 15, D. C., U. S. A.
Dr. C. S. Bealls
Mr. C. A. Jarman
Dr. L. H. Rumbaugh
Mr. J. M. Rayner
Mr. E. Selzer

13. Joint Committee of the Associations of Meteorology and Terrestrial Magnetism and Electricity on the study of lunar variations in meteorological, magnetic and electrical elements:

Prof. S. Chapman, Chairman
California Institute of Technology, Pasadena 4, California, U.S.A. (until April 1, 1951); Queen's College, Oxford, England (after April 1, 1951)
Prof. J. Bartels
Mr. J. Egedal
Dr. D. F. Martyn
Dr. S. K. Pramańik
Dr. K. R. Ramanathan
Rev. Antonio Romañá, S. J.
Dr. P. Rougerie
Dr. O. Schneider
Mr. A. Thomson
Dr. K. K. Tschu
Dr. K. Weekes
Mr. M. V. Wilkes

PART VII

ADDRESSES

There follows a compilation of names and addresses of persons and institutions interested in terrestrial magnetism and electricity, including a list of adhering organizations for those countries which are members of the International Union of Geodesy and Geophysics. These addresses have been supplied by National Committees for member countries and by leading scientists in non-member countries. In some few cases information has not been available from either governmental or private sources, or in the Central Bureau's files, necessitating the omission of the countries concerned.

The Secretary and Director of the Central Bureau welcomes changes and corrections to these lists so that they may be kept current in future Transactions.

ARGENTINA

Adhering Organization

M. le Directeur-Général,
l'Institut Géographique Militaire,
Cabildo, 381, Buenos Aires,
Argentina

Individuals

Bruno Collasius, Jefe de la Carta Magnética, Servicio Meteorológico Nacional, Paseo Colón 317, Buenos Aires

Olaf Lützow-Holm, Jefe del Observatorio Geofísico, Pilar, Provincia de Córdoba

Rodolfo Martín, Geofísico Principal, Yacimientos Petrolíferos Fiscales, Avda. Roque Saénz Peña 777, Buenos Aires

Carlos A. Martinoli, 2do. Jefe Departamento Geofísica, Servicio Meteorológico Nacional, Paseo Colón 317, Buenos Aires

Nobel Muñoz, Jefe de Prospección Geomagnética, Yacimientos Petrolíferos Fiscales, Avda. Roque Saénz-Peña 777, Buenos Aires

Francisco P. De Luca Muro, Compañía Geotecnia, Charcas 1775, Buenos Aires

Aldo Murut, Jefe de Prospección Geomagnética, Avda. Roque Saénz Peña 777, Buenos Aires

Pedro Rey, Jefe del Departamento de Exploración, Yacimientos Petrolíferos Fiscales, Avda. Roque Saénz Peña 777, Buenos Aires

Otto Schneider, Jefe Departamento Geofísica, Servicio Meteorológico Nacional, Paseo Colón 317, Buenos Aires

Leónidas Slaucitajs, Universidad Nacional de La Plata, La Plata, Provincia de Buenos Aires

AUSTRALIA

Adhering Organization

The Secretary,
Australian National Research Council,
Science House, 157 Gloucester Street,
Sydney, N.S.W., Australia

Organizations

Bureau of Mineral Resources, 485 Bourke Street, Melbourne, C. 1, Victoria (Chief Geophysicist)
Commonwealth Observatory, Mount Stromlo, Canberra, F.C.T.
Commonwealth Scientific and Industrial Research Organization, 314 Albert Street, E. Melbourne
C.S.I.R. Radio Physics Laboratory, Chippendale, N.S.W.
Department of Civil Aviation, 522 Little Collins Street, Melbourne, C. 1, Victoria (Director General)
Ionospheric Prediction Service of the Commonwealth of Australia, 16 Wylde Street, Potts Point, N.S.W.
Magnetic Observatory, Watheroo, Western Australia (Observer-in-Charge)
Postmaster General's Department, Treasury Gardens, Melbourne, C. 2, Victoria (Chief Engineer)
Riverview College Observatory, Sydney, N.S.W.
The University, Department of Physics, Melbourne, N. 3
University of Queensland, Brisbane, Queensland
University of Tasmania, Hobart, Tasmania

Individuals

R. B. Mair, Director of Technical Services, Australian Broadcasting Control Board, Rialty Building, 495 Collins Street, Melbourne, C. 1, Victoria
G. H. Munro, Radio Research Board, C.S.I.R.O., C/o Electrical Engineering Department, University of Sydney, Sydney, N.S.W.

AUSTRIA

Adhering Organization

The President (Professor H. Hopfner),
Osterr, Kommission f.d. internationale Erdmessung,
Technische Hochschule, Observatorium,
Karlsplatz 13, Wien IV, Austria

Organizations

Lehrkanzel für Physik der Erde an der Universität Wien, Wien, IX, Boltzmanngasse Nr. 5
Zentralanstalt für Meteorologie und Geodynamik, Wien, XIX, Hohe Warte Nr. 38
Institut für Meteorologie und Geophysik der Universität Innsbruck, Schöpfstr. Nr. 41
Institut für Strahlenforschung an der Universität Innsbruck, Innsbruck
Institut für Geoelektrik, Blitzforschung, Grubenfunk und Funkmutung an der Technischen Hochschule Wien, IV, Gusshausstrasse Nr. 25

Individuals

Albert Defant, Institut für Meteorologie und Geophysik der Universität Innsbruck, Schöpfstr. Nr. 41
Heinrich Ficker, Universität Wien, Wien, IX, Boltzmanngasse Nr. 5, und Zentralanstalt für Meteorologie und Geodynamik, Wien, XIX, Hohe Warte Nr. 38
Ferdinand Steinhauser, Hochschule für Bodenkultur in Wien, XIX, Gregor Mendelstrasse Nr. 33, und Abteilungsleiter an der Zentralstalt für Meteorologie und Geodynamik
Rudolf Steinmaurer, Institut für Strahlenforschung an der Universität Innsbruck, Innsbruck

BELGIUM

Adhering Organization

The Secretary,
Academie Royal de Belgique (Classe des Sciences),
Palais des Academies,
Brussels, Belgium

Organizations

Institut Royal Météorologique de Belgique, Station Magnétique d'Uccle, 3 avenue Circulaire, Uccle, Bruxelles
Institut Royal Météorologique de Belgique, Station Magnétique de l'Université de Liège a Manhay, Manhay, Province de Luxembourg

Individuals

Joseph Bertrand, 88 avenue Paul Deschanel, Bruxelles
M. Dehalu, 17 Quai du Halage, Visé, Province de Liège
Edmond Hoge, 38 rue du Marteau, Bruxelles
Louis Koenigsfeld, 17 rue de l'Etat Thiers, Liège
Edmond Lahaye, 31 avenuë Wolvendael, Bruxelles
L. J. Pauwen, 7 avenue de Cointe, Sclessin, Liège

BELGIAN CONGO

Organizations

Station Magnétique d'Elisabethville, Météo, Elisabethville

Individuals

G. Heinrichs, 282 rue du Noyer, Bruxelles, ou Météo, Elisabethville
P. Herrinck, 12 avenue du Couronnement, Woluwé St. Lambert, Bruxelles, ou Météo, Elisabethville

BRAZIL

Organizations

Centro Brasileiro de Pesquisas Físicas, Rua Álvaro Alvim 21, 21º andar, Rio de Janeiro
Diretoria de Hidrografia e Navegação, Ilha Fiscal, Rio de Janeiro
Faculdade de Filosofia Ciencias e Letras, Departamento de Física, R. Alfredo Ellis 301, S. Paulo
Serviço Geografico e Histórico do Exército, Morro da Conceição, Rio de Janeiro

Individuals

Djalma Polly Coelho, Pr. Almirante Jaceguay 61, ap. 102
Erico da Costa Fernandes, R. Villela Tavares 114, c.14, Rio de Janeiro

CANADA

Adhering Organization

The Secretary,
Associate Committee on Geodesy and Geophysics,
National Research Council,
Ottawa, Ontario, Canada

Organizations

Dominion Observatory, Ottawa, Canada.
University of Toronto, Toronto, Ontario, Canada.
Radio Propagation Laboratories, Defence Research Board, Ottawa, Canada.
Division of Physics, National Research Council, Ottawa, Canada.
University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
Meteorology Division, Department of Transport, Toronto, Ontario, Canada.

