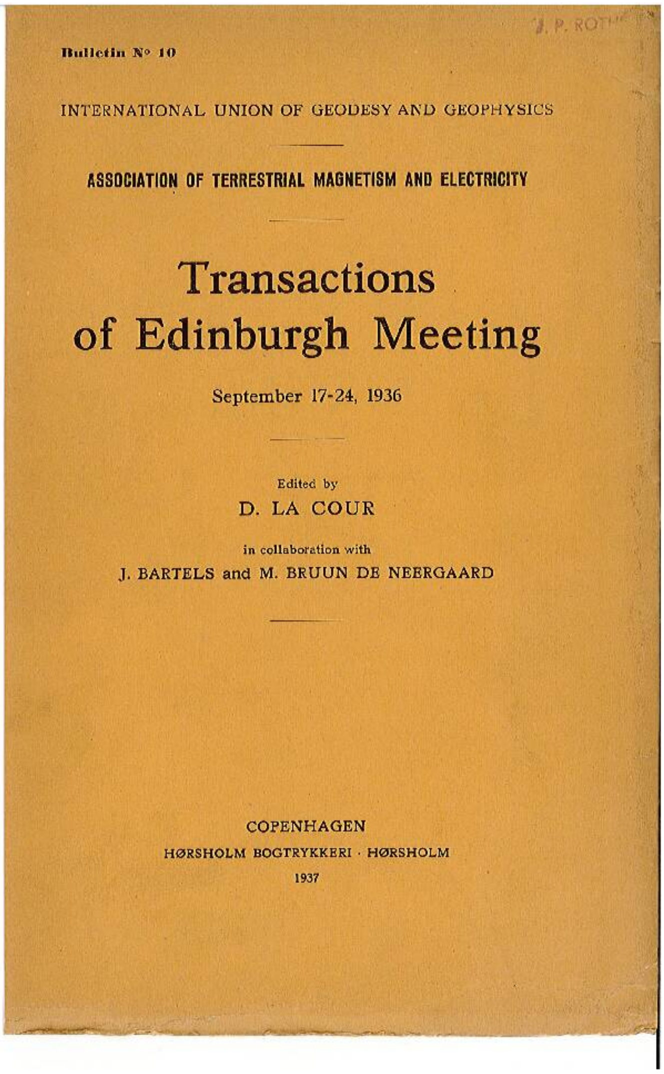

Bulletin N° 10

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY

Transactions of Edinburgh Meeting

September 17-24, 1936

Edited by
D. LA COUR

in collaboration with
J. BARTELS and M. BRUUN DE NEERGAARD

COPENHAGEN
HØRSHOLM BOGTRYKKERI · HØRSHOLM
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How to cite:

IAGA (1937). ***IATME Bulletin No. 10, Transactions of Edinburgh Meeting, September 17-24, 1936.*** **IUGG.** **https://doi.org/10.25577/9y2w-n249**

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INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION

Edinburgh Meeting, September 17-26, 1936

INTERNATIONAL ASSOCIATION OF
TERRESTRIAL MAGNETISM AND ELECTRICITY

PROVISIONAL AGENDA

I. Address of President.

II. Report of Secretary and Director of Central Bureau.

III. Report of Dr. van Dijk on the publication of numerical magnetic character of days.

IV. Statutes.

V. Finances. — Report of Director of Central Bureau.

VI. Election of officers of the Association.

VII. National Reports.

VIII. Reports of Committees and Reporters appointed at the Lisbon Assembly:
  a) Report of Committee on the selection of sites of new observatories for terrestrial magnetism and electricity.
  b) Report of Sub-Committee on the distribution of observatory work in Europe.
  c) Report of Committee on the study of sudden commencements of magnetic storms.
  d) Report of Auroral Committee.

e) Report of Committee on the study of the numerical magnetic characterization of days.
f) Report of Committee on the study of the relationship between solar activity and terrestrial magnetism.
g) Report of the Polar Year Sub-Committee.
h) Report of Committee on magnetic secular-variation stations.
i) Report of Committee on the study of electrical characterization of days.
k) Report of Prof. Chapman on international collaboration for promoting the study of the influence of the moon on geophysical phenomena.
l) Report of Dr. Wait on ion-counters.

IX. The Warsaw Meeting, September 1935, of the International Commission of Terrestrial Magnetism and Atmospheric Electricity:
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    2) Hourly values of magnetic activity (p. 19).
    3) Centralization of magnetic data (pp. 24 & 87-89).
    4) Reports on the activity of various observatories.
  b. Subjects proposed for collaboration with the Association:
    1) Publication of daily magnetic character-numbers and the numerical character of days for the Polar Year.
    2) Frequent comparisons by means of instruments sent by mail.
    3) Uniform methods and codes to adequately describe magnetic disturbances and perturbations.
    4) Convention as regards the sense of earth-current components.
    5) International magnetic classification of Greenwich days prior to 1906.
    6) International agreement on the uniformity of magnetic charts all over the world.

X. Polar Year 1932-1933.
  a) Report on the activity of the Polar Year Commission of the International Meteorological Organization.
  b) Discussion of International Polar Year results and presentation of reports on this subject.
  c) Discussion of ways and means to permit effective continuation of compilations, reductions, discussions, and publications of results.
  d) See also: IX.b.1 & XI.m.

XI. Communications on miscellaneous subjects:

a) *W. Smosarski:* On the characteristics of the Gerdien apparatus and their seasonal variation.
b) *Ch. Maurain:* Presentation of a treatise titled: "Magnétisme terrestre".
c) *G. Grenet & A. Jarleton:* On the measurement of the electric field and its sudden changes and on the relations between the electric field and the solar radiation.
d) *J. Coulomb & B. Benac:* Influence of the direction of the wind on the electrical field at Côte de Landais.
e) *J. A. Fleming:* Intercomparisons of magnetic standards and control of standards.
f) *L. V. Berkner, W. Wells & S. L. Seaton:* Automatic multifrequency technique for ionospheric measurements.
g) *L. V. Berkner & W. Wells:* Studies of the E-region of the ionosphere at low latitudes.
h) *L. V. Berkner & W. Wells:* New factors in the investigation of the high region of the upper atmosphere.
i) *S. E. Forbush & E. A. Johnson:* Results of international intercomparisons of magnetic horizontal-intensity with C. I. W. sine-galvanometer 1.
k) *D. la Cour:* Trials made with the QHM by the Danish Meteorological Institute.
l) *D. la Cour & E. Sucksdorff:* Control of variometers by means of the QHM.
m) *O. H. Gish & W. J. Rooney:* New aspects of earth-current circulations revealed by Polar-Year data.
n) *O. H. Gish & K. L. Sherman:* Information to be obtained from atmospheric-electric measurements in the stratosphere.
o) *E. A. Johnson:* Application of alternating-current methods of detection to earth-inductors for marine and land observations.
p) *H. F. Johnston:* Short-period magnetic pulsations at the Watheroo Magnetic Observatory.
q) *A. G. McNish:* Concerning non-cyclic change.
r) *A. G. McNish:* Progress of research in magnetic diurnal-variations at the Department of Terrestrial Magnetism, Carnegie Institution of Washington.
s) *A. G. McNish:* The new C. I. W. vertical-intensity induction-variometer.
t) *A. G. McNish:* Investigation of magnetic bays.
u) *L. Slaucitajs & A. G. McNish:* The field of magnetic storms as deduced from the mean difference of magnetic intensity on quiet and disturbed days.

v) *G. R. Wait:* Change from year to year in the potential gradient and electrical conductivity of the atmosphere at Ebro, Watheroo and Huancayo.

x) *J. Hawley:* The attitude of the U. S. Coast and Geodetic Survey, Washington, towards four branches of international work in terrestrial magnetism.

y) *H. E. McComb:* Review in some detail of the work at Cheltenham. (Withdrawn).

z) *D. la Cour & E. Hoge:* The effect of the electrification of the railway passing in the vicinity of the Copenhagen Magnetic Observatory.

aa) *George Hartnell:* Comparison of Z-Variometers.

ab) *D. la Cour & Johs. Olsen:* Contribution to the knowledge of the behaviour of modern variometers working under disadvantages.

ac) *V. F. Hess:* New results of cosmic ray research.

ad) *Kurt Molin:* An earth-magnetic investigation of the Mainland of Sweden. (Inserted in the Swedish National Report).

ae) *H. Norinder:* The variation of lightning currents.

af) *U. S. Hydrographic Office, Washington:* World Magnetic Charts.

ag) *Th. Dahlblom:* Temperature and magnetization of the Earth's crust.

ah) *A. Tanakadate:* Preliminary short reports of magnetic and electric observations made in the Far-East during the total solar eclipse of June 19th, 1936.

ai) *E. Sucksdorff:* Occurrence of rapid micro-pulsations at Sodankylä in 1932-1935.

XII. Subjects for discussion during the Assembly:

a) Thesaurus of magnetic values. Proposed by *A. Nippoldt* †.

b) Installation of insensitive equipment to obtain complete records of intense magnetic storms. Proposed by the *President*.

c) Character of publication of data from observatories. Proposed by the *President*.

d) Greater attention in the investigation of small periodic and irregular variations. Proposed by the *President*.

e) Publication of world-list of magnetic and electric observatories.

f) Magnetic standards and methods of intercomparison. Proposed by the *President*. (See also IX.b.2 & XI.e).

g) Memorandum on circulation of QHM for intercomparisons of measurements and for control of variometers. Presented by *D. la Cour*.

h) Research in the ionosphere:
1) Methods of research.
2) Distribution of stations.
3) Dissemination of data.
Proposed by the *President.*

i) Atmospherics and atmospheric electricity. Proposed by *R. Bureau.*

k) Increase of earth-current data. Proposed by the *President.*

l) Atmospheric electricity:
1) Electric state of the troposphere and the stratosphere in general.
2) Electric state of the air at sea during fair and during stormy weather.
3) Variations in conductivity and potential gradient from year to year.
Proposed by the *President.*

m) Secular-variation program at sea. Proposed by the *President.*

n) Definition and adoption of symbols pertaining to geomagnetic coordinates, magnetic coordinates, and geomagnetic time. Proposed by the *President.*

o) Auroral charts and observations. Proposed by the *President.*

p) Proposal concerning classification of magnetic literature. By *Mario Bossolasco.*

q) Agreement upon selected international disturbed days for the period 1906-1914. Proposed by *S. Chapman.*

r) Selection of international quiet and disturbed days for the period before 1906. Proposed by *S. Chapman.*

s) Establishment in Iceland of temporary stations for quick-run registration. Proposed by *S. Chapman & D. la Cour.*

XIII. Subjects for deliberation by Committees.

XIV. Appointment of Committees and Reporters.

XV. Resolutions.

SUPPLEMENTARY AGENDA

XI. Communications on miscellaneous subjects:

ak) *J. A. Fleming & C. C. Ennis:* Latest annual values of the magnetic elements at observatories.

al) *O. H. Gish:* The mean electric character of eight widely distributed stations.

am) *W. E. H. Greaves:* The suitability of the unifilar magnetometer for absolute observations.
an) *Mario Bossolasco:* Sur la nature des perturbations magnétiques.
ao) *F. J. W. Whipple:* Electrical characterization of days. (Withdrawn).
ap) *A. H. R. Goldie:* Observations of horizontal force with the unifilar magnetometer: The P and Q coefficients.
aq) *G. S. Ljungdahl:* Note on the average range of magnetic anomalies in Sweden.
ar) *H. Labrouste:* Sur l'étude des périodes des phénomènes magnétiques.
as) *R. Jouaust:* Sur l'étude des relations entre les perturbations de la radio et les perturbations magnétiques.
at) *H. Israël-Köhler:* Vorschläge zur Vereinheitlichung von Luftionenmessungen.
au) *L. V. Berkner & W. Wells:* Report on ionospheric observations during solar eclipse of June 19, 1936.

XII. Subjects for discussion during the Assembly:
t) *J. M. Stagg:* Methods of investigating possible relationships between aurorae and magnetic disturbances.
u) *J. M. Stagg:* The assignment and use of auroral intensity figures.
v) *J. M. Stagg:* The technique of measurement of aurora photographs; alternatives to the Norwegian process.

Participation in the Edinburgh Assembly of the Association of Terrestrial Magnetism and Electricity, September 17-24, 1936.
The presence in the various sessions is indicated by „p“.

	Name	Country	Meeting of September							
			17 p. m.	18 a. m.	19 a. m.	21 a. m.	21 p. m.	22 a. m.	22 p. m.	24 a. m.
Mr.	Agostinho	Portugal	p	—	—	—	—	—	—	—
–	Appleton	Great Britain	—	—	—	p	p	p	p	p
–	Bartels	Germany	p	p	p	p	p	p	p	p
–	Berkner	U. S. A.	p	p	p	p	p	p	p	p
–	Bowie	U. S. A.	—	p	—	—	—	—	—	—
–	Braak	Holland	—	—	—	—	p	—	—	—
Miss	Bruun de Neergaard	Denmark	p	p	p	p	p	p	p	p
Mr.	Chapman	Great Britain	p	—	p	p	p	p	p	p
–	Coulomb	France	p	p	p	p	p	—	p	—
–	la Cour	Denmark	p	p	p	p	p	p	p	p
–	Dahlblom	Sweden	—	p	—	—	p	—	p	—
–	van Dijk	Holland	p	p	p	p	p	p	p	p
–	Dobson	Great Britain	—	—	—	p	p	—	—	—
–	Eblé	France	p	p	p	p	p	p	p	p
–	Egedal	Denmark	p	p	p	p	p	p	p	p
–	van Everdingen	Holland	—	—	—	—	p	p	—	—
–	Ferraro	Great Britain	p	p	p	p	p	p	—	—
–	Fleming	U. S. A.	p	p	p	p	p	p	p	p
–	Fryer	Great Britain	—	—	—	—	—	p	p	—
–	Geddes	Great Britain	—	—	—	p	—	—	—	—
–	Greaves	Great Britain	p	p	p	p	p	p	p	p
–	Grenet	France	—	—	—	p	p	p	p	—
–	Harradon	U. S. A.	p	p	p	p	p	p	p	p
–	Heck	U. S. A.	p	p	p	p	p	—	p	—
–	Hess	Austria	—	—	p	p	p	—	—	—
Miss	Ingram	Great Britain	—	—	p	p	p	—	p	—
Mr.	Spencer Jones	Great Britain	p	p	p	p	—	p	p	p
–	Jouaust	France	—	—	—	—	—	—	p	—
Miss	Kalinowska	Poland	p	p	p	p	p	p	p	p
Mr.	Kalinowski	Poland	p	p	p	p	p	p	p	p
–	Keränen	Finland	p	p	p	p	p	p	p	p
–	Labrouste	France	p	p	p	p	p	—	p	p
Mrs.	Labrouste	France	p	p	p	p	p	p	p	p
Mr.	Laursen	Denmark	p	p	p	p	p	p	p	p
–	Linke	Germany	—	—	—	p	—	—	—	—
–	Ljungdahl	Sweden	p	p	p	p	p	p	p	p
–	Lyot	France	p	—	p	—	—	—	—	—
–	Martyn	Australia	p	p	—	—	p	—	—	p
–	Mathias	France	p	p	p	p	p	p	p	p
–	Maurain	France	p	p	p	p	p	p	p	p
–	Crichton Mitchell	Great Britain	—	—	—	p	p	p	p	p
–	Mitra	Great Britain	—	p	—	p	p	—	—	—
–	Norinder	Sweden	p	p	p	p	p	p	p	p
–	Noto	Japan	p	p	p	p	—	p	p	p

Name	Country	Meeting of September							
		17 p. m.	18 a. m.	19 a. m.	21 a. m.	21 p. m.	22 a. m.	22 p. m.	24 a. m
Mr. Olsen	Denmark	p	p	p	p	p	p	p	p
– Paton	Great Britain	—	—	—	—	p	—	—	—
– Pekeris	U. S. A.	—	—	—	—	p	—	—	—
– Penndorf	Germany	—	—	—	p	p	—	—	—
– Peters	U. S. A.	p	—	—	—	p	—	—	—
– Piddington	Great Britain	p	—	—	—	—	—	—	—
– Roux	Morocco	—	—	p	—	—	—	—	—
Father Rowland	Great Britain	p	—	—	—	—	—	—	—
Mr. Salamon	Czechoslovakia	p	—	p	p	—	—	—	p
Sir George Simpson	Great Britain	—	—	—	p	—	—	—	—
Mr. Slaucitajs	Latvia	p	p	p	p	—	p	p	p
– Smosarski	Poland	p	p	p	p	p	p	p	p
– Stagg	Great Britain	p	p	p	p	p	p	p	p
– Stetson	U. S. A.	p	p	p	p	p	—	—	p
– Trumpy	Norway	p	p	p	p	p	p	p	p
– Vegard	Norway	—	p	p	p	p	p	p	p
– Visser	Holland	—	p	—	—	—	—	—	p
– Wentworth	U. S. A.	—	—	—	—	—	—	—	p
– Whipple	Great Britain	—	—	—	p	—	—	—	—
– Witchell	Great Britain	—	—	p	p	—	p	p	p
– Wulf	U. S. A.	—	—	—	p	—	—	—	—
Total attendance		39	37	39	48	45	35	39	37

MINUTES OF EDINBURGH MEETING, SEPTEMBER 17-24, 1936

Session of September 17, 1936

The meeting was opened at 14.30 by the President, Dr. Jno. A. Fleming.

The President read his *opening address* (I of Agenda — App., p. 27).

The following committees were nominated by the President and were elected by the Association:
Committee on Resolutions: The President, the Secretary, Capt. Heck and Prof. Maurain.
Audit Committee: Dr. van Dijk, Mr. Harradon and Prof. Keränen.

The Secretary and Director of the Central Bureau presented his *report* (II of Agenda — App., p. 34). He commented on the question of inserting a list of addresses in the Transactions indicating the difficulties connected therewith. He emphasized the necessity of the collaboration of the National Committees and indicated the desirability of a resolution on this matter (Resolution 2). He called attention to the collection of registrations on films at the Central Bureau, and stated that he had brought a large number of these films to Edinburgh which were available for examination by those interested.*) He mentioned the part taken by the Association in the intercomparisons of instruments with QHM. He also presented his *financial report* through December 31, 1935 (App., p. 38).

Dr. van Dijk presented his *report on the publication of numerical magnetic character of days* (item III of the Agenda — App., p. 163).

It was decided that the discussion of the proposed *Statutes* should be deferred until the following meeting in order to allow more time for their study (p. 11).

It was also decided to defer the consideration of the *Report on Finances* until the Audit Committee had rendered its report (p. 22).

*) See pp. 415-421.

Item VI of the Agenda. *The following officers* were unanimously elected: President: Dr. Fleming; Vice-Presidents: Prof. Maurain and Prof. Chapman; Secretary and Director of Central Bureau: Dr. la Cour*); Members of the Executive Committee: Dr. Crichton Mitchell, Dr. van Dijk, Prof. Keränen, Prof. Störmer and Prof. Tanakadate.

The *National Reports* (VII of Agenda) were then presented in abstract by various delegates (Part III. — National Reports. Pp. 51-162).

The *Reports of Committees* appointed at the Lisbon Assembly (VIII of Agenda) were then taken up and some of them were presented in abstract:

Item VIII. a *(Committee on Observatories* — App., p. 164). In this connection the Chairman of the Committee (Dr. Fleming) suggested that a resolution be passed regarding periodic examination of magnetic instruments (Resolution 3). At the end of the report a resolution on the preparation of a new list of magnetic observatories was recommended (Resolution 1). (See, further, consideration of item XII.n of the Agenda, minutes of meeting September 22, morning session). It was further proposed that the Committee be continued (No. 1).

Item VIII. b *(Observatory-Work in Europe).* No separate report was submitted.

Item VIII. c *(Sudden Commencements of Magnetic Storms).* No report was submitted by the Chairman (Prof. Tanakadate), but comments were received from Father Rodés (App., p. 177).**) It was decided that the Secretary should write a letter to Father Rodés expressing the appreciation of the Association for the successful work he has been doing for so many years and conveying the hope that no discontinuance would occur in it.

Items VIII.d and VIII.e of the Agenda were deferred to subsequent meetings. (Minutes of the meetings of September 21 (afternoon) and of September 19).

Item VIII. f *(Solar Activity and Terrestrial Magnetism).* The Chairman of the Committee (Dr. Fleming) gave a summary of the report (App., p. 187). The Committee was continued (No. 3).

The meeting adjourned at 12.30.

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*) In view of his election (September 24, 1936) as President of the Union Dr. la Cour felt he could not also act as Secretary and Director of the Association's Central Bureau; the Executive Committee therefore selected Dr. A. H. R. Goldie as Secretary and Director of the Central Bureau to fill the vacancy caused by Dr. la Cour's resignation.

**) A report on sudden commencements of magnetic storms in Japan was later received from Prof. Tanakadate (App., p. 174).

Session of September 18, 1936

The meeting was opened at 10.00 by the President, Dr. Fleming.

The minutes of the meeting of September 17 were read and approved with minor corrections.

The proposed *Statutes* (item IV of Agenda) were taken up for consideration and were approved, section by section, after brief discussion which resulted in some minor corrections (Part II. — Statutes. Pp. 43-50). The President called special attention to the last paragraph of section IV empowering the Executive Committee to depart from the decision and the instructions of the General Assembly or from the strict interpretation of these Statutes, if it should consider necessary or desirable to do so. The section VI, dealing with the budget, was approved in principle only, and the Executive Committee was authorized to modify this section in accordance with the financial policy to be adopted by the Union.

Item VIII of the Agenda *(Reports of Commissions)* was then continued.

Item VIII. g *(Polar-Year Sub-Committee).* The Secretary reported that he had received from the Chairman of the Polar-Year Sub-Committee (Prof. Störmer) the suggestion to discontinue the Sub-Committee. As a member of the Sub-Committee Dr. la Cour himself offered no objection to the proposal of Prof. Störmer, as the international work relating to the Polar Year in reality is centralized in the International Polar Year Commission of the International Meteorological Organization. However, in view of the fact that the Sub-Committee is a joint Committee of the Magnetic and Meteorological Associations, Prof. Maurain was asked to consult with Mr. Wehrlé regarding the opinion of the Meteorological Association before any final decision should be taken. The Secretary further stated the necessity, in case the Sub-Committee should be discontinued, of deciding what disposition should be made of the apparatus for auroral observations, procured by the Sub-Committee for use during the Polar Year; he proposed that the instruments be taken over by the Auroral Committee. (Further consideration: see minutes of the meeting of September 19).

Item VIII. h *(Secular-Variation Stations).* The Report of the Committee (App., p. 189) was given in abstract by the Chairman (Capt. Heck). His suggested resolutions on this subject were referred to the Committee on Resolutions for action (Resolution 11). It was agreed to continue this Committee (No. 4).

Items VIII. i, k and l were deferred to subsequent meetings (morning session of September 21).

Consideration was then given to item IX of the Agenda, the *Warsaw Meeting,* September 1935. The Secretary indicated some items in the transactions of that meeting of interest to the Association:

(1) The Commission had decided not to publish in the transactions reports on the activity of various observatories in order to avoid duplication of work and to permit concentration of such reports in one place, but to ask the Association for reprints of the National Reports received by that body. The Secretary recommended sending not only reprints but the complete transactions to members of the Commission who do not receive them otherwise. The Association agreed.

(2) The Commission had entrusted its Secretary (Dr. la Cour) with the preparation of a list of Polar-Year stations from which it would be especially desirable to have hourly values of magnetic activity. This list has been prepared, and several of the observatories have already sent to Copenhagen tables of these values which are made available on films. The list contains the following stations: Point Barrow, Fairbanks, Fort Rae, Meanook, Chesterfield Inlet, Thule, Godhavn, Julianehaab, Eskdalemuir, Lerwick, Sodankylä, Franz Joseph Land, Matotchkine Schar, Kandalakscha, Dickson and Jakoutsk.

Prof. Vegard called attention to the importance of an international agreement for the purpose of obtaining — in the annual publications of magnetic observatories — more complete and quantitative data on magnetic disturbance than are given by character-numbers. The Committee of the Norwegian Institute of Cosmical Physics has given much consideration to this question and has introduced a scheme of publication according to which hourly values of the perturbing force were given, and they also furnish material for a *quantitative* representation of storminess as a function of time. If observatories all over the world agreed to a scheme of this type, we should obtain important information regarding the laws governing magnetic perturbations and their relations to aurorae, to ionized atmospheric layers, and solar activity in general.

(3) It was agreed to adopt a resolution on the question of centralization of copies of registrations as favorably considered in Warsaw (Resolution 8).

Further the Commission of Terrestrial Magnetism and Atmospheric Electricity ask for collaboration with the Association on the following subjects:

(1) *Publication of daily magnetic character-numbers and the numerical character of days for the Polar Year* (IX.b.1 — App., p. 218). Dr. van Dijk, entrusted with the preparation of this publication, described briefly the development of this work.

The cost of publishing the daily magnetic character-numbers would probably amount to about 200-250 florins. He was requested by the Association to continue this valuable compilation. The Secretary suggested that the Association, in order to obtain data from all the Polar Year stations, pass a resolution expressing the desirability of publishing the daily magnetic character-figures for the Polar Year, and this suggestion was agreed to (Resolution 4).

(2) *Frequent comparisons by means of instruments sent by mail* (IX.b.2). Dr. la Cour set forth his ideas regarding the organization of an international body to be responsible for intercomparisons (App., p. 220).

The President stressed the importance of checking standards for all magnetic elements. He thought that very often errors in the H-measurements arise from changes of the moment of inertia, and that difficulties in the determinations of inclination could be referred to earth-inductors not properly adjusted or to inability of observers. He further drew attention to small station-differences too often assumed to be negligible, and stressed the importance of interchange of stations. He emphasized that comparisons by means of instruments circulated by mail, should in no way entail discontinuance of personal contacts through the visits of observers to foreign observatories for instrumental intercomparisons. (Further consideration was given in the meeting of September 19).

The meeting adjourned at 12.30.

Session of September 19, 1936

The meeting was opened at 10.00 by the President, Dr. Fleming.

The minutes of the meeting of September 18 were read and approved with minor changes.

The consideration of item IX.b.2 *(Intercomparisons)* was continued. In the course of the discussion Capt. Heck asked whether the QHM is entirely satisfactory, and does it require special mounting, and made query as regards the time required for work proposed at isolated observatories. To these queries Dr. la Cour replied that while the instrument was not ideal in all respects, it has great advantages, and he cited data in support of his statements. Determinations could be made with the QHM in about 5 minutes, and the instruments could be mounted on any theodolite. The determination of constants was also discussed.

Dr. Fleming pointed out that the preliminary correction of QHM on the Sine-Galvanometer with one instrument in February at Washington was -4γ, and that with three instruments in the summer it was $+6\gamma$, and he considered this difference too great. Dr. la Cour answered that all the measurements referred to had been *previously* indicated as trials only, and that the three instruments mentioned had been hastily prepared in order to be sent via Washington to Japan in the hope of having them back before the meeting in Edinburgh.*) The temperature-coefficient had therefore not been finally determined before the instruments were sent away, and as the temperature was rather high (34° C) during the measurements in Washington, this probably accounts for the differences found. According to his experience the accuracy of the measurements is much greater than that indicated by Dr. Fleming's figures.

After considerable discussion in which Messrs. Vegard, la Cour, Fleming, Maurain, Heck, Spencer Jones, Olsen, Greaves, Kalinowski and Chapman took part, Resolution 5 suggested by Prof. Chapman, was approved. (See also p. 40).

The President announced that Prof. Maurain having consulted with Mr. Wehrlé, reported that the latter accepts, in the name of the Meteorological Association, the suggestion that the *Polar Year Committee of the Union* be discontinued (minutes, September 18, item VIII.g); the discontinuance of that Committee was therefore approved. It was agreed that the special equipment purchased by the Association from its grants for the Polar Year be transferred to the Auroral Committee.

Item VIII.e of the Agenda *(Magnetic Characterization)*. The Chairman of the Committee (Dr. Crichton Mitchell) presented his report (App., p. 185). The two proposals at the end of the report were approved.

Dr. van Dijk raised the question whether the Association wished to continue the publication of the numerical magnetic characterization in its present form, especially as to whether the publication of the sum of the two components should be continued. This matter was discussed in detail by Messrs. Crichton Mitchell, Fleming, Vegard, van Dijk, la Cour, Bartels, Maurain, Chapman, Stagg and Egedal. As a result of this discussion the President appointed a Committee consisting of Messrs. Chapman (Chairman), Bartels, Crichton Mitchell and van Dijk, to report on this matter to the Association some time during the Assembly. (See minutes of the meeting of September 24).

Resuming item IX of the Agenda *(Warsaw Meeting)*, Dr. Fleming as Chairman of the joint Committee of the Commis-

*) The report on the measurements in Japan is given on page 260.

sion of Terrestrial Magnetism and Atmospheric Electricity and of the Association on *uniform methods and codes to adequately describe magnetic disturbances and perturbations,* summarized the report (IX.b.3 — App., p. 222), calling attention particularly to the suggested code as given in the report. Dr. la Cour asked if it would not be well to try these suggested designations for a year at an observatory where many perturbations occur. The President suggested that it might be well to select three widely-distributed observatories for this purpose. Prof. Keränen was asked and stated that this could be done for Sodankylä. In the absence of Capt. Heck, Dr. Fleming stated that he felt sure that the trial could be made for one of the five U. S. Coast and Geodetic Survey Observatories, and that the Department of Terrestrial Magnetism of the Carnegie Institution of Washington would be glad to do the same for Watheroo and Huancayo. (Committee No. 11).

The Report of the Sub-Committee of the Commission on *convention regarding the sense of earth-current components* was then presented in abstract by Dr. Fleming (IX.b.4 — App., p. 235). He called attention to the resolution suggested in the report which was approved (see Resolution 6).

The President commented briefly on the report of the Sub-Committee of the Commission on *international magnetic classification of days prior to 1906* (IX.b.5 — App., p. 237). At the suggestion of Prof. Chapman it was decided to ask the Commission that the Sub-Committee be continued.

The following papers were then presented to the Association:

"Mitteilung über erdmagnetische und elektrische Arbeiten in der U. d. S. S. R. in den Jahren 1931-35" by N. W. Puschkow (*Terr. Magn.,* 40, 1935, p. 393-399);

"Der Zustand des Netzes der Magnetischen Observatorien der U. d. S. S. R. und weitere Perspektive seiner Entwicklung" by N. Rose (*Terr. Magn.,* 40, 1935, p. 401-406);

"On the Type of the Diurnal Variations of the Terrestrial Magnetism on Quiet Days" by M. Hasegawa *(Proc. Imp. Acad. Tokyo,* Vol. XII, p. 88-90);

"A Statistical Study of the Type of Diurnal Variations of Terrestrial Magnetism on Quiet Days" by M. Hasegawa (*Proc.Imp.Acad.Tokyo,* Vol. XII, p. 185-188);

"The Eccentric Dipole approximating the Earth's Magnetic Field" by J. Bartels (*Terr. Magn.,* 41, 1936, p. 225-250).

The meeting adjourned at 12.30.

Morning session of September 21, 1936

The meeting was opened at 10.00 by the President, Dr. Fleming.

The minutes of the meeting of September 19 were read and approved.

With regard to item VIII.i of the Agenda *(Electrical Characterization* — App., p. 208) Dr. Whipple gave an account of the system of characterization adopted at the observatories of the British Meteorological Office. His remarks were illustrated by two slides, one showing the percentage distribution of days according to electric character at Kew, Eskdalemuir and Lerwick, and the other diurnal variation of potential gradient at Eskdalemuir on "0a" days and on "1a" and "2a" days. Dr. Whipple urged that the attention of the directors of observatories should be called to the resolution adopted by the Association in 1927 (Prague Meeting) recommending the publication of the duration of negative potential gradient each day and suggested that a summary giving for each month the number of days with negative potential gradient lasting more or less than three hours, should be forwarded to the Carnegie Institution year by year. Further Dr. Whipple put forward his proposals quoted in the report of the Committee. It was decided to continue the Committee for another 3-year period (No. 5).

Commenting on Dr. Wait's *report on ion-counters* (VIII. l — App., p. 215), Dr. Whipple gave a short account of the work at Kew Observatory on ion-counting. It appeared that whereas in fine weather in a pure atmosphere it was possible to count such ions by a single counter like the Ebert instrument it was essential at an urban station to use more complicated apparatus.

Prof. Chapman summarized his *report on international collaboration for promoting the study of the influence of the Moon on geophysical phenomena* (item VIII.k — App., p. 214). After some discussion it was agreed to authorize the Executive Committee to continue to support Prof. Chapman in this work.

The report of the Sub-Committee on *international agreement on the uniformity of magnetic charts all over the world* (appointed by the Commission at its *Warsaw Meeting)* (IX.b.6 of Agenda — App., p. 238) was read by Prof. Keränen who exhibited specimen-charts. Commenting on this report, Dr. Ljungdahl made the following statement: While the magnetic elements and the magnetic lines are subject to great and unceasing changes according to the secular variation, the magnetic anomalies, being associated with the structure of the earth's crust, remain generally constant, at least for considerable periods of time. It seems self-evident that magnetic charts *for almost all purposes* should distinguish, as far as possible, between the part which remains constant and that which varies. Furthermore, the map should indicate to what extent the values are ascertained by observations, or merely obtained by interpolation. He drew attention to his paper: "An attempt to simplify magnetic charts"*). Mr. Greaves stated that this is a question of practical interest and desired to know how the material should be collected and distributed. Prof. Chapman considered that no hasty action on this matter should be taken, and suggested that two small committees should be appointed to handle the matter: one to consider what steps should be taken in the organization of the work, and the other concerned with the methodology. He considered, in order to take advantage of the methods already developed at the leading existing organizations, that the first committee should consist of the Astronomer Royal, Capt. Heck, Dr. Ljungdahl and Prof. Maurain, and a German representative to be appointed by the Executive Committee; and that Messrs. Keränen, Ljungdahl and Chapman with the addition of two Russian representatives, should serve on the second. The final appointment was left to the Executive Committee. (Committee No. 6).

The discussion of item X of the Agenda (*Polar Year*) was deferred until a later meeting (morning session of September 22).

Item XII (*Subjects for Discussion)* was then taken up.

In the absence of Prof. Nippoldt item XII.a *(Thesaurus of Magnetic Values)* was discussed by the President who considered the plan an excellent one and suggested that the thesaurus could be published in connection with the new "List of Observatories" (Resolution 1). The Executive Committee was instructed to take such steps as are necessary for the realization of this proposal.

The President commented on item XII.b *(Intense Magnetic Storms),* citing the approach of increased sunspot-activity, and suggested that the Association recommend the installment of equipment for recording storms at certain observatories. Dr. la Cour stated that it is easy to secure records of great magnetic storms, even by means of sensitive instruments, utilizing optical methods. Prof. Bartels stated that some of the most interesting parts in the famous storm of May 1921 were lost on the records of nearly all observatories. It should be one of the main duties of an observatory to obtain a complete record of the magnetic field just at these most crucial moments in the history of terrestrial magnetism. Simple means

*) Terr. Magn., 41, 1936, pp. 101-104.

for obtaining sufficiently insensitive records were for instance introduced by Ad. Schmidt and by Dr. la Cour. The best way seems to install an independent set of insensitive instruments. It was decided that a resolution be adopted, recommending to all observatories that they should add to their equipment a device for securing complete records of magnetic storms (Resolution 7).

Items XII.c *(Publication of Magnetic Data)* and XII.d (*Investigation of Small Variations*) were discussed together. The President considered that greater attention should be paid to unique features, such as bays, pulsations, sudden commencements, etc. On the suggestion of Prof. Vegard, it was decided that this question be referred to a committee on publication-methods (No. 8). He further suggested that Dr. Trumpy be added to this committee.

Regarding item XII.e *(World-List of Observatories)* the President stated that favorable action had been taken already in the meeting of September 17 (Resolution 1).

Items XII.f and XII.g of the Agenda *(Intercomparisons)* — (App., p. 425): Action already taken as in Resolution No. 5 (meeting of September 19).

Item XII. h (*Research of Ionosphere)* was then presented by Dr. Berkner who after setting forth the status of the subject, suggested that with the approval of the Association there be appointed a sub-committee to collaborate with the Committee on the study of the relationship between solar activity and terrestrial magnetism, for the study of the ionosphere. This sub-committee must act with the International Scientific Radio Union and with the International Meteorological Organization. He concluded with the following proposals: (1) to encourage establishment of additional stations in necessary locations, (2) to encourage operation along observatory-lines and to recommend such uniformity of observations as is necessary for study, (3) to study such methods and publication of data as make possible the most useful interchange of data, and to encourage this important form of international activity. Prof. Appleton emphasizing the importance of the work, stated that it began with the International Scientific Radio Union. After further comments on this subject by Messrs. Linke, Vegard, Stetson, Maurain and Spencer Jones, it was agreed that Messrs. Berkner and Appleton should confer on this matter and make recommendations to the Executive Committee for appointment of a joint committee of the International Scientific Radio Union and of the Association (see minutes of the meeting of September 24).

Item XII. i (*Atmospherics*) was deferred to a later meeting (meeting of September 22, afternoon session).

Item XII. k of the Agenda (*Earth-Current Data*): The Committee on Resolutions was instructed to prepare a resolution on the establishment of suitable additional earth-current stations (Resolution 9).

The Association then proceeded to discuss item XII.l of the Agenda: (1) *Electrical state of the troposphere and the stratosphere in general:* It was agreed that the Association should lend its support to obtaining information whenever opportunity permits; (2) *Electric state of the air at sea during fair and during stormy weather:* The *Carnegie* has shown the desirability and manner of doing such work, and it was hoped that with the aid of the *Research* such work would be done in future; (3) *Variations in conductivity and potential gradient from year to year:* It was agreed that the Association should encourage the continuity of such work at observatories not already doing such work (Resolution 10). Dr. Spencer Jones stated that it is intended to include atmospheric-electric work in the programme of the *Research,* and that instruments are in course of development. Prof. Smosarski emphasized the importance of the proposal contained in item XII.l.3, and stated that he has published two years ago a paper in French language, "Electricité Atmosphérique près de Poznań"*) in which he has investigated the variation in the mean potential gradient of atmospheric electricity on the earth's surface in different months from year to year (1927-1933); he had found that the variation is in agreement with the variation in the mean temperature and in the mean water vapour content of the air as well in summer as in winter. He added that some further suggestions concerning the subject are given in that paper.

The President stressed the importance of additional data from the oceans (XII.m of Agenda), and stated that the *Research* represented a long step in this direction. Following discussion Resolution 12 was adopted.

The meeting adjourned at 12.30.

Afternoon session of September 21, 1936

The meeting was opened by the President, Dr. Fleming, and was devoted to the presentation of papers (XI of Agenda).

Prof. Hess presented his paper on new results of cosmic-ray research (App., p. 368).

Dr. Berkner summarized three papers by Berkner, Wells and Seaton (App., pp. 340, 357 & 362). Prof. Appleton stated that

*) Polish Agricultural and Forest Annual, Vol. 33, Poznan, 1934, pp. 6-12.

one cannot emphasize too much the importance of the matter presented and the fact that the work had been extended to the Southern Hemisphere. Messrs. Stetson and Mitra also discussed the papers presented.

In the absence of the Chairman (Prof. Störmer) Dr. Stagg presented a *report for the Auroral Committee* (VIII.d of Agenda — App., p. 179). Further, he summarized his *papers on aurorae* (XII. t, u & v — App., pp. 443, 447 & 449). He proposed: (1) that suitable steps be taken to review and if necessary, to modify the Fritz's lines of auroral frequency, keeping in mind that these lines may not be stationary; (2) with a view to minimizing unnecessary effort in future auroral photography at observatories with limited financial and staff resources, that the procedure recommended for such photography during the Polar Year (and outlined in App., p. 182) be reintroduced during a specified period near the maximum of the present sunspot cycle; (3) that a simple standard for determining auroral intensity be introduced and adopted at all auroral observatories (App., p. 447); (4) that the Auroral Committee be continued. (No. 2). — Prof. Chapman urged that it was desirable to design a simple apparatus for measurements of pairs of simultaneous auroral photographs. Prof. Vegard approved the proposal to correct to the present epoch the Fritz's lines of auroral frequency as they are of considerable physical significance, and emphasized the importance of obtaining better methods for indicating the intensities of aurorae. He gave a report on spectroscopic study of aurorae (App., p. 371).

Dr. la Cour then gave a demonstration of photographic reproductions of various records on films. (See p. 415).

The meeting adjourned at 16.30.

Morning session of September 22, 1936

The meeting was opened at 10.00 by the President, Dr. Fleming.

The Secretary stated that owing to illness in London on route to Edinburgh, Prof. Nippoldt had been forced to return to Germany. He had, however, sent in a report on magnetic work in Germany (see Part III. — National Reports. Germany, p. 88).

The minutes of the meeting of September 21, morning session, were read and, after correction, approved.

Discussion of item XII of the Agenda was then resumed.

With regard to item XII. n (*Symbols for Coordinates and Time*), Prof. Bartels considered that geomagnetic coordinates should be given in the proposed "List of Observatories" to be published by the Association, and indicated that the Magnetisches Observatorium der Universität Berlin, which has published such data for former years, would be willing to submit these coordinates for publication in that list. He thought it advisable not to hide the simple meaning of such coordinates behind some Greek symbols, but to define them wherever necessary, in a few words. The question of geomagnetic time was discussed by Messrs. Stagg, Greaves, Bartels and Vegard, the latter emphasizing the usefulness for the study of phenomena in the polar regions of that conception and of magnetic azimuth as well, introduced by him some 25 years ago. Following a proposal by Dr. Fleming, it was agreed to include in the proposed list, a chapter dealing with these conceptions, leaving to the discretion of investigators whether to follow such suggestions.

As to item XII.o *(Auroral Charts)*, reference was made to Dr. Stagg's proposals (minutes of the meeting of September 21, afternoon session).

Consideration was then given to item XII.p *(Classification of Magnetic Literature)*. Dr. la Cour commented on the report submitted by Dr. Bossolasco (App., p. 436). The Executive Committee was empowered to take action regarding this proposal (Resolution 13). (See also p. 40).

With regard to item XII.q Prof. Chapman stated that there are no *internationally selected disturbed days for the period 1906-1914* but that Dr. van Dijk has already made a selection for his own use. He proposed that the Association give official recognition of these days. They were adopted (App., p. 440).

As to item XII.r it was suggested by Prof. Chapman and approved that the *five quiet and five disturbed days* be selected *for years prior to 1906*. Dr. van Dijk in consultation with Prof. van Everdingen is to make the selection.