Individuals

R. Bailey, Division of Physics, National Research Council, Ottawa, Canada.
E. C. Bullard, University of Toronto, Toronto, Ontario, Canada.
B. W. Currie, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
F. T. Davies, Radio Propagation Laboratories, Defence Research Board, Ottawa, Canada.
R. T. Hutchinson, Dominion Observatory, Ottawa, Canada.
M. J. S. Innes, Dominion Observatory, Ottawa, Canada.
R. G. Madill, Dominion Observatory, Ottawa, Canada.
J. H. Meek, Radio Propagation Laboratories, Defence Research Board, Ottawa, Canada.
W. Petrie, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
D. C. Rose, Division of Physics, National Research Council, Ottawa, Canada.
W. E. Ross, Meteorology Division, Department of Transport, Toronto, Ontario, Canada.
J. C. W. Scott, Radio Propagation Laboratories, Defence Research Board, Ottawa, Canada.
P. Serson, Dominion Observatory, Ottawa, Canada.

A. Thomson, Meteorology Division, Dept. of Transport, Toronto, Ontario, Canada.
J. T. Wilson, University of Toronto, Toronto, Ontario, Canada.

CHILE

Director Humberto Barrera V., Revista Andina, Casilla 1823, Santiago, Chile

COLOMBIA

Adhering Organization

The Director,
Instituto Geographico Militar y Catastral
(Seccion Geodesia),
Ministerio de Hacienda y Credito Publico,
Bogota, Colombia

Individuals

Clemente Garavito, Instituto Geografico Militar y Catastral, Bogota
Santiago Garavito, Universidad Nacional, Bogota
J. E. Ramirez, S.J., Instituto Geofisico de los Andes, Bogota
Carlos Ortiz Restrepo, S.J., Universidad Pontifica Javeriana, Bogota
Dario Rozo, Instituto Geografico Militar y Catastral, Bogota
Jose Ignacio Ruiz, Instituto Geografico Militar y Catastral, Bogota
Belisario Ruiz Wilches, Observatorio Astronomico, Bogota

CZECHOSLOVAKIA

Adhering Organization

The Secretary,
National Committee of Geodesy and Geophysics,
Vysoké školy technické,
Husova 5, Prague I, Czechoslovakia

Individuals

Dr. Fr. Link, Assistant Professor of Charles University at Prague, National Observatory, Ondřejov u Prahy, Czechoslovakia
Dr. Ing. Jan Smetana, Directeur Scientifique de l'Institut National Hydrotechnique T. G. Masaryk, Praha SIS - Podbaba, Czechoslovakia

DENMARK

Adhering Organization

The Secretary,
The Royal Danish Academy of Sciences,
Dantes Plads 35, Copenhagen,
Denmark

Organizations

Det Danske Meteorologiske Institut, Köbenhavn K, Denmark.
Magnetisk Observatorium, Godhavn, Greenland. (c/o Grönlands Styrelse, København K, Denmark)
Magnetisk Observatorium, Thule, Greenland. (c/o Grönlands Styrelse, Köbenhavn K, Denmark)
Universitetsbiblioteket, Nörre Allé 49, Köbenhavn N, Denmark.
Statsbiblioteket, Århus, Denmark.
Danmarks tekniske Bibliotek, Östervoldgade 6 C, Köbenhavn Ö, Denmark.
Sökortarkivet, Toldbodvej 19, Köbenhavn K, Denmark.
Astronomisk Observatorium, Östervoldgade 3, Köbenhavn K, Denmark.
Flådens Kompasvaesen, Holmen, Köbenhavn K, Denmark.
Danmarks Geologiske Undersögelse, Rådhusvej, Charlottenlund, Denmark.
Geodaetisk Institut, Proviantgården, Köbenhavn K, Denmark.
Danish-American Prospecting Company, Gammeltorv 6, Köbenhavn K, Denmark.

Individuals

Dr. phil. N. Arley, Institutet for teoretisk Fysik, Blegdamsvej 15, Köbenhavn Ö, Denmark.
Magister R. Bögvad, Gröndalsvej 42, Köbenhavn F, Denmark.
Statsmeteorolog J. Egedal, Det Danske Meteorologiske Institut, Köbenhavn K, Denmark.
Statsmeteorolog V. Laursen, Det Danske Meteorologiske Institut, Köbenhavn K. Denmark.
Director N. E. Nörlund, Geodaetisk Institut, Proviantgården, Köbenhavn K, Denmark.
Statsmeteorolog Johannes Olsen, Det Danske Meteorologiske Institut, Köbenhavn K, Denmark.
Director Helge Petersen, Det Danske Meteorologiske Institut, Köbenhavn K, Denmark.

EGYPT

Adhering Organization

The Secretary,
Ministry of Education,
Cairo, Egypt

Individuals

Dr. M. R. Madwar, Director, Royal Observatory, Fouad El-Awal University, Helwan, Egypt

FINLAND

Adhering Organization

The Secretary,
National Committee of Geodesy and Geophysics,
Isostatic Institute,
Messeninksenkatu 10A,
Helsinki, Finland

Organizations

Geofysikaalinen observatorio (Geophysical Observatory), Sodankylä.
Ilmatieteellinen keskuslaitos (Meteorological Office), Helsinki, Vuorikatu 24.

Individuals

T. Hilpelä, Sodankylä.
J. Keränen, Helsinki, Topeliusk. 1A.
E. Sucksdorff, Helsinki, Temppelik. 15A.

FRANCE

Adhering Organization

The Secretary,
Académie des Sciences,
Quai Conti,
Paris VIe, France

Organizations

Institut de physique du Globe de Paris, 191, rue Saint-Jacques, Paris Ve
Institut de physique du Globe de Strasbourg, 38, boulevard d'Anvers, Strasbourg, Bas-Rhin
Institut de physique du Globe du Puy de Dôme, Observatoire du Puy-de-Dôme, Côte de Landais, à Clermont-Ferrand
Institut de physique du Globe du Pic-du-Midi, Observatoire du Pic-du-Midi, Bagnères-de-Bigorre, Hautes-Pyrénées
Laboratoire national de radioélectricité, 196, rue de Paris, Bagneux, Seine
Compagnie générale de géophysique, 48, boulevard de La Tour-Maubourg, Paris VIIe
Institut géographique national, 140, rue de Grenelle, Paris VIIe
Office de la Recherche scientifique coloniale, 22, rue Oudinot, Paris VIIe
Observatoire de Lyon, à Saint-Genis-Laval, Rhône
Observatoire de Haute-Provence, Saint-Michel l'Observatoire, Basses-Alpes
Institut d'astrophysique, 98 bis, boulevard Arago, Paris XIVe

Individuals

Daniel Barbier, Observatoire de Paris, Institut d'astrophysique, 98 bis, boulevard Arago, Paris XIVe