The subject of *establishment in Iceland of temporary stations for quick-run magnetic registration* (XII.s of Agenda) was then brought forward. Dr. la Cour pointed out that it has been found during the Polar Year 1932-1933 that Giant Pulsations were remarkably frequent in Iceland. Referring to the reasons given in the paper submitted by Messrs. Chapman and la Cour (App., p. 441), he recommended that the proposed quick-run magnetic registrations be made in Iceland on the initiative of the Association. Messrs. Vegard, Norinder, Stagg, Chapman, Crichton Mitchell and la Cour discussed the utility of extending the investigations to other stations, especially to those in Northern Scandinavia and Scotland, and the advisability of carrying out the proposed investigations in years other than those of minimum magnetic activity. The Executive Committee was empowered to take action regarding this proposal (Resolution 16). (See also p. 40).

The *Report of the Audit Committee* (V of Agenda) which reported the accounts of receipts and disbursements by the Secretary in good order, was read by the Chairman (Dr. van Dijk) and approved (p. 39). An expression of thanks was then extended to the Secretary for his careful administration of the funds of the Association.

Polar Year (X of Agenda). Dr. la Cour referred to his report presented to the Conference of Meteorological Directors at Warsaw, September 1935*). The present task of the Bureau of the International Polar Year Commission is not to do scientific work, but to facilitate and support such work within certain limits. For this purpose the Bureau has been generously assisted by subventions from the Rockefeller Foundation of New York and from the Meteorological Association. On behalf of the Polar Year Commission he wished to express the sincere thanks of the Commission to the Association of Terrestrial Magnetism and Electricity for its valuable support and collaboration. He mentioned as of interest to the Association, the work initiated by the Polar Year Commission of preparing a catalogue of all observations available from the Polar Year, and the card-index of published papers and reports; at present this card-index, as compiled by Dr. Bossolasco, embraces not less than 700 cards.

The President proposed that a resolution should be passed urging the desirability of prompt publication of Polar Year data. Dr. la Cour desired to add a resolution recommending that data which will not be published elsewhere, should be reported to the Polar Year Commission so that these data may be available to investigators. It was decided that the Committee on Resolutions should draw up resolutions pertaining to these matters (Resolutions 14 and 15).

Prof. Maurain presented, on behalf of the French Polar Year Commission, Volume I of "Publications des Travaux Français pendant l'Année Polaire". This volume contains observational results and discussions of the following subjects: Aurorae, Ozone, and Cosmic Rays, by Mr. Dauvillier; Terrestrial Magnetism, by Mr. Jean Rothé.

The last half hour of the meeting was devoted to the presentation of the following papers: "The suitability of the

*) Secrétariat de l'Org. Mét. Int., Publication No. 29. Tome II, pp. 97-100. — Further: The Second General Assembly of the Int. Council of Scient. Unions, Brussels, July 1934 (London 1935), pp. 191-207; U. G. G. I. Sixième Assemblée Générale à Edimbourg, Septembre 1936 (London and Southampton 1937), pp. 142-145.

unifilar magnetometer for absolute observations" by Mr. Greaves (See pp. 91-93), and "Measurements of H with unifilar-distribution-constants" by Dr. Goldie (App., p. 335) which were both presented by Mr. Greaves. Dr. Fleming indicated that unifilars when properly controlled yielded high accuracy.

Prof. Labrouste gave an account of the work made by Mrs. Labrouste and himself on periods of magnetic phenomena (App., p. 338).

The meeting adjourned at 12.30.

Afternoon session of September 22, 1936

The meeting was opened at 14.30 by the President, Dr. Fleming, and was devoted to the presentation of communications (XI of Agenda).

Mr. Dahlblom gave a lecture on temperature and magnetization of the Earth's crust.

Prof. Maurain presented a treatise on terrestrial magnetism.*) It is the first fascicule of a series relating to Geophysics. It contains an exposition on the status of our knowledge and researches in terrestrial magnetism in which are analyzed several memoirs indicated in the French National Report (pp. 62-88) in particular a paper by Mr. Maurain on the interval of time between the solar phenomena and corresponding magnetic phenomena.

Prof. Appleton summarized and discussed a communication by Mr. Bureau (item XII. i of the Agenda — App., p. 429).

Prof. Norinder presented a communication on the variation of lightning currents (App., p. 397).

Prof. Smosarski presented a communication on the characteristics of the Gerdien apparatus and their seasonal variations (App., p. 375).

Prof. Jouaust gave a paper on the study of radio fade-outs and their relation with solar and terrestrial magnetic phenomena (App., p. 339).

Dr. Slaucitajs presented a study by himself and Mr. McNish of the differences in magnetic intensity on quiet and disturbed days (App., p. 289).

Mr. Grenet summarized two papers by himself and Miss Jarleton on the measurement of the electric field and its sudden changes.**)

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*) Actualités Scientifiques et Industrielles. 287. Paris, 1935.

**) Bull. de l'Inst. et Obs. de Phys. du Globe du Puy-de-Dôme, No. 7, p. 49 et p. 52.

Mr. Coulomb presented a paper by himself and Mr. Benac on the influence of the direction of the wind on the electrical field at Côte de Landais.*)

Capt. Heck summarized a paper by Mr. George Hartnell on comparison of Z-variometers (App., p. 307). In this connection Dr. la Cour drew attention to a paper by himself and Dr. Olsen regarding the behaviour of Z-variometers of the Godhavn type in arctic regions.**)

Prof. Chapman was appointed to discuss what arrangements shall be made for a round-table conference, or joint meeting of several Associations including scientific hydrology, to consider the manifold relations of research in hydraulic laboratories to other geophysical sciences.

Dr. la Cour presented the papers by Dr. Hoge and himself on the effect of the electrification of the railways near the magnetic observatory at Copenhagen (App., pp. 302 & 306). After discussion Resolution 17 bearing on this subject was adopted.

Dr. van Dijk proposed a resolution which was adopted concerning the undisturbed continuation of the magnetic work at De Bilt (Resolution 18).

Other papers for which time did not permit presentation in abstract were indicated by title (as shown by the list given on pp. 412-415).

The meeting adjourned at 16.20.

Final session September 24, 1936

The meeting was opened at 10.10 by the President, Dr. Fleming.

The minutes of the meetings of September 21 (afternoon session) and of September 22 (morning and afternoon sessions) were read and approved with some additions.

The report by Messrs. Appleton and Berkner regarding the proposed ionosphere sub-committee on the study of the relationship between solar activity and terrestrial magnetism (minutes of meeting of September 21, morning session, item XII.h of the Agenda) was presented. On the proposal of Prof. Maurain the name of Mr. Jouaust was added to the committee. (No. 12). With this addition the report was approved (App., p. 374).

*) Bull. de l'Inst. et Obs. de Phys. du Globe du Puy-de-Dôme, No. 8, p. 92.

**) Communications Magnétiques., etc., de l'Inst. Mét. de Danemark, No. 17.

ASSOCIATION TERRESTRIAL MAGNETISM AND ELECTRICITY, ESKDALEMUIR OBSERVATORY, SEPTEMBER 23, 1936

Dr Laursen Dr Olsen Mr Harradon Dr Bartels Mr Greaves Lt Commdr Frayer Mr Whipple Major Noto

Dr Visser Prof Slaucitajs Dr Egedal Dr Stagg

Dr Ljungdahl Capt Heck Dr Spencer Jones Dr Normand Mr Heywood Prof Appleton Prof Keränen Mr Paton Mr Wentworth

Dr la Cour Dr Geddes Mr Witchell Dr Whipple Dr Norrinder Prof Dahlblom Dr Grenet Dr Labrouste

Dr Everdingen Prof Kalinowski Dr Braak Dr Weickmann Dr Bjerknes Rev J.P. Rowland Prof Maurain M. Coulomb Dr van Dijk

Mr Crichton Dr Penndorf Dr Goldie Mme Maurain Mrs Goldie Mrs Crichton M. Eblé M. Mathias M. Smosarki Dr Fleming

Mrs Nebeker Miss la Cour Miss Kidner Miss la Cour Mrs Fleming Miss Heck Mrs Harradon Mme Coulomb Mrs Greaves

Miss Kalinowski Miss Ingram Mrs Wentworth Mme Grenet Mrs la Cour Sir George C. Simpson Mrs van Dijk Mrs Geddes Mrs Ljungdahl Miss Bruun de Neergaard Mme Labrouste

Prof. Chapman as chairman of the Committee on the publication of numerical character figures (minutes of meeting of September 19, item VIII.e of Agenda) recommended that for the three years 1937, 1938 and 1939, the sum $HR_H + ZR_Z$ be replaced by the daily range of declination R_D expressed in minutes of arc (Resolution 19).

No more subjects being left for deliberation (XIII of Agenda) the Association proceeded to items XIV and XV.

The *Resolutions* as drawn up by the Committee on Resolutions were considered and approved with some changes (Part VII. — A. Resolutions. Pp. 453-456).

Committees and Reporters were appointed (Part VII. — C. and D., Pp. 457-458).

The President announced his intention of presenting a brief report on the work of the Association to the General Assembly of the Union.*)

Votes of thanks were given to Prof. S. *Chapman*, Chairman of the Organising Committee of the British National Committee, Dr. H. *Spencer Jones* (Magnetic Section of the Organising Committee), and Dr. J. M. *Stagg*, Local Secretary, Mr. J. *Crichton*, Superintendant of the Eskdalemuir Observatory, the members of his *staff*, and Mrs. *Crichton*, for the excellent arrangements for this excursion which were as near perfection as they could be.

The Executive Committee was authorized to read and approve the minutes of this meeting.

Grateful appreciation of the services given, especially by Dr. *Goldie* and his *staff*, was expressed both by the President and by the Secretary and Director of Central Bureau.

The meeting adjourned at 11.55.

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*) U. G. G. I. Sixième Assemblée Générale à Edimbourg, Septembre 1936 (London and Southampton 1937), pp. 126-128.

APPENDIXES TO THE MINUTES

ADDRESS OF THE PRESIDENT*

Since the Lisbon Assembly in 1933 many eminent investigators in our fields have died. The Association has suffered particularly in the loss of its senior Vice-President, Professor V. Carlheim-Gyllensköld, who died December 13, 1934. He was widely known for his researches in terrestrial magnetism, and through his great activity in advancing that field of Earth physics in Sweden he stimulated and encouraged investigators everywhere. He was a vigorous supporter of our Association's development, and lent his aid and was a delegate at most of our triennial assemblies. We may well pay admiring homage to his services in our fields of geophysics.

Among other eminent investigators whose deaths occurred from 1933 to August 1936 there are the following:

Dr. Georges Le Cadet, March 11, 1933, who, although chiefly interested in astronomy and meteorology, made investigations of the variation of potential gradient of the atmosphere with altitude and embodied his results in a thesis "Etude du champ électrique de l'atmosphère".

Reverend Edmund Goetz, S. J., August 19, 1933, who was for many years in charge of the Observatory at Bulawayo, Rhodesia, and who took part in the magnetic and astronomical survey of north-west Rhodesia.

Dr. J. P. van der Stok, March 29, 1934, Director of Section of Oceanography and Marine Meteorology of the Royal Meteorological Institute of the Netherlands from 1899-1923, and formerly Director of the Magnetical and Meteorological Observatory at Batavia.

Dr. Bruno Rolf, May 4, 1934, who was senior meteorologist in the Meteorological-Hydrographical Institution at Stockholm and who, from 1915, was in charge of the geophysical work at the Abisko Observatory.

Professor Domenico Pacini, May 23, 1934, professor of experimental physics at the University of Bari who, during 1906-27 when connected with the Ufficio Centrale di Meteorologia

* Presented at the first meeting of the Association at Edinburgh, September 1936.

e Geodinamica in Rome, did much work on atmospheric electricity and on penetrating radiation.

Dr. Ole Krogness, May 28, 1934, Director of the Magnetic Bureau at Bergen, Norway, who made extensive studies of the aurora and its relations to cosmical and terrestrial phenomena, and who, as a member of the Executive Committee of the Norwegian Institute of Cosmical Physics, greatly assisted in the organization of the auroral observatory at Tromsö, particularly in planning the magnetic work.

Sir Edgeworth David, August 28, 1934, emeritus professor of geology at the University of Sydney, known for his exploratory work in Antarctica and who, in the course of Shackleton's expeditions of 1907-09, led the first sledge-party toward the South Magnetic Pole.

Dr. David Stenquist, September 8, 1934, Chief of the Bureau of the Swedish Telegraphic Service, whose scientific attention was devoted particularly to the study of earth-currents.

Sir Arthur Schuster, October 14, 1934, who was preeminent in promoting the study of the geophysical sciences and in increasing our knowledge of terrestrial magnetism through fundamental researches.

Professor Stefan Hlasek-Hlasko, October 21, 1934, formerly Director of the Pavlovsk Observatory, of the Magnetic Observatory at Tiflis, and the National Meteorological Institute of Poland.

Professor Veryl R. Fuller, May 30, 1935, in charge of the Department of Physics at the Alaska Agricultural College and School of Mines (now University of Alaska), particularly known for his auroral observations at College, Alaska.

Major-General Adolphus W. Greely, October 20, 1935, arctic explorer and student who, as leader of the United States Expedition to Lady Franklin Bay during the First International Polar Year, was responsible for the many geophysical and particularly magnetic data obtained during 1882-83 at the Fort Conger station in Grinnell Land.

Miss Valentine Vassilievna Gavrilova, November 22, 1935, who at the time of her death at the early age of 27 years was engaged as chief of the party carrying out magnetic-survey work in the Sverdlovsk Sector and south of the Ural, she having previously been principal magnetician at Matotchkin Shar.

Christian Huff, January 14, 1936, electrical engineer and instrument designer of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington who rendered notable service to geophysics through the design and construction of magnetic and electric instruments used in the field, at observatories, and aboard the *Carnegie.*

Reverend Father Joseph de Moidrey, S. J., February 7, 1936, a pioneer in magnetic work in China who was connected with the Observatory of Zikawei for 38 years and was Director of the Magnetic Observatory of Lukiapang from 1908-32; he made frequent contributions during his long services at Lukiapang and more recently was engaged in a series of studies of terrestrial magnetism which were published by the Observatory of Zikawei.

Dr. N. A. F. Moss, March 12, 1936, Director of the Bombay Observatory for nearly a quarter of a century (1896-1919); his work in two volumes "Colaba magnetic data 1846-1905" presented and discussed in great detail this remarkable series of observations extending over 60 years and represents a prodigious amount of labor, forming an outstanding contribution to the science of terrestrial magnetism and a storehouse of information for its students.

The interval since the Lisbon meeting of the Association has been one of excellent progress in investigations of terrestrial magnetism and electricity.

The publication in June 1934 of the Transactions of the Lisbon Assembly of the Association through the indefatigable labors of our General Secretary, Dr. D. la Cour, with the help of his assistant, Miss M. Bruun de Neergaard, furnishes a splendid and stimulating cross-section of world-wide progress in our fields. While these Transactions have received wide distribution, in accordance with resolution 19 adopted at Lisbon, it is feared that distribution may not have been as wide as its contents justify. In this connection it is believed that the resumption of publication of a list of addresses, such as was published in the Transactions of the Stockholm and Prague assemblies, arranged according to countries, organizations, and individuals interested, would add materially to the value of our proceedings. The preparation and maintenance of such a list are not easy and corrections from time to time are troublesome, but expenditures on these accounts looking toward more general distribution are well worth while. After all, the aim of our organization in forwarding coordinated national and international effort must be most effectively advanced in a far-reaching dissemination of our publications with the discussions, resolutions, reports, and comments offered at the triennial meetings.

It is a source of congratulation that fullest cooperative and harmonious relations have been maintained between the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization and our Association. The Transactions of the Warsaw meeting of the Commission in September 1935, so promptly published, afford ample evidence in its communications and resolutions of this effective cooperation. This close contact makes the existence of the two bodies of mutual benefit, which is further assured by the apointment of joint committees to study basic problems. Thus, loss of time, duplication of effort, and unnecessary expense of publication that would otherwise result have been almost entirely eliminated. The service given by the Central Office of the International Meteorological Organization in preparing and publishing the daily magnetic characters and the daily numerical character-figures is of inestimable value in geophysical fields and one for which our Association is most grateful. These daily magnetic characters have proved so valuable in many directions of inquiry that we may well record a desire that they be extended back from 1906, when they were begun, to selected long series of records, thus furnishing material for long-time consideration of magnetic activity and its correlation. We should therefore adopt the resolution of the Commission of Terrestrial Magnetism and Atmospheric Electricity at its Warsaw meeting to compile such data from records older than the De Bilt publications.

The remarkable success attending the program of the Commission of the Second International Polar Year is made more and more patent in the constantly increasing amount of compiled data being made available by its Central Bureau, so well directed by President la Cour, and by the numerous articles which have already appeared discussing many aspects of terrestrial magnetism and electricity. Our Association can make no wiser use of its resources than by extending continued aid, both moral and financial, to the International Polar Year Commission in support of its Central Bureau in Copenhagen. In this connection we should consider the desideratum of recommending the establisment of additional permanent arctic stations and of additional installations of open-scale magnetographs.

An outstanding event since our Lisbon meeting was the decision of the British Admiralty to construct a non-magnetic vessel to resume the magnetic and electric surveys of the oceans which were interrupted in 1929 by the loss of the non-magnetic yacht *Carnegie*. Our Association may well follow the action of the Commission of Terrestrial Magnetism and Atmospheric Electricity at Warsaw in expressing through suitable resolutions its thanks, and those of geophysicists everywhere, for this. Resumption of such work is particularly urgent to forward investigation of isoporic changes and study of the movements of isoporic foci — an investigation of great promise in studies of the Earth's crust. Another advance is the reported decision of the Union of Socialist Soviet Republics to build also a nonmagnetic ship — one suitable for work in the Arctic Ocean.

The need of reliable data over the oceans for all general discussions of the phenomena of the Earth's magnetism and electricity fully warrants the construction and use of a much larger number of such non-magnetic vessels. It therefore appears appropriate that we urge the various maritime nations to provide like means for more intensive magnetic surveys of the oceans and their islands. Concomitant with such matters may well be considered an international service for magnetic charts and selection of common epochs of reduction for magnetic data.

The agenda proposed for this meeting naturally concern aspects distinctly of interest in the coordination and development of international activities. We are fortunate in the various commissions and reporters, whose reports will be presented, affording a review of progress and upon which may be based resolutions to advance research in our fields.

An important item is a comprehensive discussion of ways and means which will permit more effective and economical continuation of compilations, reductions, discussions, and publication of results — a vital need if geophysics may reap full benefit of the vast material accumulated by the Second International Polar Year of 1932-33 and by the magnetic and electric surveys of the countries and organizations whose reports we are to receive. The importance of this subject is emphasized by past experience in that there always seems lacking additional funds, and even sometimes, that enthusiastic interest, so necessary to carry on the arduous reductions and compilations to realize the purpose of such observational programs. We must encourage and develop competent investigators to this end.

It seems appropriate that we review carefully not only instrumental methods and technique but also character of publications of data and their distribution. Consideration of the study of such data along more specific lines of inquiry appears desirable — for example, unique phenomena recorded at observatories, methods of research in the troposphere and stratosphere to forward understanding of cosmical relations, and possible interpretations in terms of physical laws by experimental procedure in the laboratory. The rapid development in recent years of precise methods for electrical measurements indicates promise, through the application of electro-magnetic methods to magnetic observations, to increase the accuracy and range of absolute standards perhaps not now possible with magnetic methods so generally used. There is evidence that such methods may be applied successfully to replace our present variometers to record the constantly fluctuating variations of terrestrial magnetism.

As vital to progress as the establishment of new observatories are improved methods and maintenance through periodic tests of adjustments of apparatus — frequently overlooked — since otherwise resulting geophysical data may not have that accuracy necessary to their interpretation.

May not more effective methods of publication to insure greater use by investigators be possible than those now commonly used in the hourly tabulations? The reproduction on motion-picture film of photographic records obtained, as introduced by the Polar Year Commission, appears to be an approach which will make for greater utilization of the complex variations recorded at so many observatories and for unscrambling of their now seeming vagaries. Such reproduction must permit intensive study of the distribution, period, and magnitude of pulsations, and of many other unique features and correlations.

While the report of the Committee on Observatories, approved at the Lisbon meeting, recommended that there be printed a revised edition of the list of observatories published in 1910 giving complete details of magnetic and electric observatories, with brief statements of geographical coordinates, elevations, instrumental equipment, data published regularly, data available on special request, and special remarks covering operation and investigations, there was no specific resolution adopted to provide for such publication. This should have attention at this meeting. Reference may be made to resolution 9 of the Commission of Terrestrial Magnetism and Atmospheric Electricity at its Warsaw meeting. The value of such a list would be enhanced by providing also that triennial supplements be issued to keep the information current. The suggestion offered by Dr. Nippoldt that a thesaurus of all magnetic values at observatories for full series be arranged is excellent and is one which may be considered at the same time.

We should support any program which may permit and extend adequate and frequent intercomparisons of standards at observatories throughout the world (see resolution 6 of the Warsaw meeting of the International Commission). However, it is to be stressed that such intercomparisons should be made not only with standards in horizontal intensity but also with those for inclination (vertical intensity) and declination in accordance with the need for such comparisons found in the extensive work in intercomparisons at observatories in all parts of the world done for many years by the Carnegie Institution of Washington through its Department of Terrestrial Magnetism.

An important aid to study of cosmical correlations of the Earth's magnetic and electric fields is the observation of variations of the electrical conditions in the ionosphere. Recent developments have made possible the design and construction of recording apparatus giving continuous records for interpretation of the variable conditions prevailing in its several regions. The following are worthy of our discussion in this connection: (1) Methods of ionospheric research with particular reference to recently developed automatic multifrequency technique and its application to geophysical problems; (2) the strategic distribution of stations over the Earth with a view to more comprehensive understanding of upper atmospheric ionization; (3) discussion concerning the dissemination of ionospheric data, particularly as related to maximum ionisation (or critical penetration-frequencies) and lowest virtual heights of the several ionospheric regions.

More earth-current data are desirable as an aid to the study of such phenomena as (a) magnetic variations and (b) deep structure of the Earth's crust. Our Association would do well to consider the most helpful distribution of stations recording earth-currents which would appear to be (a) near 20° magnetic latitude, (b) at magnetic latitudes greater than 55°, and (c) on small islands surrounded by an expanse of deep sea.

Atmospheric-electric problems awaiting more extensive programs include: (1) Those which may be furthered by the acquisition of additional definite data regarding the electric state of the troposphere and the stratosphere; (2) that of obtaining further information regarding the electric state of the air at sea during fair weather and during stormy weather; (3) those relating to variations in electrical conductivity and potential gradient of the atmosphere from year to year. The problems under (3) suggest the possibility of some universal agency and indicate the desirability of adding atmospheric-electric schedules at observatories not now engaged in such work and the continuance of these observations at observatories now doing such work, since only relatively long series of observations from properly situated stations can be used effectively in this problem.

A subject which needs consideration is that of the definition and adoption of symbols pertaining to geomagnetic coordinates, magnetic coordinates, and geomagnetic time. The differences of conception among investigators has resulted in considerable uncertainty in reading and in referring to published papers. Adoption of uniform symbols and definitions will eliminate these and will make for clarity on the part of those working in associated and correlated fields, for example, cosmic radiation.

Among recommendations which were considered but not definitely acted upon at the meeting of the International Commission at Warsaw was one that there be prepared as soon as possible a revised edition of Fritz's chart of isochasms utilising auroral data accumulated since the original publication of that chart in 1881. Such a revised chart may prove useful in developing better understanding of ionospheric relations to terrestrial magnetism and electricity.

A distinct step forward in the unification of researches in Earth physics is that taken by the International Union of Geodesy and Geophysics in the appointment for this Assembly of a Commission for the Study of the Earth's Crust. The proposed joint meetings or round-table conferences of our several associations to discuss points of contact of their activities must be advantageous and of profit to general advance in mutual understanding and appreciation of related problems. Our Association doubtless can contribute helpfully in these conferences through communications relating to the long-period and short-period phenomena of terrestrial magnetism and electricity which apparently have bearing upon crustal conditions.

In conclusion, we may say that noted progress has been made in our fields during the past three years. Let us hope that the ever-widening prospect presented may in coming years furnish ample incentive to achieve increased understanding and interpretation of the many experimental data Nature so prolifically gives us the opportunity of observing.

Washington, D. C., July 31, 1936.

RAPPORT DU SECRÉTAIRE ET DIRECTEUR DU BUREAU CENTRAL POUR LA PÉRIODE 1933-36

Siège du Secrétariat

Depuis l'Assemblée de Lisbonne le Bureau Central de l'Association a été établi à Copenhague à l'Institut Météorologique de Danemark, où se trouvaient déjà le Bureau de la Commission Internationale de l'Année Polaire 1932-1933 et le Secrétariat de la Commission Internationale de Magnétisme terrestre et d'Electricité atmosphérique; la réunion de ces affaires internationales dans un seul endroit a beaucoup facilité le travail pendant la période en question.

Finances

Conformément aux instructions données par l'Union, le Bureau Central a dressé et envoyé au Secrétaire Général de l'Union un relevé des recettes et dépenses de l'Association pendant la période du 1er avril 1933 au 31 décembre 1935 (voir page 38). — Par suite de l'incertitude financière, soulignée par l'Union à l'Assemblée de Lisbonne, on a eu soin de ne disposer que des fonds liquides, tout en espérant de recevoir des crédits nouveaux de la part de l'Union. Il est évident qu'il y aura toujours des dépenses obligatoires et bien qu'il faut éviter autant que possible des dépenses continues de cette catégorie, le Secrétaire considère qu'il serait un grand avantage si les Statuts de l'Union assurent à chaque Association une certaine somme fixe des recettes de l'Union; un tel procédé lui semble nécessaire pour que notre Association puisse établir son programme de travail à longue échéance, et quelles que soient les facilités rendues de la part des institutions et des personnalités intéressées il faut que l'Association ait les crédits indispensables pour pouvoir assurer, le cas échéant, les fonctionnements fondamentaux de la coopération internationale.

Les finances de l'Association ont été administrées conformément aux directives données à l'Assemblée de Lisbonne par le Comité Exécutif, et, avec l'approbation du Président, les fonds ont été convertis en livres sterling et gardés en dépôt sans intérêts.

Voici quelques remarques relatives aux dépenses budgétées pour la période 1933-1936: Il n'a fallu que la moitié de la somme prévue pour l'impression des Comptes-Rendus de Lisbonne; les dépenses de bureau ont été considérablement réduites grâce à l'appui de l'Institut Météorologique de Danemark; on a versé, comme prévu, aux recherches sur l'effet de la Lune et à la publication de l'activité magnétique numérique respectivement 100 livres sterling par an; d'autre part, les crédits accordés par le Comité Exécutif pour procurer et discuter les résultats de l'Année Polaire (125.000 francs français) sont encore loin d'être épuisés.

Le Secrétaire profite de l'occasion pour attirer l'attention sur le papier millimètré que le Bureau Central a fait faire pour servir à l'étude des observations de l'Année Polaire. Ce papier est en vente à prix de revient, à l'échelle de un ou de deux millimètres, en rouge ou en bleu, avec texte français ou anglais ou bien sans texte.

En 1935 le Comité Exécutif a consenti une nouvelle dépense pour l'acquisition de 3 Q. H. M.

Correspondance

Pendant la période depuis l'Assemblée de Lisbonne jusqu'au 1er septembre 1936, le Bureau Central a reçu 374 lettres et en a expédié 430 dont plusieurs lettres circulaires. Par l'intermédiaire du Ministère des Affaires Etrangères du Danemark, le Bureau a communiqué à divers Gouvernements les résolutions et les vœux que l'Association avait formulé à leur sujet.

Activité du Bureau Central

En décembre 1933 a paru le «Rapport Préliminaire de l'Assemblée de Lisbonne» contenant les procès-verbaux, les résolutions, etc. (20 pp.). Ce rapport fait partie du rapport définitif, les «Comptes-Rendus de l'Assemblée» qui ont paru en juin 1934 comme le Bulletin No. 9 de l'Association (354 pp.). L'ancien secrétaire de l'Association, M. Maurain, a bien voulu entreprendre la première rédaction de ce rapport. Dans ce bulletin ont été suivis quelques principes nouveaux: sans exception les articles n'ont été imprimés que dans *une* langue laissant aux auteurs le choix de cette langue; les articles déjà imprimés ou les articles qui seraient imprimés ailleurs, n'ont pas été insérés, mais on en a donné soit un résumé soit le titre seul. La liste d'adresses a été supprimée, d'une part parce que la plupart des magnéticiens dont le nom et l'adresse seraient donnés, sont déjà indiqués dans la publication courante No. 5 de l'Organisation Météorologique Internationale, de l'autre parce qu'une telle liste, qui est très difficile à limiter et qui vieillit très vite, nous semble peu satisfaisante si elle n'est pas à jour: une liste de ce genre nous semble à sa place non pas dans un livre, mais dans un périodique. Ensuite, il a été jugé utile de reprendre l'exemple du premier Secrétaire de l'Association, le regretté Docteur Bauer, d'indiquer dans le rapport les prix des diverses publications de l'Association — car, bien que les publications soient distribuées gratuitement aux intéressés et à titre de propagande, elles présentent une certaine valeur commerciale.

La distribution rationnelle des Comptes Rendus de l'Assemblée de Lisbonne a rencontré des difficultés considérables. Le Secrétaire est d'avis que la distribution des publications ne pourra se faire d'une manière satisfaisante que dans les pays où les Comités Nationaux prêtent leur collaboration effective et, pour mettre en lumière les difficultés actuelles, le Secrétaire pense utile de relever que des 37 Comités Nationaux auxquels le Bureau Central s'est adressé au sujet de la distribution des Comptes-Rendus, 23 seulement ont répondu à la première lettre et 7 autres à la seconde lettre à ce sujet. De plus, les réponses ont évidemment été établies sur des principes bien différents: quelques pays ont demandé un nombre d'exemplaires extrêmement modeste, tandis que d'autres pays paraissent en avoir réclamé un nombre plus élevé que celui de leurs institutions et des personnes travaillant dans le domaine des recherches de l'Association.

Dans sa réunion de Lisbonne, le Comité Exécutif a décidé d'assister la Commission Internationale de l'Année Polaire 1932-1933 dans ses efforts pour faciliter les études et les discussions des nombreuses observations et des enregistrements de l'Année Polaire. Faisant suite à cette décision, le Bureau Central de l'Association a créé des archives de photographies sur films normaux, prises à l'aide du caméra Leica. Ces archives contiennent surtout des enregistrements magnétiques de cette période et des mesures et discussions inédites, mais de grand intérêt pour quelques chercheurs; jusqu'ici ont été obtenues des copies de 39 observatoires, mais il convient d'ajouter que ces reproductions ne sont pas toutes complètes. (Pour plus d'informations, voir pp. 417-421).

La collection actuelle s'est déjà montrée très utile en permettant aux chercheurs d'y puiser des copies des enregistrements qu'ils désireraient pour leurs recherches. Ces archives qui n'occupent que peu de place et qui sont par suite faciles à transporter à un autre lieu, représentent déjà une collection unique, de grande valeur pour l'étude approfondie des nombreux enregistrements faits avec tant d'efforts et à tant de frais. Sur la recommandation de la Commission Internationale de l'Année Polaire, on s'occupe pour le moment d'établir un dépôt des copies photographiques aussi en Amérique, au siège du Département Magnétique de l'Institution Carnegie à Washington.

Convaincu, à maintes reprises, de la nécessité pour les experts de connaître les détails des enregistrements faits simultanément à plusieurs stations, le Secrétaire conseille de poursuivre autant que possible la reproduction de tous les enregistrements faits, avec l'indication de l'interprétation, et recommande vivement à l'Association de prier les administrations des observatoires d'y collaborer, soit en prêtant au Bureau Central de l'Association leurs enregistrements originaux, pourvus de données de réduction, soit en reproduisant eux-mêmes sur films leurs enregistrements conformément aux modèles et aux indications dudit Bureau.

Depuis l'institution de la Section de Magnétisme et Electricité Terrestres, la question de comparer entre elles les mesures des divers observatoires a joué un rôle important. Comme tout le monde sait, le Département de Magnétisme de l'Institution Carnegie à Washington et avant tous les deux chefs de ce Département, l'ancien directeur Dr. Bauer et notre honoré Président, ont rendu des services admirables pour établir sur toute la terre des mesures comparables. Malgré cela, il reste encore à pouvoir faire des mesures de contrôles. Grâce à un petit appareil nouveau, le Q. H. M., l'Institut Météorologique de Danemark a pu faire quelques essais à cette fin, en envoyant cet appareil par la poste. Le Comité Exécutif a décidé de prendre part à ces essais et le Bureau Central a organisé quelques mesures avec les trois Q. H. M. appartenant à l'Association.

Quant aux autres aspects de l'activité manifestée, il faut mentionner que le Bureau Central a servi en plusieurs cas comme un bureau de conseils ou d'informations soit au sujet des instruments soit pour d'autres questions techniques (par exemple, sur les méthodes de réduction, etc.).

Ensuite, le Bureau Central a profité de la réunion de la Commission Internationale de Magnétisme terrestre et d'Electricité atmosphérique à Varsovie (septembre 1935) pour faire de la propagande pour les archives photographiques des enregistrements magnétiques. Le Bureau a aussi fait de son mieux pour réaliser la coopération entre la Commission et l'Association sur diverses questions, proposées à cette occasion par la Commission et mises à l'ordre du jour de l'Assemblée d'Edimbourg.

FINANCES

Report of Director of the Central Bureau of the Association for the period April 1933 — December 1935

RECETTES	*Francs suisses*
L'Actif du Bureau Central au 1er Avril 1933	25.580.71
Reçu du Secrétariat Général d'Avril 1933 jusqu'au Décembre 1935	36.730.26
Vente de copies photographiques, etc.	222.84
	62.533.81

PAIEMENTS	*Francs suisses*
Impression des Comptes-Rendus de l'Assemblée de Lisbonne, etc.	3.916.07
Pour la publication du caractère magnétique numérique des jours 1933-35	3.040.00
Pour les recherches systématiques de l'effet de la lune sur le magnétisme terrestre	4.560.00
Dépenses relatives aux traitements des observations de l'Année Polaire	6.406.87
Dépenses relatives aux appareils magnétiques pour comparaisons internationales	988.00
Dépenses relatives à l'équipement pour reproductions photographiques des documentations	809.67
Autres dépenses (dépenses de bureau, de port, etc.)	799.35
Perte au cours	394.04
Actif au 31 Décembre 1935	41.619.81
	62.533.81

RAPPORT DE LA COMMISSION DES FINANCES

La Commission a le plaisir de rapporter qu'elle a trouvé entièrement en règle l'administration du Secrétaire de l'Association et Directeur du Bureau Central; elle lui exprime son hommage pour son administration excellente.

Au 8 septembre 1936 *l'actif* se montait à £ 2711-1-9 et couronnes danoises 840.21.

Les *recettes* se composent des sommes reçues de M. Maurain, le précédent Secrétaire de l'Association équivalentes à £ 2381-4-11½ et des sommes reçues du Secrétariat Général de l'Union en total 30318.00 frcs. suisses; ensuite de quelques petites sommes pour la vente de copies photographiques etc.

Parmi les *paiements* on peut citer: pour la publication du caractère magnétique numérique des jours £ 300.-, pour les recherches systématiques de l'effet de la lune sur le magnétisme terrestre £ 300.-, pour l'impression des Comptes-Rendus de l'Assemblée de 1933 à Lisbonne etc. couronnes danoises 5771.05, puis un montant considérable pour: traitement des observations de l'Année Polaire, instruments magnétiques pour des comparaisons internationales, installation pour des reproductions photographiques, dépenses de bureau, etc.

Edimbourg, le 22 *septembre* 1936.

J. KERÄNEN. G. van DIJK.
H. D. HARRADON.

SUMMARY OF MINUTES OF THE EXECUTIVE COMMITTEE

Sessions of September 14, 15, *and* 16, 1936

The Executive Committee held two informal meetings and one regular session before the first plenary session of the Association. During those meetings estimates for the budget 1936-39 were made in order to be able to advise the General Secretary of the Union of the needs of the Association; the time-table for all the sessions of the Association and also the new statutes and the election of officers of the Association for the coming three years were discussed. It was agreed with regard to publication of the transactions of the Edinburgh Assembly of the Association that Dr. Bartels, Eberswalde, should be called upon as a referee regarding questions of complete publication of any paper, and that the articles should be published in one language only, this language being one using ordinary Latin fonts; matters pertaining to charts of the distribution of aurorae were referred to the Auroral Committee.

Members of the Executive Committee present were: Dr. Fleming, Colonel Agostinho, Prof. Chapman, Dr. la Cour, and Dr. Crichton Mitchell.

Sessions of September 25 *and* 26, 1936

Members of both the old and the new Executive Committee assisted at these meetings as far as they were present in Edinburgh, viz. Dr. Fleming, Prof. Chapman, Dr. la Cour, Dr. Crichton Mitchell, Dr. Goldie, Prof. Keränen and Prof. Maurain.

Two sessions were held on September 25. The following decisions were taken:

As after the final meeting of the Association Dr. la Cour was elected President of the Union, Dr. A. H. R. Goldie, Edinburgh, was appointed Secretary and Director of the Central Bureau of the Association for the forth-coming period.

Prof. Tanakadate and Prof. Keränen were chosen by lot to hold office as members of the Executive Committee for one period only.

In accordance with the actions taken by the Association, September 19, 21 (morning session) and 22 (morning session) the Executive Committee appointed the following Committees:

Committee to organize the registration in Iceland for the investigation of Giant Pulsations with power to add members (Committee No. 7, p. 458).

Committee on methods of observatory-publication (Committee No. 8, p. 458); — it was understood that Dr. Bartels should act as Dr. Fleming's proxy, and the committee is to collect and digest the opinion of those concerned in publications of magnetic results.

Committee on classification of magnetic literature (Committee No. 9, p. 458).

Committee to promote international comparisons of magnetic standards (Committee No. 10, p. 458); — this committee is to report from time to time to the Executive Committee.

In accordance with Resolutions adopted by the Association and following previous decisions the following allotments were recorded for the period 1936-1939:

		£
Res. 1:	Department of Terrestrial Magnetism, Carnegie Institution of Washington, should proceed and carry this matter through; — expenditures were approved at	200
Polar Year work:	Out of the £ 1200 left from the allotment made at Lisbon, be allotted to the realization through Dr. van Dijk of Res. 4:	125
	and be immediately set aside for current minor expenses at the discretion of the President of the International Polar Year Commission:	100
		425

(Continued):	425
Res. 5: For purchase of 12 QHM and other expenses involved:	300
Res. 8: For necessary assistance to carry out photographic work for centralization of magnetograms:	450
Res. 16: To the investigation in Iceland of Giant Pulsations:	400
Publication of numerical character numbers during the next three years:	300
Preparation of magnetic character numbers for the years before 1906 — (it was agreed that the numbers before the year 1906 were to be published as regards annual means in the *Journal of Terrestrial Magnetism* and the daily values to be manifolded in some convenient way):	100
Lunar work: For continuation of the lunar investigations by Prof. Chapman:	300
Publication of Transactions of Edinburgh Assembly:	400
Total	£ 2675

It was further agreed that one session of the Washington Meeting 1939 should be devoted to detailed discussion of one or two selected subjects. A leader is to be designated and notification is to be given one year on beforehand.

Messrs. Fleming, Crichton Mitchell, and la Cour having been authorized by the Executive Committee to approve the minutes of the last meeting of the Association, these were read during an informal meeting September 26, and were adopted with minor corrections.

PART II

STATUTES

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

I. — *Objets de l'Association*

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*

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*

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.

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*

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

L'Association aura un Comité Exécutif qui comprendra le Président, les deux Vice-Présidents, le Secrétaire, et cinq membres de plus, tous élus par l'assemblée générale de l'Association.

Chacun des membres du Comité Exécutif demeurera en fonctions jusqu'au 1er janvier de l'an qui suit celui de l'élection de son successeur. L'intervalle entre deux dates successives de transfert des pouvoirs, sera appelé, pour les buts de ces statuts, une période. Sauf disposition contraire, personne ne sera rééligible avant l'expiration d'une période après la cessation de ces fonctions.

Le Président restera en fonctions pour une période et les Vice-Présidents pour deux périodes. Le Secrétaire se retirera après une période mais il peut être réélu pourvu que son administration continue ne dépasse pas trois périodes. Les cinq membres additionnels du Comité Exécutif resteront en fonctions pendant deux périodes.

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.

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.

Les Vice-Présidents, ou l'un ou l'autre, conformément à la disposition du Comité Exécutif, présideront les assemblées générales en l'absence du Président.

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 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.

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.

Si, pour un motif qui semblerait bon et suffisant, le Comité Exécutif le 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*

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

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.

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.

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.

L'ordre du jour d'une assemblée générale sera préparé par le Secrétaire et communiqué aux membres de l'assemblée générale au moins quatre 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*

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.

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*

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

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*

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*

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*

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.

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*

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

The Executive Committee of the Association shall consist of the President, the two Vice-Presidents, the Secretary, and five additional members, all being elected by the general assembly of the Association.

Each member of the Executive Committee shall hold office until January 1 of the year immediately following that in which his successor in office has been elected. The interval elapsing between two successive dates of transfer of offices shall, for the purposes of these Statutes, be termed a period. Except where otherwise provided, no person shall be eligible for the same office before the expiry of one period after his demitting such office.

The President shall hold office for one period, and the Vice-Presidents for two periods. The Secretary shall hold office for one period but shall be eligible for reelection, provided that any continuous tenure of office shall not exceed three periods. The five additional members of the Executive Committee shall hold office for two periods.

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.

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.

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.

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 for examination and audit 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.

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.

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*

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.

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.

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.

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.

The agenda of a general assembly shall be prepared by the Secretary and circulated to members of the general assembly not less than four 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*

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.

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*

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

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

AUSTRALIA

REPORT ON RESEARCHES IN ATMOSPHERIC ELECTRICITY DURING 1933-1936

By D. F. MARTYN

(1) *Commonwealth Solar Observatory.*

Researches on this subject are being continuously pursued at the observatory. The results of recent work have been published in the following papers:

Atmospheric Electric Observations, by A. R. Hogg, *Gerl. Beit. z. Geophys.*, 41, 4, p. 1 (1934).

Average Life of Small Ions and Atmospheric Ionisation Equilibria, by A. R. Hogg, *ibid.*, 41, 1, p. 32 (1934).

Continuous Observations of the Rate of Production of Small Ions in the Atmosphere, by A. R. Hogg, *ibid.*, 43, p. 359 (1935).