Pierre Bernard, Institut de physique du globe, 32, avenue d'Alsace-Lorraine, Antony (Seine)
René Bernard, Laboratoire de Physique, Faculté des sciences, Lyon (Rhône)
Jean Bricard, Institut de physique du globe, 191, rue Saint-Jacques, Paris Ve
Robert Bureau, Laboratoire national de radioélectricité, 196, rue de Paris, Bagneux (Seine)
Louis Cagniard, Faculté des sciences de Paris, 397, rue de Vaugirard, Paris Ve
Jean Coulomb, Faculté des sciences, Institut de physique du globe, 191, rue Saint-Jacques, Paris Ve
Alexandre Dauvillier, Collège de France, 11, place Marcelin Berthelot, Paris Ve
Henri Dessens, Observatoire du Puy-de-Dôme, Côte des Landais, Clermont-Ferrand
Jean Dufay, Observatoire de Lyon, Saint-Genis-Laval, (Rhône)
Hubert Garrigue, Observatoire du Puy-de-Dôme, Côte des Landais, Clermont-Ferrand (Puy-de-Dôme)
*Raymond Jouaust, Laboratoire central d'électricité, 18, boulevard Saint-Michel, Paris VIe
Robert Lecolazet, Institut de physique du globe de Strasbourg, 38, boulevard d'Anvers, Strasbourg (Bas-Rhin)
_____ le Donche, 191, rue Saint-Jacques, Paris Ve
R. P. Pierre Lejay, Bureau ionosphérique, 35, rue de Sèvres, Paris VIe
Charles Maurain, Institut de physique du globe, 79, rue du faubourg Saint-Jacques, Paris XIVe
_____ Migaux, Compagnie générale de géophysique, 48, boulevard de la Tour-Maubourg, Paris VIIe
Marcel Pauthenier, Faculté des sciences de Paris, 6, place du Panthéon, Paris Ve
Philippe Pluvinage, Faculté des sciences, Strasbourg (Bas-Rhin)
_____ Pontier, boîte postale 86, Lomé (Togo)
René Rivault, Faculté des sciences, Poitiers (Vienne)
Edmond Rothé, Institut de physique du globe, 38, boulevard d'Anvers, Strasbourg (Bas-Rhin)
Paul Rougerie, Institut de physique du globe, 191, rue Saint-Jacques, Paris Ve
_____ Schlumberger, Compagnie générale de géophysique, 48, boulevard de Latour-Maubourg, Paris VIIe
Paul Seltzer, Institut de physique du globe, 191, rue Saint-Jacques, Paris Ve
André Sourdillon, Moulin des Poulineries, Esvres (Indre et Loire)
Nicolas Stoyko, Observatoire de Paris, 61, avenue de l'Observatoire, Paris XIVe
Emile Thellier, Observatoire du Parc Saint-Maur, Saint-Maur-des-Fossé, Seine
Etienne Vassy, Faculté des sciences de Paris, 15, rue Daubenton, Paris Ve

FRENCH COLONIES

Organizations

Institut de physique du Globe d'Alger, Institut de météorologie et de physique du globe de l'Algérie, Alger, Algérie
Observatoire du Morne des Cadets, Fort-de-France, La Martinique

Individuals

R. P. Maurice Burgaud, Observatoire de Zô-Sé, près Changhai, Chine
_____ Crenn, I. F. O., Nouméa, Nouvelle-Caledonie
Jean Dubief, Institut de météorologie et de physique du globe de l'Algérie, Alger, Algérie

*Deceased

Gaston Grenet, Institut de météorologie et de physique du globe de l'Algérie, Alger, Algérie
_____ Metzger, Boîte postale 460, Papeete, Tahiti
Pierre Molard, Observatoire du Morne des Cadets, à Fort-de-France, La Martinique
R. P. Charles Poisson, Observatoire de Tananarive, Madagascar

GERMANY

Organizations

Geophysikalisches Institut der Universität der Leipzig, Talstrasse 35, (10b) Leipzig, C.1, Soviet Zone
Erdmagnetisches Observatorium, Fürstenfeldbruck, (13B) Oberbayern, U. S. Zone
Deutches Hydrographisches Institut, Seewartenstrasse 9, (24a) Hamburg, British Zone
Wingst Magnetic Observatory, (24a) Hoeftgrube, Niederelbe, British Zone
Adolf Schmidt Observatorium für Erdmagnetismus, Lindenstrasse 7, (2) Niemegk (Zauch Belzig), Soviet Zone

Individuals

Prof. Dr. R. Bock, Berlin-Charlottenburg 2, poste restante, U. S. Zone
Dr. F. Bahnemann, Elsastrasse 2, Munich 27, U. S. Zone
Prof. Dr. Julius Bartels, Herzberger Landstrasse 180, (20B) Göttingen, British Zone
Dr. Fr. Burmeister, Erdmagnetisches Observatorium, Fürstenfeldbruck, (13B) Oberbayern, U. S. Zone
Prof. Dr. F. Errulat, 115 Hochallee, Hamburg, British Zone
Dr. Gerhard Fanselau, Adolf Schmidt Observatorium für Erdmagnetismus, Lindenstrasse 7, (2) Niemegk (Zauch Belzig), Soviet Zone
Prof. Dr. M. v. Laue, Bunsenstrasse 16, Göttingen, British Zone
Dr. Karl Wienert, (13b) Muensterhausen 199 bei Thannhausen, Bez. Krumbach/ Schwalen, U. S. Zone

GREAT BRITAIN

Adhering Organization

The Secretary,
The Royal Society,
Burlington House,
London, W.1, England

Individuals

H. W. L. Absalom, Meteorological Office, Air Ministry, Kingsway, London, W.C.2.
Sir Edward Appleton, Principal and Vice-Chancellor, University of Edinburgh, Old College, South Bridge, Edinburgh 8.
N. F. Barber, Admiralty Research Laboratory, Teddington, Middlesex.
W. J. G. Beynon, Physics Department, The University, Swansea.
D. W. Bishopp, Geological Survey of Ireland, 14 Hume Street, Dublin, Eire.
P. M. S. Blackett, The Physical Laboratories, The University, Manchester, 13.

J. M. Bruckshaw, Department of Physics, Imperial College of Science and Technology, London, S.W.7.
J. A. Chalmers, Department of Physics, Science Laboratories, South Road, Durham.
E. A. Chamberlain, Magnetic Observatory, Abinger, Surrey.
S. Chapman, Queen's College, Oxford.
T. G. Cowling, 19 Hollin Gardens, Headingley, Leeds, 6.
G. E. R. Deacon, Admiralty Research Laboratory, Teddington, Middlesex.
The Director of Navigation, Air Ministry, Kingsway, London, W.C.2.
A. Duperrier, Birkbeck College, Verulum Buildings, London.
V. C. A. Ferraro, University College of the South West, Exeter.
A. H. R. Goldie, Meteorological Office, Air Ministry, Kingsway, W.C.2.
W. M. H. Greaves, Royal Observatory, Edinburgh 9.
W. Jackson, Royal Observatory, Greenwich, London, S.E.10.
C. A. Jarman, Ministry of Supply, Thames House, London, S.W.1.
Kew Observatory, Richmond, Surrey.
H. C. Longuet-Higgins, Admiralty Research Laboratory, Teddington, Middlesex.
A. Crichton Mitchell, 51 Merchiston Crescent, Edinburgh, 10.
H. W. Newton, The Royal Observatory, Greenwich, London, S.E.10.
T. H. O'Beirne, Ordnance Survey Office, Leatherhead Road, Chessington, Surrey.
J. Phemister, Geological Survey and Museum, Exhibition Road, London, S.W.7.
A. T. Price, Imperial College of Science and Technology, South Kensington, London, S.W.7.
A. O. Rankine, 14 Oak Avenue, Hampton, Middlesex.
G. E. Roberts, Royal Aircraft Establishment, Farnborough, Hants.
G. D. Robinson, Kew Observatory, Richmond, Surrey.
S. K. Runcorn, Physics Laboratory, The University, Manchester, 13.
F. J. Scrase, Meteorological Office, Air Ministry, Kingsway, London, W.C.2.
Sir George Simpson, 5 Mansfield House, Manor Fields, London, S.W.15.
Sir Harold Spencer Jones, The Astronomer Royal, Royal Greenwich Observatory Herstmonceux Castle, Hailsham, Sussex.
J. M. Stagg, 34 King's Road, Richmond, Surrey.
The Superintendent, Eskdalemuir Magnetic Observatory, Langholm, Scotland.
The Superintendent, Lerwick Magnetic Observatory, Scotland.
R. A. Watson, Meteorological Office, 6 Drumsheugh Gardens, Edinburgh.
J. T. Whetton, The University, Leeds.
Vice Admiral A. G. N. Wyatt, Hydrographer to the Navy, Hydrographic Department, Admiralty, Oxgate Lane, Cricklewood, London, N.W.2.