The observatory has also collaborated with the Commonwealth Radio Research Board in investigations of atmospherics, and in the examination of the ionosphere. This work is being carried out by Mr. Higgs, and is further referred to below. It is anticipated that automatic apparatus for measuring the electronic densities in the ionosphere, similar to that now in regular operation in Sydney, will shortly be installed in the observatory.

(2) *Commonwealth Radio Research Board.*

The Board's investigations of the ionosphere are being carried out in Sydney, under the direction of Prof. J. P. V. Madsen. During the period under review several investigations of the structure of the ionosphere have been made. These have led to a number of conclusions concerning the constituents and physical state of the upper atmosphere. In particular, it is found that the temperature of the F-region of the ionosphere is normally very high, and of the order 1000° K. The temperature of the E-region is found to be much lower, of the order 300° K. Evidence is found of a temperature maximum at a height of about 60 kms. The existence of such temperature inversions in the upper atmosphere, together with their diurnal and seasonal changes, must be expected to play an important part in determining the character of the corresponding changes in the external part of the earth's magnetic field. Since May 1936, an automatic apparatus has been in regular operation, recording at half-hourly intervals the electronic densities in the various regions of the ionosphere. It is anticipated that two similar equipments will be installed at Canberra and Melbourne early in 1937. The results of investigations carried out during the period are published in the following papers:

The Temperatures and Constituents of the Upper Atmosphere, by D. F. Martyn and O. O. Pulley, *Proc. Roy. Soc.,* A 154, p. 455 (1936).

The Propagation of Medium Radio Waves in the Ionosphere, by D. F. Martyn, *Proc. Phys. Soc.,* 47, p. 323 (1935).

Interaction of Radio Waves, by V. A. Bailey and D. F. Martyn, *Nature,* 135, p. 585 (1935).

Long Distance Observations of Radio Waves of Medium Frequencies, by D. F. Martyn, R. O. Cherry, and A. L. Green, *Proc. Phys. Soc.,* 47, p. 340 (1935).

Radio Studies of the Ionosphere, by D. F. Martyn and A. L. Green, *Nature,* 132, p. 523 (1933).

The Board's investigations of atmospherics are still being carried out in the Natural Philosophy Department, University of Melbourne, under the direction of Prof. T. H. Laby. During the period an expedition was sent to Toowoomba in Queensland, for the purpose of studying more intensively the locations of the main sources of atmospherics in Australia. As a result of this investigation a map has been prepared showing the summer distribution of the main sources of atmospherics near Eastern Australia. It has been found that the average power radiated by a lightning flash in a particular waveband is comparatively constant. It is found that a large percentage of the observed sources of atmospherics appear to be thunderstorm groups of the frontal type.

The results of this work are published in a paper by G. H. Munro, H. C. Webster, and A. J. Higgs, *Bulletin* 89 of the Commonwealth Council for Scientific and Industrial Research, Melbourne, 1935.

AZORES

RAPPORT SUR L'ACTIVITÉ DU SERVICE MÉTÉOROLOGIQUE DES AÇORES DANS LE DOMAINE DE MAGNÉTISME TERRESTRE DEPUIS OCTOBRE 1933

Par J. AGOSTINHO

Observatoire Magnétique de San Miguel, près Ponta Delgada. Enregistrements continuels des éléments magnétiques ont été assurés par les enregistreurs Mascart et la Cour (modèle rapide). Pour des raisons d'économie les enregistrements de H et de Z ont dû être interrompus pendant quelque temps, mais leur continuation est maintenant assurée. Les valeurs horaires de D ont été dépouillées et les moyennes horaires mensuelles seront publiées.

Caractère magnétique numérique des jours. La calculation du caractère magnétique numérique des jours est maintenant assurée. Les valeurs pour l'Année Polaire seront communiquées pour publication à la Commission Internationale de l'Année Polaire.

Station Magnétique à Angra do Heroismo (Ile Terceira). On a profité du nouveau site pour la construction de l'Observatoire Météorologique et Géophysique à Angra do Heroismo pour y établir une station magnétique où les valeurs moyennes de D sont obtenues chaque jour par des lectures directes d'un déclinomètre Mascart et des mesures absolues avec un théodolite Brunner. Les perturbations locales ne semblent être si fortes qu'à Ponta Delgada, en raison de la constitution du sol. En comparant les valeurs de D à Ponta Delgada et à Angra, on cherche à voir jusqu'à quel point les perturbations locales auront influence sur la variation journalière et séculaire de D telle qu'elle est obtenue aux Açores.

Par une coïncidence assez curieuse la différence notée jusqu'à présent entre les valeurs de D aux piliers centraux à Ponta Delgada et à Angra est de 45′ et répond à la différence qui aurait été due à la situation géographique seulement, c. à. d., si nulle perturbation locale n'existait. Cette perturbation fait qu'à Ponta Delgada et à Angra les mesures de D faites sur les piliers centraux, sont inférieurs de 1° 48′ à la déclinaison montrée sur les cartes de l'Océan Atlantique.

Stations de répétition. — On dispose d'un bon nombre de stations de répétition aux Açores. Elles sont constituées par des piliers en calcaire où des mesures absolues des éléments magnétiques sont faites de temps en temps. Le service dispose aussi de stations de répétition à Madeira.

Année Polaire 1932-33. — Les valeurs horaires de D pour tous les jours de l'Année Polaire ont été dépouillées. Le caractère magnétique des jours dans l'échelle 0-1-2 a déjà été publié et le caractère magnétique numérique est prêt pour la publication. Les valeurs mensuelles moyennes de D et les moyennes des mesures absolues de H et I pour 1932 ont été publiées dans notre Résumé d'Observations pour 1932. Le Résumé pour 1933 est sous presse.

Il est intéressant de signaler que nous avons installé à Angra un atmoradiographe Lugeon, ce qui nous apportera des données pour la connaissance des conditions dans l'ionosphère. L'instrument enregistre les parasites sur onde de 27 kcy (11000 mètres).

Nous envisageons la possibilité d'étudier les courants telluriques à Terceira, sitôt que nous aurons les moyens d'acquérir les instruments nécessaires.

Des mesures de l'ozone seront aussi faites lorsque des instruments soient obtenus.

Angra do Heroismo, Açores, Août 1936.

DENMARK

RAPPORT SUR LES TRAVAUX MAGNÉTIQUES DU DANEMARK 1933-36

Par D. LA COUR

L'Observatoire Magnétique de Copenhague (Rude Skov) a continué régulièrement et sans interruptions les enregistrements à déroulement ordinaire à l'aide de deux jeux de variomètres différents et les enregistrements à marche rapide à l'aide d'un troisième jeu de variomètres. Les déterminations des valeurs absolues des lignes de base et d'échelle ont été continuées comme auparavant.

L'électrification du chemin de fer passant dans le voisinage de l'Observatoire situé dans la forêt de Rude (Rude Skov), a été mise en vigueur depuis le printemps 1936. L'effet de l'électrification s'est montré d'une autre manière et d'une intensité beaucoup plus petite qu'il n'avait été attendu. Une note à ce sujet sera présentée à l'Assemblée d'Edimbourg par D. la Cour et E. Hoge.

Les valeurs déduites des enregistrements faits à l'Observatoire de Copenhague ont été publiées par l'Institut Météorologique de Danemark dans son *Annuaire Magnétique, 1ère Partie: Le Danemark (excepté le Groenland).* Les annuaires de 1932-1933 qui contiennent les observations de l'Année Polaire ont été rédigés selon les recommandations faites par la Commission Internationale de l'Année Polaire, en prenant comme modèle "The Observatories' Year Book" publié par le Meteorological Office, Londres. Cette nouvelle composition des matières a été retenue dans l'annuaire de 1934.

Les enregistrements faits à Rude Skov ont été mis à la disposition du Bureau Central de l'Association pour être photographiés sur films pour les archives de celle-ci. L'annuaire de 1935 paraîtra environ au commencement de 1937.

L'Observatoire de Copenhague a également continué de servir de station de base pour l'Observatoire Magnétique de Godhavn pour ce qui concerne les provisions d'instruments et d'accessoires, et à plusieurs reprises ont été faites des comparaisons mutuelles des déterminations des forces horizontales et verticales à l'aide des instruments QHM et BM envoyés de Copenhague au Groenland et vice versa.

De plus, l'Observatoire a continué d'assister des personnes et des institutions étrangères en construisant et en procurant divers instruments pour leurs recherches du magnétisme terrestre. Ainsi l'Observatoire a aussi aidé la Commission Internationale de l'Année Polaire avec le rajustement des instruments magnétiques qui ont été remaniés après leur emploi aux diverses stations pendant l'Année Polaire. Parmi les instruments procurés pour l'étranger seront mentionnés outre les variomètres et les enregistreurs à marche normale et à marche rapide du type ordinaire de l'Observatoire, les instruments QHM et BM destinés à la comparaison des déterminations des valeurs absolues et au contrôle des variomètres pour la déclinaison, la force horizontale et la force verticale, les déclinomètres à grande sensibilité (et à valeur d'échelle négative) à être employés surtout dans les latitudes basses, et enfin le HZ intensiomètre électrique pour la détermination directe des deux composantes de la force magnétique. Pour pouvoir ajuster des divers instruments dans d'autres champs verticaux que celui de l'Observatoire de Copenhague une bobine Helmholtz-Gaugain ayant un diamètre de 2 m, a été construite. Cette bobine permet de changer le champ avec une précision considérable jusqu'à 100000γ env.

Au cours des dernières années l'Observatoire a assisté à procurer pour l'étranger les instruments suivants: déclinomètres 65, variomètres pour H 65, variomètres pour Z 73, enregistreurs à marche ordinaire (15 mm/h) 28, enregistreurs à marche rapide (180 mm/h) 43, HZ intensiomètres électriques 2, BM (Balances Magnétométriques) 6 et QHM (Quartz-H-Magnétomètres) 7. Ce dernier instrument et sa fonction a été décrit dans les *Communications Magnétiques, etc.* Nos. 15 et 16, intitulées respectivement: «Le quartz-magnétomètre QHM» par D. la Cour et «Exemple d'emploi du QHM pour le contrôle des variomètres pour la déclinaison et pour la force horizontale» par D. la Cour et E. Sucksdorff.

Les erreurs systématiques originaires des inclinaisons de l'axe magnétique et de l'axe de rotation d'une balance magnétique ont été étudiées par M. Johs. Olsen *(Journal of Terrestrial Magnetism and Electricity*, 1934, pp. 173-186 et *Communications Magnétiques, etc.* No. 14) et le comportement des variomètres pour la force verticale et pour la force horizontale dans les régions arctiques a été élucidé dans le No. 17 des *Communications Magnétiques etc.,* intitulé «Contribution à la connaissance du comportement des variomètres modernes, expériences obtenues à l'Observatoire Magnétique de Godhavn» par D. la Cour et Johs. Olsen.

M. J. Egedal a continué ses travaux pour améliorer les mesures de l'inclinaison à l'aide de l'inducteur Edelmann. En remplaçant les parties magnétiques de l'inducteur, en employant des couches d'agate et en rajustant l'appareil de toutes les manières possibles, l'erreur moyenne d'une détermination de l'inclinaison à Copenhague a été réduite à $\pm$ 0.'06.

Pendant les hivers de 1934-35 et 1935-36 et en collaboration avec l'Observatoire de Sodankylä a été établie une station temporaire à Vuotso située à 83 km env. au nord de Sodankylä. La station de Vuotso a été munie d'un enregistreur à marche rapide, et des observations et des photographies des aurores boréales y ont aussi été effectuées. Cette station temporaire a été établie en première ligne dans l'intention de rassembler des informations sur les perturbations magnétiques locales aux régions arctiques dans le but d'élucider les conditions pour des recherches rationnelles des perturbations magnétiques de ces régions. Il s'est montré que de temps à temps il y a des différences assez grandes entre les enregistrements de deux stations séparées de 83 km seulement, et les oscillations les plus courtes entre celles enregistrées, sont le plus souvent tout-à-fait différentes à ces deux stations. Nous désirons exprimer ici notre gratitude sincère pour la collaboration agréable assurée par la direction de l'Observatoire de Sodankylä et par le directeur de celui-ci M. E. Sucksdorff.

L'Observatoire Magnétique de Godhavn a continué les enregistrements par trois magnétographes dont les deux à déroulement de 15 mm/h tandis que le troisième a enregistré continuellement à 180 mm/h pendant toute la période.

Les déterminations de la valeur de la force verticale à Godhavn ont été comparées à celles de l'Observatoire de Copenhague par une comparaison effectuée après l'Année Polaire à l'aide du HZ intensiomètre sur le voyage de retour de la station de Thule. Il s'est montré que l'étalon d'induction mutuelle utilisé dans l'intensiomètre n'avait pas resté constant; cet étalon fait en marbre imperméabilisé, ayant augmenté de 0.17 $^0/_{00}$ par an, on a remplacé l'étalon de marbre par un étalon de porcelaine qui semble beaucoup plus constant. Une comparaison récente a montré que la variation de l'étalon au cours des années a été régulière, ce qui a permis de réduire toute la série des enregistrements d'une manière satisfaisante.

Les déterminations de la force horizontale à Godhavn ont été comparées à diverses reprises à l'aide d'un QHM qui a été envoyé plusieurs fois au Groenland et retour à Copenhague. Le contrôle ainsi effectué a donné des résultats tout-à-fait satisfaisants (voir par ex. *Communications Magnétiques, etc.* No. 15, p. 21 et No. 17, p. 13).

Les enregistrements jusqu'à 1936 ont été mesurés à Godhavn. La seconde mesure et les réductions définitives jusqu'à 1934 ont été effectuées à Copenhague. Pourtant, jusqu'à présent seuls les résultats de 1932 et 1933, renfermant ceux de l'Année Polaire, ont été imprimés. Autres résultats, parmi lesquels des tableaux de l'activité horaire du 1. janvier 1927 au 31 décembre 1928 et du 1. août 1932 au 31 août 1933 et les enregistrements faits pendant l'Année Polaire, ont été photographiés sur films pour les archives de l'Association.

Les enregistrements faits pendant l'Année Polaire à Thule situé à la côte nord-ouest du Groenland et près de l'axe magnétique du Globe, ont été mesurés et réduits. Les résultats de cette station ne sont pas encore imprimés, mais les tableaux définitifs des valeurs horaires des éléments et de l'activité horaire ainsi que tous les enregistrements, ont été photographiés et se trouvent dans les archives de l'Association.

Les résultats des observations et des enregistrements faits pendant l'Année Polaire à Julianehaab, situé dans le Sud du Groenland, sont au même point que ceux obtenus à Thule. Les tableaux sont sous presse. Des photographies sur films des tableaux et des enregistrements se trouvent aussi dans les archives de l'Association où elles sont à la disposition des chercheurs.

La station de Julianehaab a continué à fonctionner un an après l'Année Polaire.

Un aperçu complet des observations et enregistrements faits pendant l'Année Polaire par les observatoires magnétiques danois à Copenhague (Rude Skov), Thule, Godhavn et Julianehaab, a été présenté au Bureau de la Commission Internationale de l'Année Polaire pour être inséré dans le Catalogue de la Commission sur les observations faites pendant l'Année Polaire.

FINLAND

PROGRESS OF WORK IN TERRESTRIAL MAGNETISM AND ELECTRICITY IN 1934-1936

By. J. KERÄNEN

Field Work. In the summer 1934 I have occupied the repeat stations in the southwestern archipelago of Finland. In the spring 1935 I made some magnetic measurements on the ice in the western part of Lake Laatokka. In the summer an expedition, consisting of Mr. E. Sucksdorff and myself, occupied 8 hills in Lapland, where watching stations for protection against forest-fires have been established, and 3 adjacent repeat stations.

In the current year 1936 in April I have surveyed on the ice a small district on the fairway in the vicinity of Hanko. After that the Meteorological Office and the Board of Navigation organized an expedition for magnetic measurements on the ice on the archipelago of the Gulf of Bothnia outside the town of Vaasa. The expedition worked under the leadership of Mr. V. Kääriäinen on the fairways and occupied 21 stations.

The Study of the Secular Variation. The observations on the repeat stations in the years 1932-1934 have been worked up. We have received valuable help in the form of reduction material from the authorities of the magnetic observatories of Lovö, Abisko, Slutzk (Pavlowsk), Petsamo and Sodankylä. While the repeat stations were occupied earlier in the year 1913, I could develop the general features of the secular variation during the period 1913.5-1933.5 in Finland. The distribution of this variation for the elements, declination ΔD, inclination ΔI and horizontal intensity ΔH can be represented by the equations:

$$1913.5\text{—}1933.3 \begin{cases} \Delta D = 170.'6 + 0.912\Delta\varphi - 3.961\Delta\lambda \\ \Delta I \ = 58.'07 + 1.156\Delta\varphi + 1.286\Delta\lambda \\ \Delta H = -826\gamma - 4.13\Delta\varphi - 16.21\Delta\lambda \end{cases}$$

$\Delta\varphi$ and $\Delta\lambda$ are the differences of the latitude φ and longitude λ

from the central point 64.°2 N, 23.°2 E. The observed secular change differs from the calculated value at each repeat station by ΔD $\pm 2.'3$, by ΔI $\pm 1.'6$ and by ΔH $\pm 16\gamma$ on an average. In this connection I have also reckoned the mean values of the secular variation from the earliest magnetic field observations in Finland, made in the years 1825, 1830, 1840 and 1847, up to the newest epoch, viz. 1933.5.

The result of my study of the secular variation is published in the paper: "Über die säkulare Variation der erdmagnetischen Kraft in Finnland"; Helsinki 1936.

The Magnetic Survey. I have written a monograph on the terrestrial earth-magnetic conditions in Finland in the new geographic manual of Finland *(Suomen Maantieteen käsikirja)* published by the Geographic Society of Finland. My paper is entitled "Maamagnetismi" and contains in three maps the lines of equal Declination, Inclination and Vertical Intensity on July 1, 1935. The whole magnetic observation material on land and sea will now be reduced to the epoch 1933.5, using the above mentioned results of the secular variation in Finland.

The Temporary Magnetic Observations. The observatory magnetic work is in the charge of the Academy of Science. Our small observatories are provided only with rapid-running magnetographs. The station Kajaani (64° 13′ N, 27° 46′ E) established in the Polar Year, has been in operation till June 1936. On the recommendation of the International Association of Terrestrial Magnetism and Electricity (Resolution 21, q at Lisbon) the Academy founded a magnetic station in the vicinity of Helsinki (60° 16′ N, 24° 58′ E) in January 1934. The station is still in operation. A magnetic station has been operated in 1935 from January to May and from September to April 1936 at Vuotso (68° 05′ N, 27° 06′ E). The expenses of the station have been divided between the Danish Meteorological Institute and the Finnish Academy of Science. During the winter and spring 1935 Dr. P. Th. Justesen from Denmark worked at Vuotso at his own expense and carried out an effective study of auroral phenomena.

Comparison of the Magnetic Standards. Our field instruments were compared with those of the Kungl. Sjökarteverket in Sweden in June 1934 at the repeat station of Signilskär.

In February 1936 I had the opportunity of making a comparison between the Finnish and Russian standards at Slutzk and later on in April at Sodankylä.

Results of Polar Year. The ordinary magnetic registration material, obtained during the Polar Year at Petsamo, has been worked up by Mr. M. Tommila and is now ready for printing and will appear in the course of the autumn in the Annals of the Finnish Academy of Science.

Helsinki, September 3, 1936.

REPORT REGARDING RESEARCH WORK AT THE GEOPHYSICAL OBSERVATORY SODANKYLÄ IN 1933-1936

By E. SUCKSDORFF

I. *Terrestrial Magnetism.*

The magnetic elements H, D and V have been continuously recorded with a Toepfer 20 mm/h recorder (since 1914) and a quick-run recorder, system La Cour (since December 1931). The absolute magnetic measurements are made with the magnetometer No. 101 and the earth inductor No. 104, both constructed by Schulze, Potsdam.

The magnetic results of the observatory, *Ergebnisse der Magnetischen Beobachtungen des Observatoriums zu Sodankylä*, No. 13 (for the year 1926) by H. Hyyryläinen, and Nos. 17-20 (1930-1933) by E. Sucksdorff, have been published.

In connection with the measurements, made by Dr. Johannes Olsen, Copenhagen, with two quartz-H-magnetometers (QHM) during magnetic disturbances, at Sodankylä in October 1935, was detected that the needles of the Toepfer D and H variometers do not lie accurately in their normal positions, in the direction of the magnetic lines and perpendicular towards them. This defect was investigated by Director la Cour and myself in April 1936 by means of a QHM; the results of the investigation are published in *Communications magnétiques, etc.*, No. 16 (Copenhague 1936). According to these results the elements H and D are to reckon according to the formulas:

$$H = H_0 + 10.34\, n_H + 0.465\, n_D - (t - 15^\circ) \quad \text{and}$$
$$D = D_0 + 1.114\, n_D - 0.849\, n_H,$$

where n_H and n_D mean the ordinates in mm, and t the temperature in centigrades.

In collaboration with the Danish Meteorological Institute a temporary magnetic and auroral station was established in

January 1935 at Vuotso, 84 km north of Sodankylä. This Station worked, under the leadership of a danish physician, Dr. P. Th. Justesen, till April 1935, and then again from September 1935 to April 1936 under Dr. K. Thiesen and S. Sarkkama. A preliminuary comparison of the quick-run records of Vuotso and Sodankylä shows that there in many cases are considerable differences between the curves of these two neighbouring stations during magnetic disturbances.

II. *Earth currents.*

The NS- and WE-components of the earth currents have been recorded continuously with a danish 15 mm/h normal and a 180 mm/h quick-run-recorder. The distance between the copper electrodes is 600 meters for both the components; there is also, for control, a second set of similar electrodes with respective 450 meters mutual distance. The electrodes are connected with sensitive galvanometers by Hartmann and Braun, Frankfurt a.M. The results until the year 1935 are under preparation for being published.

In the building for the earth current registrations there is set up also a quick-run-recorder (running since January 1934) for the induction currents. This apparatus consists of three great coils, in the vertical NS- and WE-planes and in the horizontal plane. These coils are connected with high-sensitive galvanometers, made by the Cambridge Instrument Co.

III. *Atmospheric electricity.*

A registration of the electrical potential gradient by means of a ionium-collector and a Benndorf quadrant-electrometer is running continuously since October 1932. Absolute determinations have been made with a Wulf electrometer.

IV. *Auroral observations.*

Some parallactic photographs have been taken during the winters 1934-1935 and 1935-1936. The number of these is rather scanty, because the last winters were very cloudy. Height measurements of quiet arcs by means of simple wooden quadrants have been continued from Sodankylä and some auxiliary stations. Visual observations of the aurora have been made every evening when possible.

Geophysical Observatory, Sodankylä.

September 5, 1936.

FRANCE

RAPPORT SUR LES TRAVAUX DE LA SECTION DE MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES DEPUIS LE CONGRÈS DE LISBONNE

Par le Secrétaire E. MATHIAS

1° Magnétisme Terrestre.

Travaux de l'Institut de Physique du Globe de Paris

Ch. Maurain — *Sur l'intervalle de temps entre les phénomènes solaires et les perturbations magnétiques terrestres.* — On peut faire cette étude de deux manières: I°) Examiner la correspondance entre un phénomène solaire déterminé et un phénomène terrestre déterminé (*méthode individuelle*); 2°) Faire des études d'ensemble portant sur des périodes assez longues en tenant compte de toutes les observations (*méthode statistique*). On emploie alors une caractérisation numérique de l'activité solaire et de l'agitation magnétique.

En 1926, la seconde méthode était préférable pour un travail étendu. Elle avait montré que l'activité solaire est maxima en moyenne 2,5 jours avant une perturbation magnétique, ce décalage étant d'ailleurs variable. Depuis, l'observation du Soleil s'étant étendue et perfectionnée, diverses publications nouvelles permettent d'appliquer la méthode individuelle aux années 1930-31-32. L'application de cette méthode au passage de taches, ou groupes de taches importants au méridien central du Soleil, et aussi à quelques phénomènes éruptifs redonne la moyenne de 60 heures ou 2,5 jours, et coïncide avec la moyenne déduite de l'étude statistique de 1926.

Ch. Maurain — annonce que le Nouvel Observatoire de Chambon-la-Forêt, destiné à remplacer celui du Val-Joyeux, est à peu près terminé. Un observateur, M. Gibault, y a emménagé en octobre 1935, et a pu ainsi se consacrer aux installations magnétiques. Après des essais préliminaires, les mesures régulières ont été commencées le 1er Janvier 1936. Des mesures sont continuées avec des appareils identiques au Val-Joyeux, où est resté comme observateur M. Charczenko. Les mesures seront faites ainsi en double pendant au moins une année, de manière à assurer le raccordement des deux séries d'observations. L'organisation du Nouvel Observatoire a entraîné diverses difficultés et un travail considérable mené à bonne fin surtout par M. Eblé et M. Gibault.

Ch. Maurain — a publié un fascicule intitulé «Magnétisme terrestre» et donnant un exposé et une étude critique de travaux récents relatifs au magnétisme terrestre. Après des généralités sur le champ magnétique terrestre, l'auteur passe en revue les variations séculaires, les variations périodiques, les variations accidentelles. Il examine les perturbations dues aux aurores polaires, aux courants telluriques et les théories relatives à ces perturbations.

Il termine enfin cette étude intéressante par la question, non encore résolue mais si importante, de la recherche de l'origine du champ magnétique terrestre (Lib. Hermann, 1935, 63 pages).

H. et Mme Labrouste — *Composante diurne et semi-diurne de la déclinaison et agitation magnétique.* — Cette étude porte sur les relations entre l'agitation magnétique et les variations d'amplitude et de phase que montrent les composantes diurne Φ et semi-diurne Φ^1, de la déclinaison. Les données utilisées sont les écarts horaires aux moyennes mensuelles de tous les jours et les écarts horaires relatifs aux 5 jours calmes de chaque mois.

Ce travail confirme les résultats obtenus antérieurement dans une autre étude où la comparaison directe des amplitudes respectives des composantes diurne et semi-diurne, jour par jour, avec l'état d'agitation avait montré l'indépendance de ces deux composantes. En outre, il met en évidence, à côté des variations d'amplitude généralement mieux étudiées, l'importance des variations de phases.

H. et Mme Labrouste — ont continué leurs travaux sur l'analyse des phénomènes périodiques par la méthode de H. Labrouste. Ils ont présenté au Congrès des Sociétés Savantes une communication *Sur la variation undécennale de la Déclinaison* et au Congrès de l'A.F.A.S. une *Comparaison entre les jours magnétiques calmes et l'ensemble au point de vue de la relation avec l'activité solaire.*

H. et Mme Labrouste — *Cycle undécennal en magnétisme terrestre, comparaison entre tous les jours et les jours calmes.*

Comparaison entre la méthode des moyennes et celles des combinaisons linéaires d'ordonnées en Physique du Globe.

Etude des composantes diurne et semi-diurne à l'aide de données horaires dans les phénomènes naturels.

Louis Eblé — *Observations magnétiques faites au Val-Joyeux pendant l'année 1932.* — J. Itié, élève de Moureaux qui, depuis la fondation de l'établissement en 1900, assurait les observations absolues, ainsi que les enregistrements et les calculs des moyennes, atteint par la limite d'âge, a quitté l'Observatoire le 31 décembre 1931. Il a été remplacé le 1er janvier 1932 par G. Gibault exercé depuis longtemps à l'usage des instruments magnétiques.

Un changement a été apporté à la forme de la publication: la définition de *l'écart diurne* a été changée. Chacun de ceux-ci est la somme des plus grands écarts de part et d'autre pris sur les marches diurnes moyennes mensuelles; auparavant, on faisait une exception pour la Déclinaison et l'on appelait ainsi la différence entre le maximum et le minimum moyens du mois, calculés en éliminant toutes les journées où la variation paraissait anormale. Maintenant, les écarts diurnes ont tous une définition identique.

L. Eblé — *Remarques sur l'agitation magnétique.* — L'auteur distingue dans les mouvements spontanés et en apparence désordonnés d'un aimant suspendu par son centre de gravité: la *perturbation* ou *orage magnétique* si les mouvements sont suffisamment amples, brusques et prolongés, *l'agitation magnétique* lorsqu'ils sont faibles. Il y a deux définitions, l'une empirique, l'autre numérique de l'agitation magnétique, que l'auteur compare et discute.

L. Eblé — a dirigé les Observations magnétiques à l'Observatoire du Val-Joyeux et donné aux *Comptes-Rendus* la *variation annuelle du champ magnétique terrestre.*

L. Eblé — a présenté au Congrès de l'A.F.A.S., qui s'est tenu au Maroc, une Note sur *les Mesures magnétiques dans l'Afrique du Nord.*

L. Eblé — a étudié la *variation annuelle du champ magnétique terrestre* d'après la série des observations au Val-Joyeux. Cette variation est très faible et, en général, mal connue. Grâce à la précision des observations au Val-Joyeux et au travail statistique effectué, l'auteur a pu préciser l'étude de la variation, et y mettre en évidence l'influence de la période undécennale de l'activité solaire.

L. Eblé — a dirigé comme d'ordinaire les Observations magnétiques à l'Observatoire du Val-Joyeux et publié dans les Annales de l'I.P.G. le mémoire qui en donne les résultats.

Ed. Salles — a publié une Note sur la *Variation diurne de la Composante horizontale du magnétisme terrestre dans l'Alaska.*

Melle Homery — *Le Magnétisme terrestre dans les Possessions françaises.* Après une douzaine d'années d'efforts dans les Colonies, Protectorats ou Mandats français, il a semblé utile à l'auteur de résumer les résultats acquis au point de vue magnétique en Algérie, Tunisie, Sahara, Maroc, Afrique Occidentale et Equatoriale françaises, à Madagascar, en Indo-Chine, dans nos possessions de l'Océanie, dans la Somalie française et en Syrie.

Melle Homery — *Déclinaison magnétique sur l'ensemble du Globe,* avec une Carte publiée avec la collaboration du Service Hydrographique de la Marine.

Mme Salles-Homery — *Première édition du Planisphère de la Déclinaison magnétique* établi d'après les documents rassemblés à l'I.P.G., imprimé par les soins du Service Hydrographique de la Marine, parue en 1934.

Mme Salles-Homery — a publié dans les Annales de Physique du Globe de la France d'Outre-Mer un exposé d'ensemble sur le Magnétisme terrestre dans nos Colonies. Elle a préparé de nouvelles mises à jour des Cartes magnétiques de France, du Planisphère de la Déclinaison et du Planisphère de l'Inclinaison.

E. Thellier — *Sur un magnétomètre insensible aux champs magnétiques troublés des grandes villes.*

Sur l'aimantation permanente des terres cuites. — Il s'agit d'une étude d'ensemble sur l'aimantation des argiles, en vue du Doctorat.

E. Thellier — a continué ses *Recherches sur l'aimantation des poteries et des roches* et a réalisé un appareil d'induction qui permet de faire, dans d'excellentes conditions, des mesures précises à Paris, malgré les perturbations constantes du champ magnétique produites par les courants industriels. Le principe et une description sommaire de l'instrument ont été donnés dans une Note.

E. Thellier — a continué ses travaux sur *l'aimantation des argiles et des briques* dans un mémoire, actuellement à l'impression.

E. Thellier — a publié une Note sur un *Appareil d'induction pour la mesure des faibles moments magnétiques.* — Beaucoup de roches et de terres cuites grossières (briques) ayant une aimantation très irrégulière, les mesures magnétométriques ne conviennent pas, et il est indispensable d'employer pour elles une méthode d'induction. L'appareil réalisé par l'auteur possède à un haut degré les 3 qualités indispensables: champ uniforme dans un grand volume (4 litres), zéro très stable, et forte sensibilité.

Avec un échantillon de 4 litres, une composante de l'aimantation de 10^{-4} u. e. m. donne une déviation de 8 mm. Cet appareil a servi à déterminer en direction et grandeur les aimantations prises par des briques cuites dans des fours de campagne, c'est-à-dire dans un champ terrestre non perturbé.

P. Charczenko — *Mesures de la susceptibilité magnétique de quelques minéraux et de quelques roches basiques.* — Les mesures ont été faites avec 3 appareils différents: 1°/ La balance de *Curie,* modifiée par G. Grenet; 2°/ un magnétomètre à champ horizontal; 3°/ un magnétomètre à champ vertical. L'auteur n'a cherché que les susceptibilités massives apparentes; il a étudié: le gabbro, le basalte, le basalte basanitoïde, la magnétite cristallisée, le titane magnétite, la ferropicotite.

P. Charczenko, Jouravsky et Choubert — ont publié une Note sur le *Magnétisme rémanent* induit des roches éruptives. — Il résulte de leur étude que le magnétisme rémanent induit est une fonction additive des conditions minéralogiques de la roche et que l'influence sur ce phénomène de la fraction non attirable à l'aimant ordinaire est considérable par rapport à sa susceptibilité. Il n'est donc pas permis de chercher à expliquer le magnétisme rémanent des roches en l'imaginant comme dû à la magnétite considérée comme constituant minéralogique unique.

Jean Rothé — *Observations magnétiques au Scoresby-Sund pendant l'année polaire.* — Les courbes enregistrées montrent que la Déclinaison présente un régime diurne très net avec un minimum vers l'Est vers 6 à 7 heures du matin (T.M.G.) et un maximum plus étalé vers l'Ouest vers 20 à 22 heures. L'amplitude diurne passe par un minimum en hiver (décembre, janvier) et un maximum au printemps ou après l'équinoxe.

L'auteur a étudié la variation de la Déclinaison magnétique pendant une perturbation. Il a aussi étudié l'agitation magnétique.

Jean Rothé — *Activité magnétique et activité solaire.* — L'auteur est conduit à se demander si le retour des journées agitées ne serait pas dû au passage au méridien de zones solaires dont le caractère échappe actuellement aux observations astronomiques, conclusion à laquelle Bartels est arrivé récemment.

Jean Jung — *La Géologie profonde de la France d'après le nouveau Réseau Magnétique et les mesures de la pesanteur.* — Important travail dans lequel il semble que l'auteur ait utilisé beaucoup plus les anomalies de la pesanteur que les anomalies du magnétisme terrestre pour étudier les problèmes géologiques.

Jean Chevrier — L'étude magnétique de la Syrie, pays très troublé, a été reprise par l'auteur qui a publié en même temps que le détail de ses mesures, une carte très détaillée de la Déclinaison à l'époque 1931,0. Des cartes analogues de I, H et Z ont été établies, mais n'étaient pas encore publiées en 1934.

Travaux de l'Institut et Observatoire de Physique du Globe du Puy-de-Dôme

G. Grenet — *La théorie des poudres ferromagnétiques et la susceptibilité magnétique des roches.* — On a proposé trois formules pour la relation entre la susceptibilité apparente d'une roche et sa teneur en constituants ferromagnétiques. L'auteur a établi la première. Une deuxième, plus approchée, a l'auteur par un calcul analogue à celui de M. Chevallier et conété obtenue par *R. Chevallier.* La troisième a été obtenue par stituant une meilleure approximation. Pour le cas de grains non ellipsoïdaux il admet qu'il y a une équivalence entre un solide magnétique de forme quelconque et un ellipsoïde de même composition, de même volume et de même susceptibilité apparente moyenne.

G. Grenet — a poursuivi ses travaux sur *l'aimantation permanente des roches.* Les mesures effectuées confirment que certaines coulées conservent la même direction sur de grandes distances (20 kms).

G. Grenet — a effectué des mesures d'aimantation permanente de roches de la région de Clermont-Ferrand au moyen d'un dispositif d'induction très sensible. Ces résultats ne seront publiés que lorsqu'ils seront assez nombreux pour pouvoir être interprêtés d'une façon intéressante.

Travaux du Service de Météorologie et de Physique du Globe d'Algérie

A. Lasserre — *Le Magnétisme terrestre à Tamanrasset.* — Le pavillon affecté à l'étude du Magnétisme terrestre à Tamanrasset (Hoggar) a été achevé en novembre 1933. Les mesures absolues se font sur un pilier indépendant abrité par une cabane. L'enregistrement des variations a pu être obtenu en septembre 1933, à la faveur d'une interruption des travaux de construction; il a repris le 15 novembre suivant. Le dépouillement des diagrammes a fourni des renseignements intéressants qui permettront, par comparaison avec ceux des autres Observatoires, l'étude de la propagation des perturbations.

Ces recherches sont au moins aussi assujettissantes que les observations météorologiques, et les appareils demandent une surveillance constante. La publication des résultats commencera dans le Bulletin du 2ème semestre 1933.

Satisfaisante est la nouvelle de l'achèvement du pavillon de magnétisme terrestre; malheureusement il est construit en mortier d'argile, refuge des termites et se délayant sous la pluie. Dans certaines parties du pavillon météorologique, les termites pullulent déjà; il n'y aura d'autre remède que de refaire les enduits en dur. Pour l'instant, le personnel est au complet.

A. Lasserre — donne, sur l'Observatoire de Tamanrasset et les travaux magnétiques qui s'y effectuent, les renseignements suivants. Les coordonnées géographiques de l'Observatoire du Hoggar sont:

Longitude: 3° 9′ Est de Paris; Latitude: 22° 47′ N; Altitude: environ 1350 m.

L'enregistrement avec les appareils Mascart, un instant interrompu, a repris le 24 avril 1934 jusqu'à la fin de l'année. Le dépouillement des courbes enregistrées, terminé pour la Déclinaison, n'est pas encore complètement achevé pour I et H. En août 1935, on aura les feuilles de l'enregistreur La Cour et l'enregistrement de la Déclinaison depuis le 1er Janvier 1935.

Jointes à ce rapport sont deux photographies des cartes de la déclinaison D à la date de 1931,0 en Algérie et dans les Territoires du Sud, établies à l'aide de toutes les mesures anciennes figurant dans les mémoires de Mme Salles-Homery et de celles que Melle Malbos et M. Lasserre ont faites jusqu'au 30 juin 1934. Il y a en outre, sur la carte des Territoires du Sud, trois points déterminés par M. Dubief, dont le mode de réduction paraîtra dans les Annales de Physique du Globe de la France d'Outre-Mer, n° de juin 1935.

M. Lasserre a fait depuis avec Melle Malbos, des mesures dans diverses localités de l'ouest: Miliana, Méchéria, Beni-Ounif, Colomb-Béchar, déjà visitées au début de leurs campagnes magnétiques, cela en vue d'une réduction de la Carte Magnétique de l'Algérie à une date qui sera probablement 1936,0 et qui nécessitera, bien entendu, d'autres campagnes au cours desquelles des points nouveaux seront pris (en particulier, dès le mois de juin 1935, la bordure tunisienne).

On remarquera, à ce propos, que M. Lasserre a mis la Tunisie dans la Carte magnétique de l'Algérie, avec le consentement de M. Lacroux, la réduction à 1931,0 ayant donné des renseignements intéressants pour la Tunisie, où aucune mesure récente n'a été faite.

M. Lasserre et Melle Malbos pensent donner, en même temps que la seconde carte de la Déclinaison pour l'Algérie, les cartes entièrement nouvelles de l'Inclinaison et de la Composante horizontale pour la même région.

Avec l'achèvement des installations de Tamanrasset (où il faut comparer les boussoles aux instruments de voyages, que M. Lasserre étalonne tous les ans au Val-Joyeux, et installer définitivement le matériel d'électricité atmosphérique), les cartes dont il vient d'être question représenteront ce qu'il sera tout juste possible de faire avant la retraite de M. Lasserre, qui atteindra ses 70 ans en novembre 1936.

La carte magnétique de l'Algérie contient peu de points étudiés pour une étendue aussi grande. Quant à celle des Territoires du Sud, on juge par les blancs qui y restent, du travail énorme qu'il reste à y faire, d'autant que les anomalies magnétiques y paraissent nombreuses et étendues.

A. Lasserre et Melle Malbos — dans leur tournée de décembre 1935, n'ont pu effectuer que 4 mesures de Déclinaison à Médéah, Ain-Ben-Noui, Biskra et Constantine. Les jours très courts, le ciel défavorable, la nécessité de rentrer au plus vite à Alger ne leur ont pas permis de faire davantage.

Ils ont fait à diverses reprises, des mesures sur le pilier de Bouzaréah (observatoire astronomique), où M. *Mansfield,* de la *Carnegie Institution,* a opéré les 25 et 26 juin 1935, alors que M. Lasserre n'était pas encore rentré du Conseil des

Instituts et Observatoires de Physique du Globe, dont la séance a eu lieu le 23 juin.

Les boussoles du Service de l'Algérie ont été reétalonnées en août 1935. Le déclinomètre moyen modèle n° 174 ne l'avait pas été depuis 2 ans; les constantes de ses barreaux relatives à la mesure de H avaient varié, pour chaque barreau, d'une quantité qui correspondrait à une variation de H de 7 γ par mois.

Le déclinomètre petit modèle n° 98, qui sert en campagne, avait au bout d'un an seulement varié aussi, l'un des barreaux de 7 γ par mois, comme pour le modèle moyen, mais l'autre barreau de près de 13 γ par mois. Aussi les 2 barreaux de la boussole de voyage, d'accord au moment de l'étalonnage, donnent-ils maintenant des valeurs de H qui diffèrent de 100 γ.

Visiblement, pour des raisons inconnues, l'un des barreaux paraît avoir subi un choc important, qui le rend actuellement impropre aux mesures de précision de H, mais n'empêche pas la mesure de D.

A. Lasserre — a rendu compte de la construction des cartes de la Déclinaison pour l'époque 1931,0, présentées l'an dernier à la 4e Section. Les localités algériennes du 1er mémoire de Mme Salles-Homery sont au nombre de 87; M. Lasserre a opéré dans 40 d'entre elles et dans 35 autres; il y a donc seulement 87 + 35 = 122 points connus dispersés sur une étendue plus grande que la France. Toutes les mesures ont été ramenées en 1931,0 en rapportant la variation séculaire de chaque station à celle de Bouzaréah, où la courbe de D est connue depuis 1887, année de la campagne de Moureaux dans le Bassin occidental de la Méditerranée. A cause de l'étendue de la carte et des anomalies étendues de la Déclinaison qui se trouvent dans différentes régions, il n'a pas été possible de résumer en peu de mots un si gros travail.

Les mesures faites en 1935 lui laissent espérer que leur réduction à 1936,0 donnera des résultats assez conformes à ceux qu'on peut déduire de ses formules, sauf dans le SW algérien (Colomb-Béchar) où paraît se manifester l'influence perturbatrice de l'anomalie marocaise de Tilialit.

Mais il serait nécessaire d'avoir des résultats récents pour la Tunisie où se trouvent 2 stations fondamentales de la Carte (Tunis et Sfax), pour lesquelles M. Lacroux a dit à M. Lasserre qu'il n'a pas été fait de mesures depuis longtemps.