GREECE

Adhering Organization

The Secretary,
Commission Géodésique et Géophysique Hellenique,
Service Géographique de l'Armée,
Athens, Greece

Organizations

La Commission Géodesique et Géophysique Hellénique
L'Observaitoire d'Athènes
Le Service Géographique de l'Armée, Athènes
Le Service Hydrographique de la Marine, Athènes

HUNGARY

Organizations

Hungarian-American Oil Industrial Company, Limited, Budapest, V, Roosevelt tér 5
Hungarian "Baron Roland Eötvös" State Institute of Geophysics, Budapest, Vorosilov ut 14
Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
Palatine-Joseph University of Technical Sciences, Budapest-Sopron
P. Pázmány University of Sciences, Budapest, Muzeum körut 6-8

Individuals

László Aujeszky, Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
Gyula Banai, Hungarian "Baron Roland Eötvös" State Institute of Geophysics, Budapest, Vorosilov ut 14
Jenő Barnóthy, Institute for Experimental Physics, P. Pázmány University of Sciences, Budapest, Muzeum körut 6-8
Mrs. J. Barnóthy, Institute for Experimental Physics, P. Pázmány University of Sciences, Budapest, Muzeum körut 6-8
György Barta, Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
Zoltán Berkes, Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
József Bucsy, Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
Tibor Dombai, Hungarian "Baron Roland Eötvös" State Institute of Geophysics, Budapest, Vorosilov ut 14
László Egyed, Institute for Geology, P. Pázmány University of Sciences, Budapest, Muzeum körut 6-8
László Facsinay, Hungarian-American Oil Industrial Company, Limited, Budapest, V, Roosevelt tér 5
István Béla Haáz, Budapest
Jenő Hofhauser, Kőszeg, Király utca 5
Károly Kántás, Institute for Geodesy and Geophysics, Palatine-Joseph University of Technical Sciences, Sopron
Kálmán Kenessey, Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
Károly Oltay, Institute for Geodesy, Palatine-Joseph University of Technical Sciences, Budapest
Szilárd Oszlaczky, Hungarian-American Oil Industrial Company, Limited, Budapest V, Roosevelt tér 5
János Renner, Hungarian "Baron Roland Eötvös" State Institute of Geophysics, Budapest, Vorosilov ut 14
Antal Réthly, Hungarian Institute for Meteorology and Terrestrial Magnetism, Budapest, Kitaibel Pál u. 1
István Rybár, Institute for Experimental Physics, P. Pázmány University of Sciences, Budapest, Muzeum körut 6-8
Viktor Scheffer, Hungarian-American Oil Industrial Company, Limited, Budapest, V, Roosevelt tér 5

Károly Sebestyén, Hungarian-American Oil Industrial Company, Limited, Budapest, V, Roosevelt tér 5
Miklós Szecsődy, Hungarian "Baron Roland Eötvös" State Institute of Geophysics, Budapest, Vorosilov ut 14
Antal Tárczy-Hornoch, Institute for Geodesy and Geophysics, Palatine-Joseph University of Technical Sciences, Sopron

INDIA

Adhering Organization

Under Secretary to the Government of India,
Department of Scientific Research,
New Delhi, India

Organizations

Surveyor General, Survey of India, Old Secretariat Buildings, Civil Lines, Delhi.
President, Geodetic Branch, Survey of India, Dehra Dun (U.P.).
Director, Meteorological Observatory, Colaba and Alibag, Bombay.
Officer-in-charge Geophysical Branch, c/o Director, Geological Survey of India, Calcutta.
Officer-in-charge Geophysics, Mysore State Geological Department, Bangalore.
Director, Meteorological Observatory, Trivandrum.
Director, Meteorological Observatory, Alipore, Calcutta.
The Secretary, National Institute of Sciences of India, University Buildings, Delhi.
The Director, Indian Institute of Sciences, Maleswaram P.O. Bangalore.
President, Indian Academy of Sciences, Malleswaram P.O. Bangalore.
Indian Association for the Cultivation of Science, 210, Bowbazar, Calcutta.
The Director, Physical Research Laboratory, Ahmedabad.
The Director, Geological Survey of India, Calcutta.
The Director, Meteorological Office, Poona 5.
The Director General, Indian Meteorological Department, Lodi Road, New Delhi.
The Director, Solar Physics (Magnetic) Observatory, Kodaikanal (South India).
The Chairman, Central Electricity Commission, Clermont, The Mall, Simla.
The Chairman, Central Waterpower, Irrigation and Navigation Commission, Curzon Road, New Delhi.
The Director, Indian Bureau of Mines, North Block, Central Secretariat, New Delhi.
The Secretary, Central Board of Irrigation, Kennedy House, Simla.

Individuals

S. K. Banerji, Director General of Observatories, Lodi Road, New Delhi.
J. N. Bhar, University College of Science, 92 Upper Circular Road, Calcutta.
S. K. Chakravarty, 2 Preonath Banerji Street, P.O. Ahmerst St., Calcutta 9.
A. C. Deb, University College of Science, 92 Upper Circular Road, Calcutta.
S. N. Ghosh, University College of Science, 92 Upper Circular Road, Calcutta.
B. L. Gulatee, President, Geodetic Branch, Survey of India, Dehra Dun, U.P.
S. L. Malurkar, Director, Colaba and Alibag Observatories, Colaba, Bombay.
S. K. Mitra, Professor, University College of Science, 92 Upper Circular Road, Calcutta.
S. M. Mukherjee, Meteorological Office, Poona 5.

S. K. Pramanik, Deputy Director General (Climatology and Geophysics), Meteorological Office, Poona 5.
K. R. Ramanathan, Professor, Physical Research Laboratory, Ahmedabad.
M. N. Saha, Palit Professor of Physics, University College of Science, 92 Upper Circular Road, Calcutta.
J. M. Sil, Director, Regional Meteorological Centre, New Delhi.
D. N. Wadia, Geological Advisor, Department of Scientific Research, New Delhi.
W. D. West, Director, Geological Survey of India, Calcutta.

INDO-CHINA

Adhering Organization

M. le Directeur du Service Geographique de l'Indo-Chine,
Dalat, Indo-China

IRELAND (EIRE)

Adhering Organization

The Director,
Meteorological Service,
44 Upper O'Connell Street,
Dublin, Ireland

ITALY

Adhering Organization

The President of the National Council of Research
(Consiglio Nationale delle Ricerche),
Rome, Italy

Individuals

Dr. Mario Bossolasco, Istituto Geofisico Italiano, Casella Postale 3689, Milano-Ferrovia, Italy
Prof. Ing. Gino Cassinis, Politecnico di Milano, Piazza Leonardo da Vinci, 32, Milano, Italy
Prof. Enrico Medi, Istituto Nazionale di Geofisica, Roma, Italy
Dr. Antonio Lo Surdo, Director, National Institute of Geophysics, University of Rome, Rome, Italy

JAPAN

Organizations

Japanese National Committee for Geodesy and Geophysics, c/o Geophysical Institute, Kyoto University, Kyoto
Kakioka Magnetic Observatory, Kakioka, Ibaraki Prefecture

Meteorological Institute, The Central Meteorological Observatory, Koenji, Suginami-ku, Tokyo.
Geophysical Institute, Faculty of Science, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
Astronomical Observatory, Tokyo University, Mitaka, Kitatama-gun, Tokyo.
Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
Geophysical Institute, Tohoku University, Katahira-cho, Sendai.
Research Institute of Atmospherics, Nagoya University, Toyokawa, Aichi Prefecture.
Fundamental Research Section, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
Geographical Survey Bureau, Kurosuna-cho, Chiba.
Hydrographic Department, Tsukiji, Chuo-ku, Tokyo.
Scientific Research Institute, 31, Kamifujimae-cho, Bunkyo-ku, Tokyo.
Institute of Low Temperature Science, Hokkaido University, Nishi 5 cho-me, Kita-hachijo, Sapporo, Hokkaido.