A. Lasserre — Observatoire de Tamanrasset. — Les mesures magnétiques (D et H) ont été faites d'abord tous les dix jours par M. Dubief, puis pendant son absence, tous les quinze jours par M. Loisel et M. Debeau.

Dans la première semaine de décembre 1935, il y a eu trois groupes de mesures encadrant celles que M. Dubief faisait dans la Koudla, au cours d'une petite campagne magnétique autorisée par le Directeur.

Les mesures de l'Inclinaison ont été plus rares.

L'enregistrement a été fait au Mascart et au La Cour; mais celui de H, au Mascart a été interrompu par la rupture d'un fil du bifilaire, que M. Dubief a remplacé dès son retour.

Le Bulletin du 2e Semestre de 1933 et celui du 1er Semestre 1934 ont paru. Melle Grandjean travaille à la mise au point du numéro suivant, qui comprendra les résultats de 1933 et 1934 en magnétisme terrestre.

Service de Physique du Globe des Colonies

J. Debrach — *Le Magnétisme terrestre au Maroc.* — L'auteur fait l'historique complet des mesures magnétiques sur les côtes et dans l'intérieur.

Il n'existe actuellement au Maroc aucune station magnétique permettant la mesure des variations des différents éléments du champ. Une série de mesures de D, à Rabat, d'heure en heure, par le Capitaine Bidan, entre 6 h. et 19 h., donne ce que l'on sait sur la marche diurne de D (amplitude 7'71 à Rabat, 11'23 au Val-Joyeux le même jour, rapport 0,69). Le minimum est à 8h., le maximum à 13h.½.

Aucune mesure directe ne donne les variations diurnes de I ni de H, qui sont assez faibles (1' pour I et 20 à 30 γ pour H).

Par contre, des mesures à différentes époques sur le littoral et dans les pays limitrophes donnent approximativement la variation séculaire des diverses composantes.

Le Service Topographique chérifien a dressé la carte de D (1931,0) d'après 196 déterminations, de ½ degré en ½ degré, sans utiliser les mesures les plus anciennes qui auraient donné des résultats trop discordants. Cette carte révèle des perturbations étendues et considérables, dont deux sont particulièrement importantes, l'une dans le Moyen-Atlas, l'autre dans le Grand-Atlas.

Pour les cartes de I et de H on a utilisé toutes les mesures, peu nombreuses, et sans leur appliquer de correction diurne. La carte de l'Inclinaison est de degré en degré, celle de H de 0,005 en 0,005 u. e. m. C. G. S. Les valeurs adoptées pour la variation séculaire de I et de H sont un peu supérieures à celles qui avaient été données antérieurement par Melle Homery (Ann. P. G. France d'Outre-Mer, avril 1935, p. 36).

Jean Chevrier — *Le Magnétisme terrestre dans les Etats du Levant sous Mandat français.* — L'auteur avait publié en 1932, une carte des isogones avec 67 stations (1931,0) et établi pour la même époque des cartes relatives à H, I, Z, qui n'ont pas été publiées à cause de leur caractère provisoire. En 1933, le

Bureau Topographique des Troupes françaises du Levant a publié de l'auteur une carte des isogones pour 1933,0, plus complète, avec 86 stations. Elle montre qu'en ces pays, la déclinaison est l'objet de perturbations notables, son tracé paraissant influencé par la structure géologique du sol. (Ann. P. G. France d'Outre-Mer, avril 1935, p. 39).

Romer — *Le Magnétisme terrestre à la Martinique.* — L'auteur fait l'historique des mesures de D depuis 1682 et des mesures de D, I, H, de *l'Institution Carnegie.* En 1932, le Service de Physique du Globe de la Colonie a commencé ses observations. Pour l'étude des variations, une Station d'enregistreurs Mascart est installée au Morne-des-Cadets dans un bâtiment isolé, à 300 m. des autres locaux. Toutefois, ne disposant pas d'une station de référence, l'auteur ne peut étalonner ses appareils, ni s'en servir.

L'Observatoire de la Martinique est situé à 650 km de la Station magnétique de San Juan de Porto-Rico, la station unique de la Martinique au voisinage d'un volcan actif présente le plus haut intérêt. Les observations comparées de San Juan et du Morne-des-Cadets permettront de distinguer les perturbations qui sont dues spécialement à la Montagne Pelée.

Si la méthode comparative donne des résultats probants, le problème de la prévision des éruptions volcaniques sera pratiquement résolu, car il semble vraisemblable à l'auteur que le phénomène se présente toujours suivant un processus où les phases se succèdent dans un ordre déterminé, et les premières une fois observées, permettront de prévoir les suivantes (Ann. P. G. France d'Outre-Mer, avril 1935, p. 43).

Henry Hubert — *Une carte du XVIIIe siècle donnant la déclinaison magnétique en Afrique — La carte magnétique du Major Rennell.* — En l'an VIII (1800) paraissait à Paris, chez Dentu, un Voyage à l'intérieur de l'Afrique (1795-1797) de *Mungo Park,* traduction française de *J. Castéra,* sur la 2e édition anglaise. Le 2e volume contient en appendice des *Observations sur la Géographie de l'Afrique* dues probablement au *Major Rennell.* Le 3e chapitre indique comment ont été établies les cartes géographiques accompagnant l'ouvrage. Une grande partie des observations ayant été perdues et le sextant de Mungo Park lui ayant été volé à Jarra, il fallait pour reconstituer un itinéraire satisfaisant, connaître les différentes valeurs de D dans les territoires parcourus. Pour cet important travail, le Major Rennell utilisa les matériaux fort complets des régions maritimes. Dans l'intérieur de l'Afrique, il ne pouvait que tracer des isogones au sentiment, sauf peut-être pour la région comprise entre l'embouchure de la Gambie et Jarra. Heureusement, il n'y a pas dans le continent africain d'anomalies exceptionnellement graves. Nous avons donc, très probablement, là, la première carte magnétique de nos colonies d'Afrique.

Le dessin géographique des côtes est excellent et est superposable pratiquement à la carte, à la même échelle, donnée cette année par le Service Hydrographique de la Marine. En redressant la carte du major Rennell et en la rapportant sur 39° vers l'Ouest, à latitude constante, on a 2 *dessins superposables dans leurs grandes lignes et quant aux valeurs des isogones.* La seule divergence importante affecte l'isogone 0° vers Ceylan. La rotation a eu lieu *autour de l'axe du monde, non autour des pôles magnétiques.* Pendant ce temps, dans une autre région, à la même latitude moyenne et à 135° dans l'Est (voisine de notre Indo-Chine) les isogones *sont en opposition et se rapprochent.* L'auteur conclut qu'une étude systématique de la déclinaison dans notre belle Colonie d'Extrême Orient donnerait des renseignements d'un intérêt scientifique élevé. Cette raison s'ajoute à beaucoup d'autres, d'ordre pratique, qui militent en faveur de l'installation d'une station de magnétisme terrestre en Indo-Chine. (Ann. P. G. France d'Outre-Mer, avril 1935, p. 53).

2° Electricité atmosphérique.

Travaux de l'Institut de Physique du Globe de Paris

Ch. Maurain et J. Devaux — *Etude de la conductibilité électrique de l'atmosphère au cours d'un voyage au Groenland.* — Les mesures ont été faites par la méthode de la déperdition, avec un appareil du genre Elster et Geitel, sur le navire le »Pourquoi-Pas?« en mer et au mouillage, en différents endroits suivant la direction du vent, de manière à faire porter les mesures sur l'air non souillé par les fumées du navire. Les valeurs moyennes pour le Scoresby-Sund sont nettement plus fortes que les valeurs moyennes pour la traversée. La conductibilité paraît donc particulièrement grande dans les mers arctiques, ce qui est d'accord avec les diverses mesures antérieures.

Ch. Maurain et J. Devaux — *Etude des noyaux de condensation atmosphériques au cours d'un voyage au Groenland.* — Les noyaux ont été dénombrés pendant le voyage et le séjour au Groenland avec un appareil d'Aitken. Ils sont nettement moins nombreux au Groenland qu'en mer pendant le voyage, surtout à terre. Ces noyaux interviennent dans la formation des gros ions à partir de petits ions se fixant sur les noyaux.

A beaucoup de points de vue, les terres polaires présentent, dès leurs côtes, des analogies avec la haute montagne des régions tempérées.

Ch. Maurain — a rédigé le chapitre de l'Electricité atmosphérique dans le Traité de Climatologie biologique et médicale publié sous la direction du Dr. Piéry.

Ed. Salles — *Observation du Champ électrique au Val-Joyeux pendant l'année 1932.* — L'enregistrement du champ électrique de l'atmosphère a continué avec les mêmes appareils que les années précédentes. Les isolants vont être à bref délai, remplacés par d'autres munis d'un chauffage électrique. Des expériences de laboratoire ont été faites à ce sujet et ont donné des résultats satisfaisants.

Ed. Salles — *Modes de mesure de la conductibilité et de l'ionisation de l'atmosphère.*

— *Appareils pour l'étude de l'électricité atmosphérique.*

— *Note sur les phénomènes d'ionisation par collision observés par temps d'orage dans l'atmosphère.*

Ed. Salles — a perfectionné l'enregistrement du champ électrique de l'atmosphère pendant l'année 1933. Les isoloirs à l'ambre ayant été munis d'un dispositif de chauffage électrique permettent une dessication parfaite de cette résine isolante. Deux montages ont été essayés; l'un constitué par une spirale chauffante parcourue par un courant, l'autre par de petites lampes électriques du modèle utilisé sur les automobiles. Ces dispositifs avaient été préalablement étudiés au laboratoire dans des conditions se rapprochant le plus possible de la réalité.

Ed. Salles — a rédigé le chapitre *Radioactivité de l'atmosphère* dans le Traité de Climatologie biologique et médicale du Dr. Piéry.

Ed. Salles — *Variation diurne du champ électrique de l'atmosphère au Val-Joyeux.* La méthode employée est la méthode du fil, appliquée dans un rectangle de 100 m sur 40 m recouvert d'herbe passée régulièrement à la tondeuse. Un fil d'acier de 22 m de long et 0,5 mm de diamètre est tendu horizontalement à 2 m du sol entre deux piquets. Sa direction est sensiblement perpendiculaire au vent SW, le plus fréquent, et est isolé à ses deux extrémités par des isoloirs en ambre placés dans des chapeaux métalliques protecteurs dont l'atmosphère est desséchée thermiquement. Au milieu du fil est fixée une plaque portant du radium recouvert d'un émail perméable aux rayons α. L'une des extrémités aboutit à deux électromètres enregistreurs Benndorf, l'un à faible, l'autre à grande sensibilité, étalonnés chaque semaine; le zéro est vérifié matin et soir. Les potentiels utilisés sont les valeurs positives prises aux heures rondes sans distinction de catégories de jours. On a utilisé les enregistrements de 11 années 1924-1934 (avec une lacune de 3 mois en 1926).

L'auteur pense qu'il y a, pour la variation diurne, deux régimes différents, celui d'été et celui d'hiver, séparés l'un de l'autre par deux régimes de transition, ceux d'automne et de printemps.

Ed. Salles — a fait une communication sur l'*Electricité atmosphérique et la médecine,* dans laquelle il a voulu faire ressortir que l'influence de la charge électrique de l'air, fût-elle dix fois supérieure à la normale, ne pouvait avoir, par ses ions, qu'une action sur le sang absolument nulle, contrairement à ce que pensent les médecins pour lesquels, les rhumatisants, par exemple, se sentiraient à l'aise avec un champ électrique d'un certain signe, et mal à l'aise avec une polarité de signe contraire.

Ed. Salles a dirigé, comme d'ordinaire, le service d'électricité atmosphérique au Val-Joyeux.

— Est en train de mettre au point un appareil réalisant l'enregistrement difficile de la conductibilité électrique de l'atmosphère.

Mme Odette Thellier — *Mesure de la conductibilité électrique de l'air par une méthode de zéro.* — C'est le commencement d'un travail de longue haleine sur l'état électrique de la basse atmosphère et le rôle des particules en suspension; la nouvelle méthode de zéro élimine certaines difficultés présentées par les mesures en question.

Mme O. Thellier — a établi un ensemble de dispositifs permettant la mesure presque simultanée des divers éléments relatifs à l'état électrique de l'atmosphère: petits ions, gros ions, particules en suspension, conductibilité, par une méthode nouvelle très originale et supprimant les causes d'erreur dues aux fuites. Elle a publié le détail de ses installations et des exemples des résultats, qu'elle va étendre sur un long espace de temps en vue de l'étude des variations périodiques et accidentelles.

Mme O. Thellier — *Mesures simultanées de divers éléments d'électricité atmosphériques.* — L'auteur a entrepris une série de mesures régulières de la conductibilité électrique de l'air et des nombres, par centimètre cube, des gros ions, des petits ions, des noyaux de condensation et des particules en suspension dans l'atmosphère, afin de préciser leurs variations périodiques et accidentelles et leurs relations entre eux. Les valeurs trouvées par des mesures croisées pourront être considérées comme simultanées si chaque mesure est rapide, passant de l'une à l'autre en un temps très court. Une série complète de 14 mesures croisées se fait en 1h.¼ environ; l'auteur les répète chaque jour à 9h., 15h. et 17h.

Au cours de la mesure des petits ions, des gros ions sont captés, d'où une correction. En mars, les petits ions sont rares, les gros ions sont très nombreux; alors, les nombres des petits ions ne représentent qu'un ordre de grandeur.

Mme O. Thellier — *Noyaux de condensation et particules en suspension dans l'atmosphère.* — Les noyaux sont facilement déterminés par le *Pocket Dust-Counter* d'Aitken. Le compteur à jet d'*Owens* donne, de même, le nombre des particules à condition que les lamelles sur lesquelles elles se déposent soient auparavant soigneusement nettoyées. Le nombre moyen des noyaux, après un millier de mesures, est 52500 (maximum 260000; minimum 3500).

Le nombre moyen des particules d'Owens par cm^3 présente une variation diurne et une variation annuelle très nettes; il est aussi en relation nette avec la température et la visibilité.

La variation des noyaux avec ces facteurs est beaucoup plus floue; il s'ensuit qu'on ne saurait confondre noyaux et particules.

M. O. Thellier a un mémoire actuellement à l'impression sur la *Mesure de la Conductibilité électrique de l'air à Paris.*

R. Guizonnier — *Gradient de potentiel électrique et pression atmosphérique.*

Phase de la composante semi-diurne du gradient de potentiel atmosphérique.

Phase de la Composante diurne du gradient de potentiel électrique terrestre. L'auteur qui applique depuis plusieurs années la méthode de H. Labrouste a donné la variation annuelle moyenne de cette phase pour la station du Val-Joyeux de 1925 à 1931. La même méthode d'analyse a été utilisée pour l'étude de cette phase sur toutes les données qu'il a pu se procurer. Les résultats obtenus classent les Observatoires en 3 groupes: le groupe A où le maximum de la composante diurne se produit à midi ou à quelques heures de midi (heure locale); le groupe B où le maximum a lieu à minuit, et le groupe C pour une même station duquel le maximum tend à se produire vers midi ou vers minuit; en hiver, le groupe C peut se rattacher au groupe A, et en été au groupe B.

C'est l'heure locale qu'il faut envisager si l'on considère la phase de la composante diurne du potentiel électrique terrestre, l'influence du Soleil sur la phase de cette composante pouvant être niée.

R. Guizonnier — *Amplitude de la composante semi-diurne du gradient de potentiel électrique terrestre et activité solaire.* — La méthode d'analyse employée fournit l'amplitude A′ de la composante semi-diurne. Les valeurs de A′ portées en courbes offrent un parallélisme remarquable avec celles qui donnent les valeurs moyennes mensuelles de la surface des taches solaires et indiquent des variations d'une durée de l'ordre de quelques mois. Avec les observations de l'Observatoire de l'Ebre seulement, le parallélisme a été vraiment net entre A′ et la surface moyenne annuelle des taches solaires (maxima en 1918 et 1929, minimum en 1922).

R. Guizonnier — a rédigé un mémoire d'ensemble en vue d'une Thèse de Doctorat.

Mme Bayard-Duclaux — *Influence de l'eau d'imbibition des roches sur leur conductibilité électrique.*

Etude de la mise en circuit d'échantillons de roches pour la mesure de leur conductibilité électrique.

— A rédigé sa Thèse de Doctorat sur la *Conductibilité électrique des roches* — a soutenu, le 14 janvier 1936, sa Thèse de Doctorat, travail important qui apporte des précisions dans cette difficile question et donne des résultats qui resteront fondamentaux.

A. Dauvillier — *Enregistrement photoélectrique continu des aurores polaires.*

Observation des Aurores polaires au Scoresby-Sund pendant l'année polaire.

Activité cosmique et activité solaire. Observation du rayon cosmique au Scoresby-Sund pendant l'année polaire.

Paul Rougerie — continue son travail étendu sur les *courants telluriques.*

— A publié une note sur l'*Analyse harmonique de la variation diurne de la composante N-S de ces courants à l'Observatoire du Parc Saint Maur.*

— *Relation entre l'activité solaire et l'amplitude diurne des courants telluriques N-S enregistrés à l'Observatoire de l'Ebre.* Les courbes obtenues en portant en ordonnées les valeurs mensuelles en mV/km de l'amplitude diurne déduite des moyennes horaires mensuelles des différences de potentiel enregistrées dans la ligne N-S à l'Observatoire de l'Ebre et les nombres de Wolf et Wolfer caractéristiques de l'activité solaire présentent une similitude de forme marquée, avec un décalage de quelques mois montrant que le maximum de l'amplitude électrique se produit après le maximum des taches solaires.

La relation évidente des deux sortes de phénomènes a permis de soumettre les valeurs de l'amplitude diurne des courants électriques N-S à l'analyse harmonique de H. Labrouste, qui a permis d'isoler des composantes de périodes variées, dont la somme reproduit sensiblement la courbe des données. La coïncidence de la plupart de ces composantes avec les composantes des taches solaires mises en évidence par M. et Mme Labrouste montre, entre l'évolution des taches solaires et l'amplitude N-S des courants telluriques à Tortosa, une grosse analogie de structure, qui contribue à préciser la relation entre l'activité solaire et les courants telluriques.

Travaux de l'Institut et Observatoire de Physique du Globe du Puy-de-Dôme

G. Grenet, J. Coulomb et P. Bénac — *Le champ électrique et ses variations à la Côte de Landais.* L'installation de la Station de la Plaine a fonctionné d'abord entre avril 1930 et mars 1931; elle est maintenant en service continu depuis le 1er avril 1932. On compare les résultats de la 1ère année complète avec ceux de

1930-31. Les moyennes mensuelles ont été faites en supprimant toutes les valeurs négatives et remplaçant les valeurs positives supérieures par 200 V/M. Les résultats de 1930-31 et 1932-33 sont assez comparables. La moyenne générale du champ est 66 V/M pour 1932-33 et 67 V/M pour 1930-31; ce champ est notablement plus faible que dans la plupart des stations européennes, Davos excepté.

G. Grenet — *Sur la mesure du champ électrique terrestre et de ses variations.* On admet généralement que les appareils de mesure du champ électrique terrestre et de ses variations lentes ne permettent pas la mesure des variations brusques de ce champ. Il n'en est rien. Les installations de mesure des variations lentes sont également sensibles aux variations brusques pourvu que le collecteur isolé soit tel que *sa charge soit constamment nulle;* auquel cas il n'a jamais de charge à écouler pour se mettre en équilibre avec le champ. A cet effet, on utilise comme collecteur une perche isolée portant une prise de potentiel en un point convenablement choisi et non à *son extrémité selon d'habitude;* de plus l'électromètre doit être de période assez faible pour ne pas introduire une nouvelle cause de retard.

G. Grenet — *La conductibilité électrique de l'air au Mont-Dore, en Août 1933.*

L'auteur a utilisé un appareil de Gerdien, muni d'un électromètre bifilaire de Wulf; le lieu d'observation a été le Cottage du Sancy, situé sur la route du Sancy, un peu au-dessus et en dehors de la ville du Mont-Dore. La conductibilité électrique totale moyenne de $4.26 \cdot 10^{-4}$ C. G. S. est environ le double de ce qu'on observe à la surface du Globe à l'altitude de 1050 m.

J. Coulomb — a mis au point, au Sommet du Puy-de-Dôme, une installation d'enregistrement du champ électrique qui peut fonctionner par les plus grands froids, malgré le givre, ce qui n'a jamais été obtenu jusqu'à présent.

J. Coulomb et P. Bénac — ont effectué un trés gros travail matériel pour étudier les *Relations entre le champ électrique* (Côte de Landais près de Clermont) *et la direction du vent.* Les résultats, en cours de publication, montrent une relation très nette entre ces deux phénomènes. Malheureusement il est très vraisemblable que cette relation est due à la proximité de l'agglomération Clermontoise, ce qui fait que la pollution de l'atmosphère est sous l'influence de la direction du vent. Ceci montre le gros intérêt que présentent les observations effectuées dans les stations éloignées de tout foyer de pollution atmosphérique.

— Bien entendu, l'enregistrement du champ électrique continue d'être effectué aux deux Stations de l'Observatoire.

Melle Jarleton — prépare un Diplôme d'Etudes supérieures sur les *Relations entre le champ électrique et la radiation solaire.* Pour suivre les variations du champ électrique, elle utilise le procédé dû à M. Grenet. Ce travail, qui est en bonne voie, a déjà permis de vérifier que le collecteur se met en équilibre avec le champ électrique en moins d'une seconde, alors que, pour les installations usuelles, il faut en général, plus d'une minute.