Individuals

T. Aoki, Electrical Technical Laboratory, Marunouchi, Chiyoda-ku, Tokyo.
Y. Aono, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
M. Fukushima, Research Institute of Atmospherics, Toyokawa, Aichi Prefecture.
N. Fukushima, Geophysical Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
K. Goto, Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
Y. Hagiwara, Astronomical Observatory, Tokyo University, Mitaka, Kitatama-gun, Tokyo.
Y. Harada, Geographical Survey Bureau, Kurosuna-cho, Chiba.
M. Hasegawa, Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
H. Hatakeyama, Central Meteorological Observatory, Otemachi, Chiyoda-ku, Tokyo.
H. Hatano, Tokyo Precision Instrument Company, Higashikamata-cho, Ota-ku, Tokyo.
H. Higashinaka, Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
K. Hirao, Geophysical Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
M. Hirayama, Kakioka Magnetic Observatory, Kakioka, Ibaraki Prefecture.
S. Imamiti, Kakioka Magnetic Observatory, Kakioka, Ibaraki Prefecture.
H. Kamiyama, Geophysical Institute, Tohoku University, Katahira-cho, Sendai.
Y. Kato, Geophysical Institute, Tohoku University, Katahira-cho, Sendai.
M. Kawano, Geophysical Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
S. Kikuchi, Kakioka Magnetic Observatory, Kakioka, Ibaraki Prefecture.
A. Kimpara, Research Institute of Atmospherics, Toyokawa, Aichi Prefecture.
T. Koono, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
Y. Koshikawa, Earthquake Research Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
K. Maeda, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
S. Matsushita, Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
F. Minozuma, Radio Wave Bureau, Ministry of Communications, Azabu-Iikura, Minato-ku, Tokyo.
K. Miya, International Telecommunication Division, Ministry of Communications, Azabu-Iikura, Minato-ku, Tokyo.

S. Miyamoto, Astronomical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
Y. Miyazaki, Scientific Research Institute, 31, Kamifujimae-cho, Bunkyo-ku, Tokyo.
H. Nagaoka, 10, Nishikata-machi, Bunkyo-ku, Tokyo.
T. Nagata, Geophysical Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
Y. Nakata, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
Y. Obayashi, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
K. Ohno, Kokusai-Denki Osaka Branch Office, Sumiyoshi, Abeno-ku, Osaka.
T. Okada, Central Meteorological Observatory, Otemachi, Chiyoda-ku, Tokyo.
M. Ota, Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
T. Rikitake, Earthquake Research Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
S. Sano, Hydrographic Department, Ministry of Transportation, Tsukiji, Chuo-ku, Tokyo.
Y. Sekido, Physical Institute, Nagoya University, Tashiro-cho, Chigusa-ku, Nagoya.
K. Senda, Electrical Engineering Institute, Nagoya University, Oizu-cho, Chigusa, Nagoya.
H. Shinkawa, Radio Wave Bureau, Ministry of Communications, Azabu-Iikura, Minato-ku, Tokyo.
M. Sugiura, Geophysical Institute, Tokyo University, Motofuji-cho, Bunkyo-ku, Tokyo.
Y. Tamura, Geophysical Institute, Kyoto University, Yoshida, Sakyo-ku, Kyoto.
A. Tanakadate, 146, Kyodo, Setagaya-ku, Tokyo.
K. Terada, Meteorological Institute, Central Meteorological Observatory, Koenji, Suginami-ku, Tokyo.
I. Tsubokawa, Geographical Survey Bureau, Kurosuna-cho, Chiba.
S. Utashiro, Geophysical Institute, Tohoku University, Katahira-cho, Sendai.
H. Uyeda, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
T. Yonezawa, Electrical Communication Laboratory, Osaki, Minato-ku, Tokyo.
S. Yoshida, Physical Institute, Nagoya University, Tashiro-cho, Chigusa-ku, Nagoya.
R. Yoshimatsu, Kakioka Magnetic Observatory, Kakioka, Ibaraki Prefecture.
T. Yumura, Kakioka Magnetic Observatory, Kakioka, Ibaraki Prefecture.

MEXICO

Adhering Organization

The Director,
Direccion de Geografia Meteorologia e Hidrologia,
Av. Observatorio 192,
Tacubaya, D.F., Mexico

Organizations

Comisión Impulsora y Coordinadora de la Investigación Científica, Puente de Alvarado No. 71, 5° piso, D.F.
Dirección de Geografía y Meteorología, Av. Observatorio No. 192, Tacubaya, D.F.
Instituto de Geofísica de la Universidad Nacional, Puente de Alvarado No. 71, 4° piso, D.F.
Sección Nacional del Instituto Panamericano de Geografía e Historia, Av. Observatorio No. 192, Tacubaya, D.F.

MOROCCO

Adhering Organization

M. le Directeur,
l'Institut Scientifique Chérifien,
Avenue Biarnay,
Rabat, Morocco

Organizations

l'Annexe au Maroc de l'Institut National Géographique à Rabat.
l'Institut Scientifique Chérifien, Avenue Biarnay à Rabat.
le Service de Physique du Globe et de Météorologie, 2 Rue de Foucauld à Casablanca.
le Bureau de Recherches et Participations Minières, 38 Rue de la République à Rabat.

Individuals

M. Bidault, Service de Physique du Globe et de Météorologie, 2 Rue de Foucauld à Casablanca.
M. Clariond, Bureau de Recherches et Participations Minières, 38 Rue de la République à Rabat.
M. Haubert, Ingénieur aux Ets. Gourvenec à Fédala.
M. Mayot, Annexe de l'Institut National Géographique à Rabat.
M. Tillolloy, Météorologie Nationale, Camp Cazes à Casablanca.

NETHERLANDS

Adhering Organization

The Secretary,
Netherlands Geodetic and Geophysics Council,
Royal Netherlands Meteorological Institute,
De Bilt, Netherlands.

Organizations

Bataafse Petroleum Maatschappij, Den Haag.
Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

Individuals

H. J. Groenewold, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.
H. P. Th. van Lohuizen, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.
J. Veldkamp, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.
S. W. Visser, Koninklijk Nederlands Meteorologisch Instituut, De Bilt.

NEW ZEALAND

Adhering Organization

The Director,
Department of Scientific and Industrial Research,
Box 18, Government Buildings,
Wellington, New Zealand

Organizations

Magnetic Survey, Christchurch (H. F. Baird, Director).

NORWAY

Adhering Organization

The General Secretary,
Det Norske Videnkaps-Akademi,
Drammensveien 78,
Oslo, Norway

Organizations

Det Norske Institutt for Kosmisk Fysikk, Fysisk Institutt, Universitetet i Oslo, Blindern, with two subdivisions:
1. Nordlysobservatoriet i Tromsö
2. Det Magnetiske Byrå i Bergen

Individuals

L. Harang, Forsvarets forskningsinstitutt, Storgaten 33, Oslo
H. Solberg, Astrofysisk Institutt, Universitetet i Oslo, Blindern
C. Störmer, Astrofysisk Institutt, Universitetet i Oslo, Blindern
B. Trumpy, Geofysisk Institutt, Universitetet i Bergen
L. Vegard, Fysisk Institutt, Universitetet i Oslo, Blindern

PERU

Adhering Organization

The Director,
Instituto Geografico Militar del Peru,
Lima, Peru

Organizations

Institute de Biologia Andina, Universidad Nacional Mayor de San Marcos de Lima, Apartado 821, Lima
Instituto Geofisico de Huancayo, Apartado 46, Huancayo
Instituto Geólogico del Perú, Apartado de Correo 2559, Lima

Individuals

Dr. J. A. Broggi, Director, Instituto Geológico del Perú, Apartado de Correo 2559, Lima

Coronel Gerardo Dianderas S., Director, Instituto Geográfico Militar, Lima

Mr. A. A. Giesecke, Jr., Technical Director, Instituto Geofísico de Huancayo, Apartado 46, Huancayo

Prof. Carlos Monge M., Director, Institute de Biologia Andina, Universidad Nacional Mayor de San Marcos de Lima, Apartado 821, Lima

PHILIPPINES

The President,
Philippine Geodetic and Geophysical Institute,
Bureau of Coast and Geodetic Survey,
O'Racco Buildings, Manila, Philippines

Individuals

Lieut. (j.g.) Francisco J. Banzon, Bureau of Coast and Geodetic Survey, Manila.

Father Charles Depperman, Jesuit Observatory, Manila.

Lieut. Avelino D. de Guzman, Bureau of Coast and Geodetic Survey, Manila.

Capt. Andres O. Hizon, Bureau of Coast and Geodetic Survey, Manila.

Lieut.-Comdr. Constancio M. Legaspi, Bureau of Coast and Geodetic Survey, Manila.

Father Miguel Selga, Jesuit Observatory, Manila.

POLAND

Adhering Organization

Very uncertain; perhaps:
Académie Polonaise des Sciences et des Lettres,
Polska Akademia Umiejetnosci,
Cracovie, Poland

or Institut de Hydrologie et Météorologie,
Ministry of Communications,
Warsaw, Poland

Individuals

Mlle. S. Kalinowska, Director, Swider Observatory, Swider, Poland

PORTUGAL

Adhering Organization

Director-General,
Instituto Geográfico e Cadastral,
Praça da Estrela,
Lisbon, Portugal

Organizations

Servico Meteorológico Nacional, Largo de Santa Isabel, Lisboa
Instituto Geofísico do Infante D. Luiz, R. Escola Politécnica, Lisboa
Instituto Geofísico da Universidade, Coimbra
Instituto Geofísico (Serra do Pilar), Vila Nova de Gaia

Individuals

H. Amorim Ferreira, Director, Serviço Meteorológico Nacional, Lisboa
A. Gama Vieira, Serviço Meteorológico Nacional, Lisboa

PORTUGUESE COLONIES

Organizations

Observatório Magnético, S. Miguel, Azores Islands
Observatório João Capelo, Luanda, Portuguese West Africa
Observatório Campos Rodriques, Lourenço Marques, Portuguese East Africa

Individuals

José Agostinho, Angra do Heroísmo, Azores Islands
A. Mendonca Dias, Centro Meteorológico, Santa Maria, Azores Islands

RUMANIA

Adhering Organization

The Director,
Military Geographic Institute,
126, Boulevard Filantropia,
Bucharest 3, Rumania

Individuals

Dr. L. Constantinescu, Surlari Geomagnetic Observatory, Rumanian Geological Institute, Sos. Kisseleff 2, Bucharest II

SIAM

Adhering Organization

The Royal Survey Department,
Ministry of Defence,
Bangkok, Siam

Individuals

Charoon V. Bunnag, Director, Meteorological Department, Royal Siamese Navy, Bangkok

SOUTH AFRICA

Adhering Organization

The Secretary,
South African Council for Scientific and Industrial Research,
P. O. Box 395,
Pretoria, Transvaal,
Union of South Africa

Organizations

The Director, Trigonometrical Survey of the Union of South Africa, Rhodes Avenue, Mowbray, Cape
The Director, Geological Survey, P. O. Box 401, Pretoria
The Director, Bernard Price Institute of Geophysical Research, c/o University of the Witwatersrand, Milner Park, Johannesburg
The Officer-in-Charge, Telecommunications Research Laboratory, University of the Witwatersrand, Johannesburg

Individuals

B. F. J. Schonland, South African Council for Scientific and Industrial Research, P. O. Box 395, Pretoria
A. M. van Wyk, Officer-in-Charge, Magnetic Observatory, Hermanus, near Cape Town

SPAIN

Adhering Organization

The Director,
Direccion General del Instituto Geographico y Catastral,
Presidencia del Gobierno,
Madrid, Spain

Organizations

Instituto Espanol de Oceanografía, Alcalá 31, Madrid
Instituto Geográfico y Catastral, General Ibáñez 3, Madrid
Instituto Nacional de Geofisica, Ministerio de Educación Nacional, Rios Rosas 9, Madrid
Observatorio del Ebro, Tortosa
Seccion Meteorologica y Sismica del Observatorio Fabra, Real Acad. de Ciencias y Artes, Barcelona

Individuals

Dr. José Cubillo, Jefe del Servicio de Magnetismo, Instituto Geográfico y Catastral, General Ibáñez 3, Madrid
Sr. Director General del Instituto Geográfico y Catastral, Princesa, 12, Madrid
Ministerio de Marina, Instituto Espanol de Oceanografía, Alcalá 31, Madrid
Rev. Antonio Romañá, S. J., Direccion, Observatorio del Ebro, Tortosa
Dr. José Garcia Siñeríz, Director, Instituto Nacional de Geofisica, Ministerio de Educación Nacional, Rios Rosas 9, Madrid

SWEDEN

Adhering Organization

The Secretary,
K. Vetenskapsakademiens Kamrerare,
Stockholm, Sweden

Organizations

Geofysiska Laboratoriet, Djursholm 2
Sveriges Geologiska Undersökning, Stockholm 50
Geologiska Institutionen, Lunds Universitet, Lund
Geologiska Institutionen, Uppsala Universitet, Uppsala
Institutet för högspänningsforskning, Uppsala Universitet, Uppsala
A/B Elektrisk Malmletning, Kungsgatan 44, Stockholm
Meteorologiska Institutionen, Uppsala Universitet, Uppsala
Kungl. Sjökarteverket, Avdelningen för jordmagnetism, Stockholm 100
Kungl. Tekniska Högskolan, Institutionen för elektronik, Stockholm
Chalmers Tekniska Högskola, Laboratoriet för elektronik, Göteborg

Individuals

Professor, Fil. Dr. Hannes Alfvén, Institutionen för elektronik, Kungl. Tekniska Högskolan, Stockholm
Byrådirektör, Fil. Dr. Nils Ambolt, Avdelningen för jordmagnetism, Kungl. Sjökarteverket, Stockholm 100
Byråchef, Fil. Dr. Anders Ångstrom, Sveriges meteorologiska och hydrologiska institut, Stockholm
*Statshydrograf, Fil. Mag. Sven Åslund, Avdelningen för jordmagnetism, Kungl. Sjökarteverket, Stockholm 100
Överdirektör, Fil. Dr. Per Geijer, Sveriges Geologiska Undersökning, Stockholm 50
Bergsingenjör Helmer Hedström, Eriksbergsgatan 12 A, Stockholm
Professor, Fil. Dr. Gustaf Ising, Geofysiska Laboratoriet, Djursholm 2
Professor, Fil. Dr. Hilding Köhler, Meteorologiska Institutionen, Uppsala
Fil. Dr. Ferdinand Lindholm, Skepparegatan 17, Stockholm
Lektor, Fil. Dr. Kurt Molin, Tekniska Gymnasiet, Örebro
Bergsingenjör Allan Nordström, Invernessvägen 11, Stocksund
Fil. Dr. Gunnar Nörgaard, Västergatan 17, Lund
Professor, Fil. Dr. Harald Norinder, Institutet för högspänningsforskning, Uppsala
Professor Olof Rydbeck, Kungl. Chalmers Tekniska Högskola, Göteborg
Assistent, Fil. Kand. Sven Werner, Sveriges Geologiska Undersökning, Stockholm 50

*Deceased

SWITZERLAND

Adhering Organization

The Secretary,
Schweizerische Naturforschende Gesellschaft,
Buhlplatz 5,
Bern, Switzerland

Organizations

International Meteorological Organization, 5 Rue Etraz, Lausanne
Observatorium Arosa, Arosa
Physikalisch-Meteorologisches Observatorium Davos, Villa Dora, Davos-Platz

Individuals

Prof. Dr. F. W. Paul Götz, Zürich University, Lichtklimatisches, Observatorium Arosa, Arosa

Dr. Jean Lugeon, Directeur, Station Centrale Swisse de Météorologie, Gloriastrasse 35, Zürich

Prof. P. L. Mercanton, Department de l'Agriculture, de l'Industrie et du Commerce, Service Meteorologique, 20 Avenue Eglise anglaise, Lausanne

Dr. Walter Mörikofer, Physikalisch-Meteorologisches Observatorium Davos, Villa Dora, Davos-Platz

Dr. G. Swoboda, Chief of the Secretariat, International Meteorological Organization, 5 Rue Etraz, Lausanne

SYRIA

Adhering Organization

The Director General,
Ministry of Public Works and Communications,
Damascus, Republic of Syria

TRIESTE

Osservatorio Geofisico, Trieste 11

TURKEY

Adhering Organization

Director General of Turkish Geodetic Survey, T. C., M.S.B.,
Harita Genel Mudürlügü,
Milli Savunma Bakanligi,
Ankara, Turkey

Organizations

Harta Genel Md. lüğü, Cebeci-Ankara,
Kandilli Rasatanesi, Çengelköy-İstanbul

UNITED STATES OF AMERICA

Adhering Organization

The Chairman,
National Research Council,
2101 Constitution Avenue,
Washington 25, D. C., U. S. A.

National Committee,
American Geophysical Union,
1530 P Street, N.W.,
Washington 5, D. C., U. S. A.

Organizations

Applied Physics Laboratory, Johns Hopkins University, 8621 Georgia Avenue, Silver Spring, Md.
Bartol Research Foundation, Swarthmore, Pa.
Brookhaven National Laboratory, Upton, Long Island, N. Y.
California Institute of Technology, Pasadena 4, California
Cambridge Field Station, Air Materiel Command, 230 Albany Street, Cambridge 39, Mass.
Colorado School of Mines, Department of Geophysics, Golden, Colorado
Columbia University, New York 27, N. Y.
Cornell University, Department of Physics, Ithaca, New York
Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Fordham University, New York 58, N. Y.
Geophysical Laboratory, Carnegie Institution of Washington, 2801 Upton St., N.W., Washington 8, D. C.
George Washington University, Washington 6, D. C.
Harvard Observatory, 60 Garden Street, Cambridge 38, Mass.
Institute of Geophysical Technology, 3621 Olive Street, St. Louis 8, Missouri
Johns Hopkins University, Physics Department, Baltimore 18, Md.
Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, New Mexico
Massachusetts Institute of Technology, Cosmic Terrestrial Research Laboratory, 31 Bird Street, Needham 92, Mass.
McMath-Hulbert Observatory, Lake Angeles, Route 4, Pontiac 4, Michigan
Michigan College of Mining and Technology, Houghton, Michigan
Mount Wilson Observatory, 813 Santa Barbara Street, Pasadena 4, California
National Bureau of Standards, Washington 25, D. C.
Naval Ordnance Laboratory, White Oak, Silver Spring 19, Md.
Navy Mine Countermeasures Station, Panama City, Florida
New Mexico School of Mines, Socorro, New Mexico
New York University, Department of Physics, New York, N. Y.
Ohio State University, Columbus 10, Ohio
Pennsylvania State College, State College, Pa.
Princeton University, Princeton, N. J.
Rockefeller Foundation, 49 West 49th Street, New York 20, N. Y.
Scripps Institution of Oceanography, La Jolla, Calif.
University of Alaska, Geophysical Institute, College, Alaska
University of California, Institute of Geophysics, Los Angeles 24, Calif.
University of Chicago, Ryerson Physical Laboratory, Chicago 37, Illinois
University of Colorado, Boulder, Colorado
University of Michigan, Department of Geology, Ann Arbor, Mich.
University of North Carolina, Chapel Hill, N. C.
University of Pennsylvania, Randal Morgan Laboratory of Physics, Philadelphia 4, Pa.

University of Rochester, Rochester 3, N. Y.
University of Utah, Salt Lake City, Utah
University of Virginia, Department of Physics, Charlottesville, Va.
University of Wisconsin, Department of Geology, Madison, Wisconsin
U. S. Coast and Geodetic Survey, Washington 25, D. C.
U. S. Geological Survey, Washington 25, D. C.
U. S. Hydrographic Office, Navy Department, Washington 25, D. C.
U. S. Naval Observatory, Washington 25, D. C.
U. S. Naval Research Laboratory, Anacostia Station, Washington 20, D. C.
U. S. Weather Bureau, Washington 25, D. C.
Washington University, St. Louis, Missouri
Woods Hole Oceanographic Institution, Woods Hole, Mass.
Yale University, Sloane Physics Laboratory, New Haven, Conn.

Individuals

Leroy R. Alldredge, 3133 Jennings Road, Kensington, Md.
James R. Balsley, Jr., U. S. Geological Survey, Washington 25, D. C.
John Bardeen, 5 Primrose Place, Summit, N. J.
Samuel J. Barnett, Research Associate, California Institute of Technology, Pasadena 4, Calif.
Carl A. Bays, 1110 W. Illinois Street, Urbana, Ill.
Roland F. Beers, Box 1015, Troy, N. Y.
Lloyd V. Berkner, 7213 Bradley Boulevard, Bethesda 14, Md.
Ervin H. Bramhall, Box 433, Route 1, Annandale, Va.
Charles R. Burrows, 116 Mitchell Street, Ithaca, N. Y.
Arthur H. Compton, Chancellor, Washington University, St. Louis 5, Mo.
Richard A. Craig, Harvard Observatory, 60 Garden Street, Cambridge 38, Mass.
Albert P. Crary, Cambridge Field Station, Air Materiel Command, 230 Albany Street, Cambridge 39, Mass.
J. Howard Dellinger, 618 Pickwick Lane, Chevy Chase, Md.
E. A. Eckhardt, Gulf Research and Development Co., P. O. Drawer 2038, Pittsburgh 30, Pa.
Walter M. Elsasser, Department of Physics, University of Pennsylvania, Philadelphia 4, Pa.
Frank C. Farnham, Winans Road, Route 2, Owings Mill, Md.
John A. Fleming, 1026 - 16th St., N.W., Apartment 701, Washington 6, D. C.
Scott E. Forbush, 6509 Brennon Lane, Chevy Chase, Md.
Carl W. Gartlein, Department of Physics, Cornell University, Ithaca, N. Y.
T. N. Gautier, Jr., National Bureau of Standards, Washington 25, D. C.
R. E. Gebhardt, U. S. Coast and Geodetic Survey, Washington 25, D. C.
O. H. Gish, 2211 S. 17th Street, Lincoln 2, Nebr.
John W. Graham, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Ross Gunn, 4437 Lowell Street, N.W., Washington 16, D. C.
Lawrence R. Hafstad, 4532 Fairfield Drive, Bethesda, Md.
Sigmund I. Hammer, Gulf Research and Development Co., P. O. Drawer 2038, Pittsburgh 30, Pa.
Carl A. Heiland, Heiland Research Co., P. O. Box 360, Denver 1, Colo.
Roland G. Henderson, 2401 Ontario Road, Washington 9, D. C.
Victor F. Hess, 20 William Street, Mount Vernon, N. Y.
Robert E. Holzer, Institute of Geophysics, University of California, Los Angeles, 24, Calif.
H. Herbert Howe, 1313 N. Wayne Street, Arlington, Va.

M. King Hubbert, Shell Oil Co., 3737 Bellaire Boulevard, Houston 5, Texas
Edward O. Hulburt, Naval Research Laboratory, Anacostia Station, Washington 20, D. C.
John J. Jakosky, 10663 Chalon Road, Bel Air, Los Angeles 24, Calif.
Henry R. Joesting, U. S. Geological Survey, Washington 25, D. C.
Ellis A. Johnson, 419 Essex Avenue, Chevy Chase, Md.
Thomas H. Johnson, Beaver Dam Road, Brookhaven, N. Y.
H. Freeborn Johnston, 6503 Ridgewood Avenue, Chevy Chase, Md.
J. Wallace Joyce, 6641 - 32nd Street, N.W., Washington 15, D. C.
Joseph Kaplan, Institute of Geophysics, University of California, Los Angeles 24, Calif.
Fred Keller, Jr., 2125 Suitland Terrace, S.E., Washington 20, D. C.
Sherwin F. Kelly, P. O. Box 23, Amawalk, N. Y.
David G. Knapp, 3827 W Street, S.E., Washington 20, D. C.
Serge A. Korff, Department of Physics, New York University, New York 53, N. Y.
Frederick W. Lee, Owings Mills, Md.
Eugene G. Leonardon, Schlumberger Well Surveying Corporation, P. O. Box 2175, Houston 1, Texas
W. A. Longacre, 110 W. South Avenue, Houghton, Mich.
Gerald R. MacCarthy, P. O. Box 544, Chapel Hill, N. C.
James B. Macelwane, S.J., Institute of Geophysical Technology, 3621 Olive Street, St. Louis 8, Mo.
John W. Mauchly, 219 St. Marks Street, Philadelphia 4, Pa.
Harold E. McComb, 417 Emerson Street, N.W., Washington 11, D. C.
A. G. McNish, 311 Essex Avenue, Chevy Chase 15, Md.
Donald H. Menzel, Harvard College Observatory, Cambridge 38, Mass.
Robert A. Millikan, California Institute of Technology, Pasadena 4, Calif.
L. L. Nettleton, Gravity Meter Exploration Co., 1348 Esperson Building, Houston 2, Texas
Seth B. Nicholson, 1785 Pepper Drive, Altadena, Calif.
W. Dudley Parkinson, Physics Department, Johns Hopkins University, Baltimore 18, Md.
Wilfred C. Parkinson, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Chaim L. Pekeris, 7 Goodman Road, Princeton, N. J.
Mrs. Marcella L. Phillips, Union Farm, Route 1, Alexandria, Va.
Sylvain J. G. Pirson, 3174 - 22nd Street, Tulsa, Okla.
Robert S. Richardson, Mount Wilson Observatory, 813 Santa Barbara Street, Pasadena 4, Calif.
Elliott B. Roberts, U. S. Coast and Geodetic Survey, Washington 25, D. C.
Irwin Roman, U. S. Geological Survey, 203 Custom House, Baltimore 2, Md.
L. H. Rumbaugh, 13 Whittier Street, N.W., Washington 12, D. C.
Walter E. A. Ruska, 2336 Watts Road, Houston 5, Texas
H. Leroy Scharon, Department of Geology, Washington University, St. Louis 5, Mo.
Walter E. Scott, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Stuart L. Seaton, Geophysical Institute, University of Alaska, College, Alaska
A. H. Shapley, National Bureau of Standards, Washington 25, D. C.
Joseph A. Sharpe, Frost Geophysical Corporation, P. O. Box 58, Tulsa, Okla.
Kenneth L. Sherman, Navy Mine Countermeasures Station, Panama City, Florida
Dorr C. Skeels, Standard Oil Development Co., 30 Rockefeller Plaza, New York 20, N. Y.
L. B. Slichter, Institute of Geophysics, University of California, Los Angeles 24, Calif.

Newbern Smith, 5009 Keystone Avenue, Bethesda, Md.
H. Cecil Spicer, U. S. Geological Survey, Washington 25, D. C.
Noel H. Stearn, W. C. McBride, Inc., 2101 Missouri Pacific Building, St. Louis 3, Mo.
Edgar L. Stephenson, 480 W. Pueblo Street, Reno, Nevada
Harlan T. Stetson, Cosmic Terrestrial Research Laboratory, Massachusetts Institute of Technology, 31 Bird Street, Needham 92, Mass.
H. W. Straley, III, 1635 W. Wesley Road, N.W., Atlanta, Georgia
W. F. G. Swann, Bartol Research Foundation, Swarthmore, Pa.
Joel H. Swartz, U. S. Geological Survey, 203 Custom House, Baltimore 2, Md.
Howard E. Tatel, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
O. W. Torreson, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Richard Tousey, Naval Research Laboratory, Anacostia Station, Washington 20, D. C.
M. A. Tuve, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Victor Vacquier, 143 Chestnut Street, Garden City, N. Y.
J. A. Van Allen, 8621 Georgia Avenue, Silver Spring, Md.
E. H. Vestine, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
G. R. Wait, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
Robert J. Watson, 3523 S. Troost Street, Tulsa, Okla.
Warren Weaver, Rockefeller Foundation, 49 West 49th Street, New York 20, N. Y.
Harry W. Wells, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C.
John H. Wilson, 1411 Electric Building, Fort Worth 2, Texas
George P. Woollard, Department of Geology, University of Wisconsin, Madison, Wisconsin
Everly J. Workman, Research and Development Division, New Mexico School of Mines, Socorro, New Mexico
Oliver R. Wulf, Gates and Crellin Laboratories, California Institute of Technology, Pasadena 4, Calif.
R. D. Wyckoff, Gulf Research and Development Co., P. O. Drawer 2038, Pittsburgh, Pa.

YUGOSLAVIA

Adhering Organization

M. le Director,
Council of the Academies of the F.P.P. of Y.,
51 Moskovska, Belgrade, Yugoslavia

INTERNATIONAL ASSOCIATION OF
TERRESTRIAL MAGNETISM AND ELECTRICITY

EXECUTIVE COMMITTEE

President

Prof. S. Chapman, California Institute of Technology, Pasadena, California (until April 1, 1951); Queen's College, Oxford, England (after April 1, 1951)

Vice-Presidents

Prof. J. Coulomb, 191 Rue Saint-Jacques, Paris, 5e, France

Dr. B. F. J. Schonland, P. O. Box 395, Pretoria, Transvaal, Union of South Africa

Secretary and Director of the Central Bureau

Dr. J. W. Joyce, 6641 - 32nd Street, N.W., Washington 15, D. C., U. S. A.

Members

Dr. S. K. Banerji, Meteorological Department, Lodi Road, New Delhi, India

Mr. L. V. Berkner, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington 15, D. C., U. S. A.

Dr. John A. Fleming (Past President), Carnegie Institution of Washington, 1530 P Street, N.W., Washington 5, D. C., U. S. A.

Mr. V. Laursen, Meteorological Institute, Charlottenlund, Denmark

Mr. O. Lützow-Holm, Pilar, FCCA, Province de Córdoba, Argentina

Dr. D. F. Martyn, Commonwealth Observatory, Mt. Stromlo, Canberra, Australia

PUBLICATIONS

BY THE

INTERNATIONAL ASSOCIATION OF TERRESTRIAL MAGNETISM & ELECTRICITY

Bulletins

No. 1	Organization, Minutes, and Proceedings of the Brussels Meeting, 1919	$0.15
No. 2	General Report of the Rome Meeting, 1922	0.15
No. 3	Transactions of the Rome Meeting, 1922	2.00
No. 4	General Report of the Madrid Meeting, 1924	0.15
No. 5	Transactions of the Madrid Meeting, 1924.	2.00
No. 6	Preliminary Reports on Subjects of Investigation, 1926 . . .	0.30
No. 7	Comptes Rendus de l'Assemblée de Prague, 1927.	2.25
No. 8	Comptes Rendus de l'Assemblée de Stockholm, 1930	3.65
No. 9	Comptes Rendus de l'Assemblée de Lisbonne, 1933.	2.80
No. 10	Transactions of the Edinburgh Meeting, 1936	3.50
No. 11	Transactions of the Washington Meeting, 1939	3.50
No. 12	Geomagnetic Indices, C and K, 1940-1946	3.00
No. 12a	Geomagnetic Indices, C and K, 1947	1.00
No. 12b	Geomagnetic Indices, K and C, 1948	1.50
No. 13	Transactions of the Oslo Meeting, 1948	3.50

Photographic Atlas of Auroral Forms and Scheme for Visual Observations, 1930 . . . . 3.00

Supplements to the Photographic Atlas of Auroral Forms, I, 1932 . . . 2.00

Caractère Magnétique Numérique des Jours (from 1 January 1930 to 31 December 1939) and Caractère Magnétique Numérique des Jours pendant l'Année Polaire 1932-1933 (in complete sets only) 5.60