Melle Jarleton — a soutenu avec succès en 1935 son Diplôme d'Etudes supérieures, qui a fourni des résultats sur la charge électrique des nuages. Ces résultats, qui devront être confirmés, semblent tout à fait intéressants.

E. Mathias — *Sur la réalité du reste d'éclair sphérique.* — Elle repose sur la définition physique du corps matériel, portion de matière qui existe dans le temps et dans l'espace, qui a une forme, un volume et nécessairement une masse, en sorte que, dans le champ gravifique terrestre, il se comporte comme un corps pesant obéissant au principe d'Archimède.

Le reste d'éclair sphérique peut exister successivement dans l'air et dans l'eau, et même exceptionnellement revenir dans le premier milieu pour y achever sa carrière. Par définition, le reste d'éclair étant formé de matière fulminante, celle-ci partage la réalité de celui-là.

E. Mathias — *Sur l'orage du 1er juin 1933 à Hanoï. (Tonkin).* — Cet orage, du type chaleur, a montré à côté des éclairs fulgurants habituels des éclairs ondulés d'un blanc jaunâtre, légèrement rougeâtre parfois, apparraissant un à un et pratiquement silencieux, souvent horizontaux mais quelquefois verticaux ou paraissant presque se fermer sur eux-mêmes. Leur durée totale, évaluée sérieusement, était très voisine de quatre secondes.

E. Mathias — *Action de la foudre sur l'homme et les animaux (historique).* — Cet historique a moins pour but de résumer les résultats acquis à la Science par les Anciens, dont les observations ont été le plus souvent discordantes, que de montrer les observateurs modernes très souvent dévancés par les Anciens. Il convient de remarquer la persistance de certaines erreurs qui se sont maintenues depuis des siècles jusqu'à nous et ne sont pas près de disparaître.

E. Mathias — *La foudre et sa forme globulaire.* — Article de vulgarisation et de mise au point.

E. Mathias — a attiré l'attention sur certaines *foudres globulaires nues,* modérément sulfurées, en ce qu'elles n'ont pas pris la forme serpentine bleuâtre habituelle. Elles ont conservé la forme sphérique et la couleur rouge ou orangé (jaune d'or) correspondant à leur température superficielle et, en se refroidissant, elles n'ont pas explosé comme d'ordinaire à une température où la matière fulminante, *corps optiquement noir,* est encore incandescente. Elles ont pu descendre nettement au-dessous du point où l'incandescence cesse et prendre une couleur bleuâtre pâle, peu visible, puis exploser violemment. C'est que montre une magnifique observation de M. Roubille, qui explique des observations anciennes restées jusque là incompréhensibles.

E. Mathias — montre comment, par une méthode analytique et impersonnelle reposant sur des faits on peut préciser la notion d'impureté dans les foudres globulaires nues, qu'il s'agisse de l'impureté fer, ou de l'impureté bleue qu'on ne précise pas pour l'instant. Cette méthode contraste, en la complétant, avec la méthode synthétique et volontaire employée auparavant et reposant sur l'abaissement de la tension superficielle de la matière fulminante par les substances métalliques qu'elle absorbe par sa surface.

E. Mathias — *La théorie de Dauzère sur la conductibilité de l'air dans les régions exposées à la foudre.* — Cette théorie a été vérifiée dans ses grandes lignes et précisée par les efforts associés de R. Gibrat et G. Viel.

Soit un point A de la surface du sol répondant aux questions précisées. Les deux conditions qui déterminent ce point de prédilection de la foudre (ionisation maxima et prédominance marquée des ions négatifs) sont des conditions nécessaires. On cherche les raisons pour lesquelles ces conditions nécessaires ne sont pas en général suffisantes. Cela revient à chercher les conditions pour qu'un train d'ions négatifs émis par A (où on suppose le champ électrique continuement vertical jusqu'au nuage positif zénithal N) arrive sans encombre à ce nuage.

Cela revient à détruire l'objection consistant à remarquer que les sources abondantes d'ions des 2 signes, comme les fumées des locomotives ou des usines, aussitôt formées, se dissipent dans les *vortices* qui se produisent partout dans l'air. On détruit l'objection en supposant que l'axe d'un cyclone vertical passe à un certain moment par A et y demeure. Alors les conditions nécessaires deviennent suffisantes.

Le raisonnement justifie la croyance populaire que, dans les grands orages, l'apparition du feu St. Elme signifie que le danger d'éclairs descendants est passé. Les éclairs descendants vont rencontrer le feu St. Elme qui jaillit du point que la foudre va frapper.

E. Mathias — dans un exposé strictement critique sur *la foudre et sa forme globulaire* montre comment, grâce à la conception de la *matière fulminante* (à laquelle inconsciemment l'abbé Bertholon et le Prof. Galli n'ont pu s'empêcher d'avoir recours), il est possible d'exposer d'une manière presque élémentaire et d'expliquer sans faire appel à aucune hypothèse supplémentaire, la transformation et les diverses apparences de la foudre globulaire tout en respectant les lois de la physique, de la chimie et de la mécanique. Une bibliographie abondante et une iconographie peu nombreuse mais fortement inédite, étayent cet exposé auquel M. Wehrlé, directeur de l'Office national Météorologique, a bien voulu donner l'hospitalité de son luxueux Mémorial.

Travaux de l'Institut et Observatoire de Physique du Globe du Pic-du-Midi

C. Dauzère — *L'ionisation de l'air et ses applications.* — Pour connaître l'ionisation de l'air, on mesure d'habitude les conductibilités de l'air pour les ions – et les ions +, lesquelles sont sensiblement proportionnelles aux nombres des ions par cm^3. L'auteur a modifié la méthode et l'appareil d'Elster et Geitel. A la suite de ses mesures, il énonce les résultats suivants:

1°/ *Il existe des lieux où l'ionisation de l'air est maxima, c'est à dire supérieure à celle des lieux environnants.*

2°/ *En de tels lieux, les ions négatifs sont généralement plus nombreux que les ions positifs, contrairement à ce qui se passe partout ailleurs.*

3°/ *La situation des lieux de prédilection de la foudre dépend essentiellement de la constitution géologique du sol.*

C. Dauzère et J. Bouget — *Sur les variations de la conductibilité de l'air dans les grottes.* — Les résultats les plus complets sont ceux de la Grotte des Fées, qui est au contact du gneiss du Mont Olivet avec le calcaire jurassique de Bédat. 22 fois sur 25, l'appareil d'Elster et Geitel modifié y a donné $\lambda_+ < \lambda_-$, ce qui prouve que les ions négatifs y sont presque toujours les plus nombreux.

Il y a des valeurs périodiques annuelles de la conductibilité, les valeurs maxima d'été étant 50 et 60 fois plus grandes que les valeurs minima d'hiver. Ainsi, contrairement à la température et à l'état hygrométrique dont les valeurs restent à peu près constantes dans les grottes, la conductibilité électrique de l'air y éprouve des variations alternées dont l'amplitude est considérable.

C. Dauzère — *Sur les lieux fréquemment foudroyés dans le département de l'Aveyron.* — La plupart des points foudroyés se trouvent sur la ligne de contact des schistes et des granits avec les basaltes de l'Aubrac, et au contact du lias et des calcaires jurassiques. En dehors des lignes de contact, les roches les plus dangereuses sont les granits, puis les schistes; les basaltes de l'Aubrac sont bien moins exposés; les grès rouges permiens, qui constituent le pays rougier, et le calcaire jurassique du Causse du Comtal, ne sont presque jamais foudroyés.

Les coups de foudre ne sont pas souvent distribués sur le trajet des eaux souterraines du Causse, mais surtout à leur point d'affleurement.

C. Dauzère — avec J. Bouget, puis avec A. Lutz, a étudié la conductibilité électrique de l'air dans les grottes. Les variations saisonnières reconnues l'an dernier ont été confirmées et il a été possible d'en donner l'explication complète. Elles sont produites par les courants d'air qui résultent des différences de température entre l'air libre et l'intérieur de la grotte. Celle-ci, de température presque constante, est plus chaude en hiver et plus froide en été que celle qui règne au dehors. La grotte a généralement plusieurs ouvertures à des niveaux différents. En hiver, l'air extérieur est aspiré par l'ouverture inférieure, refoulé par l'ouverture supérieure; c'est l'inverse en été. Les changements de sens se produisent au printemps et à l'automne. Un courant venant des profondeurs de la grotte amène de l'air fortement ionisé; un courant venant de l'extérieur apporte au-dedans l'air faiblement ionisé. De là vient le changement de régime observé au printemps et à l'automne.

C. Dauzère et J. Bouget — ont continué leurs études sur les phénomènes orageux dans la région de l'Observatoire du Pic-du-Midi, par les mêmes procédés que les années précédentes. Des enquêtes sur le terrain ont été effectuées et ont porté sur des bandes de territoire ravagées par les orages.

C. Dauzère — L'intérêt croissant que prennent les industriels à de telles études s'est manifesté par des demandes à la suite desquelles l'auteur a entrepris des voyages d'études dans diverses régions de la France (Tarentaise, Limousin) et en Catalogne, afin de déterminer les points dangereux pour la foudre sur le trajet des lignes électriques.

C. Dauzère a pu ainsi préciser le rôle respectif des terrains granitiques et calcaires au point de vue de la foudre. Dans les régions granitiques, la foudre tombe principalement sur les sommets des montagnes et sur les plateaux élevés; dans les régions calcaires, elle atteint des lieux situés dans le fond et sur les flancs des vallées. La cause de cette différence doit être attribuée à la radioactivité différente des roches et aux sources qui, bien souvent, attirent la foudre à cause de leur radioactivité et de l'ionisation de l'air qu'elles produisent.

Dans les pays granitiques, les sources sont disséminées sur les plateaux dans de légers vallonnements; dans les pays calcaires, les sources très abondantes jaillissent généralement sur les lignes de contact des diverses couches géologiques, recoupées par les flancs abrupts des vallées.

C. Dauzère et J. Bouget — ont continué aussi les *mesures de la conductibilité électrique de l'air* dans les grottes et galeries de mine des Pyrénées.

C. Dauzère — a opéré aussi dans les mines de potasse de Catalogne afin de vérifier l'action possible de la radioactivité du potassium; les valeurs trouvées par lui pour la conductibilité sont extrêmement faibles, ce qui semble indiquer que la radioactivité du potassium est inopérante dans ces conditions.

La vérification des recherches de C. Dauzère et la réfutation de certaines objections ont fait l'objet d'importants travaux: de G. Viel, qui a présenté un important mémoire sur ce sujet à la Conférence Internationale des grands Réseaux électriques, et de E. Mathias qui a présenté une Note à l'Académie sur le même sujet. Il suit de là que les résultats en question doivent être considérés aujourd'hui comme bien établis.

C. Dauzère — depuis le mois de juillet 1935, a porté ses efforts principalement sur la restauration de l'Observatoire du Pic-du-Midi. Ces efforts ont abouti à la mise en état de nouveaux laboratoires qui permettront aux Physiciens du Globe de travailler à haute altitude dans des conditions rarement réalisées dans le monde.

Quelques installations pourront servir pour les études si importantes à haute altitude, du champ électrique terrestre, de la conductibilité électrique de l'air, de l'ionisation et de la radioactivité de l'air, du rayonnement cosmique, des phénomènes orageux (feu St. Elme, foudre, grêle), du rôle de l'électricité atmosphérique dans les précipitations, etc.

H. Garrigue — a continué, en vue d'une thèse de Doctorat, les recherches sur *le rayonnement pénétrant d'origine terrestre*, commencées les années précédentes. Il a construit un appareil très portatif pour la mesure des faibles teneurs en radon. Cet appareil, du poids de 1040 gr., insensible dans son emballage à une chute sur la neige de 2 m. de hauteur (ses constantes ne changent pas), donne en 30 secondes des mesures exactes à 1 %.

Travaux du Service de Météorologie et de Physique du Globe de l'Algérie

A. Lasserre — Les mesures, à Alger, de *conductibilité électrique de l'air* avec appareil Gerdien et électromètre Wulf ont commencé en octobre 1935 et ont été poursuivies assez régulièrement. La préparation en a été assez laborieuse; la courbe de graduation de l'électromètre en volts a été reconnue inexacte et l'auteur l'a refaite au Laboratoire de physique industrielle de M. Vérain. Le rapport de la capacité de l'électromètre et du fil de jonction à celle du conducteur de déperdition est 0,355. Les mesures faites d'abord par l'auteur et Melles Malbos et Grandjean, ont été bientôt laissées aux soins de Melle Grandjean et de M. Gastet. Les résultats ont été très variables: sur 92 déterminations, la conductibilité négative a été la plus grande 42 fois, la positive 39 fois; il y a eu égalité 5 fois. La moyenne générale donne:

$$\lambda_- = 0.354 \cdot 10^{-4}; \quad \lambda_+ = 0.352 \cdot 10^{-4}.$$

Les valeurs extrêmes ont été:

$$\lambda_- = (0.252 - 0.035)\,10^{-4};\quad \lambda_+ = (0.796 - 0.059)\,10^{-4}.$$

Il n'a pas encore été fait de mesures d'électricité atmosphérique à l'Observatoire de Tamanrasset, les difficultés de personnel, pour raison de santé, ayant sévi plus particulièrement sur cet établissement, pour l'achèvement matériel et scientifique duquel M. Lasserre a donné un effort considérable.

Au moment où il va prendre sa retraite la 4e Section s'honorerait en rendant hommage à ses efforts persévérants et méritoires.

3° Année Polaire.

Ch. Maurain — dans un exposé étendu montre l'organisation générale et dans leurs grandes lignes, les travaux scientifiques de la Mission française.

Outre la variation diurne et annuelle des éléments habituels du magnétisme terrestre, *J. P. Rothé* a étudié au variomètre de Schmidt, une anomalie magnétique s'étendant sur la Terre de Jameson, voisine du Scoresby-Sund, et en relation avec les filons de basalte.

Aurores Polaires. — Au Scoresby-Sund avait été installée, sur l'initiative de *A. Dauvillier,* une petite tourelle hexagonale permettant l'observation constante des aurores dans de très bonnes conditions; la tourelle, de 2 mètres de diamètre, chauffée, s'élevait au-dessus de l'un des bâtiments de la Mission; les pans coupés de son toit étaient garnis de glaces à faces parallèles bien dressées, à travers lesquelles se faisait l'observation. La Mission y avait organisé une veille aux aurores, les observations y ayant été faites tout le temps qu'elles étaient possibles; une sphère céleste mue par un mouvement d'horlogerie et un dispositif de calque sur carte lumineuse du ciel avaient été établis par le Commandant Habert en vue des mesures de position. Le registre des observations, publié par A. Dauvillier, est une mine précieuse de renseignements, qui ont permis à son auteur de développer ses importants travaux sur l'aurore polaire.

Ozone atmosphérique. — Les recherches de Fabry et Buisson ont montré son influence absorbante sur les radiations de petites longueurs d'onde, cause probable du relèvement de la température dans la haute atmosphère au-dessus des couches froides de la stratosphère. L'ozone atmosphérique a été l'objet de recherches dans les régions polaires.

A. Dauvillier a étudié, au Scoresby-Sund, la teneur de l'air en ozone par un procédé chimique; il a trouvé une très forte augmentation de cette teneur pendant la nuit polaire, qui a duré deux mois, du 20 novembre au 20 janvier. De l'ensemble des résultats, A. Dauvillier conclut que la *production d'ozone est due à l'activité aurorale,* que ce gaz relativement lourd tombe dans l'atmosphère en mettant un temps de l'ordre d'un mois pour atteindre la basse atmosphère et qu'il est détruit par le rayonnement solaire.

Les teneurs en ozone observées par A. Dauvillier sont notablement supérieures à celles trouvées pour la basse atmosphère dans nos régions (qui sont de l'ordre de 2 mgr. par 100 m^3 d'air, alors que A. Dauvillier trouve un maximum de 57 mgr. par 100 m^3 d'air à la fin décembre).

Comme certaines radiations, de longueur d'onde inférieure à 2000 Å, transforment l'oxygène en ozone, on peut penser que les radiations solaires de ces régions du spectre parviennent dans la très haute atmosphère et interviennent dans la production de l'ozone; d'où l'intérêt des résultats de A. Dauvillier.

Radio-électricité. — En vue de l'étude des variations diurne et annuelle de la propagation des ondes électromagnétiques et des causes influençantes, on effectuait au Scoresby-Sund, sous la direction du lieutenant de vaisseau Douguet, des émissions sur ondes de 25 à 30 mètres, et l'écoute portait sur les émissions des postes de Pontoise, de la Tour Eiffel, du fort d'Issy, de Rugby et de Tokyo.

En diverses stations ont été faites des mesures de hauteur des couches fortement ionisées sur lesquelles se réfléchissent les ondes électromagnétiques.

La couche réfléchissante de Kennelly-Heaviside (hauteur 100 à 150 km) n'est pas unique; une autre couche, de hauteur moyenne 250 km, intervient fréquemment et, entre les deux, se produisent parfois des réflexions.

Rayons cosmiques. — Les missions de l'Année Polaire avaient l'occasion de mesurer leur intensité dans un long intervalle de latitudes. C'est ce qu'a fait A. Dauvillier entre la France et le Scoresby-Sund, le trajet suivant grossièrement le méridien magnétique. A. Dauvillier a fait de nombreuses mesures absolues de l'intensité du rayonnement cosmique et en a étudié les fluctuations, l'intensité restant parfois constante à 2 % près pendant des heures et parfois présentant des fluctuations désordonnées atteignant 17 %.

A. Dauvillier attribue l'origine des rayons cosmiques au choc des électrons solaires sur les gaz de la très haute atmosphère. Il a montré comment cette hypothèse permet d'interprêter ses résultats; la source des rayons cosmiques serait de faible intensité, mais très étendue, sensiblement constante et indépendante de l'activité solaire.

4° Publications.

Magnétisme terrestre

Ch. MAURAIN — Sur l'intervalle de temps entre les phénomènes solaires et les perturbations magnétiques terrestres. Ann. de l'Inst. de Physique du Globe de Paris, t. XII, p. 63, 1934, et C. R. Acad. Sc. Paris, t. 196, p. 1122, 1933.

Ch. MAURAIN — Magnétisme et Electricité terrestres, Fasc. 1. Magnétisme terrestre, Hermann et Cie, Editeurs, Paris, 1935.

Ch. MAURAIN — L'année polaire 1932-33. Organisation générale. Travaux Scientifiques. Annuaire du Bureau des Longitudes pour 1935 B 1-21.

H. et Mme LABROUSTE — Composante diurne et semi-diurne de la Déclinaison et agitation magnétique. Ann. Inst. Phys. du Globe de Paris, t. XII, 1934, p. 82.

H. et Mme LABROUSTE — Sur la variation undécennale de la Déclinaison. Congrès des Sociétés Savantes. 1934, p. 243.

H. et Mme LABROUSTE — Comparaison entre les jours magnétiques calmes et l'ensemble au point de vue de la relation avec l'activité solaire. Congrès de l'A. F. A. S., Maroc, Avril 1934, p. 107.

L. EBLE — Observations magnétiques faites au Val-Joyeux pendant l'année 1932. Ann. de l'Inst. de Phys. du Globe de Paris, t. XII. 1934, p. 1.

E. TABESSE — Observations magnétiques faites à l'Observatoire de Nantes pendant l'année 1932. Ann. Inst. Phys. du Globe de Paris, t. XII, 1934, p. 29.

L. EBLE et G. GIBAULT — Valeurs des éléments magnétiques à la station du Val-Joyeux (Seine-et-Oise) au 1er janvier 1934. C. R. Acad. Sc., t. 198, p. 1059.

L. EBLE — Remarques sur l'agitation magnétique. 66e Congrès des Sociétés Savantes, Toulouse, 1933, p. 424.

L. EBLE — Observations magnétiques faites au Val-Joyeux en 1933. Ann. de l'Inst. de Phys. du Globe de Paris, t. XIII, 1935, p. 1.

E. TABESSE — Observations magnétiques faites à Nantes en 1933. Ann. de l'Inst. de Phys. du Globe de Paris, t. XIII, 1935, p. 29.

L. EBLE et G. GIBAULT — Valeurs des éléments magnétiques à la Station du Val-Joyeux au 1er janvier 1935. C. R. Acad. Sc., t. 200, p. 957.

L. EBLE — Sur la variation annuelle du champ magnétique terrestre. C. R. Acad. Sc., t. 200, 1935, p. 1342.

L. EBLE — Sur l'utilité des mesures magnétiques continues en Afrique du Nord. Congrès de l'A. F. A. S., Rabat, 1934, p. 100.

Ed. SALLES — Remarques sur les faibles amplitudes de la variation diurne de la Composante horizontale observées à Sitka au cours des années 1905-1912. Congrès des Soc. Savantes, 1934, p. 253.

Melle HOMERY — Le magnétisme terrestre dans les possessions françaises, 66e Congrès des Soc. Savantes, 1933, p. 459.

Melle HOMERY — Déclinaison magnétique sur l'ensemble du Globe, C. R. Acad. Sc., t. 196, 1933, p. 797.

Mme SALLES-HOMERY — Planisphère de la Déclinaison magnétique (1ère édition) imprimé par les soins du Service Hydrographique de la Marine, 1934.

Mme SALLES-HOMERY — Exposé d'ensemble sur le Magnétisme terrestre dans nos Colonies — Ann. de Phys. du Globe de la France d'Outre-Mer, avril 1935.

E. THELLIER — Sur un magnétomètre insensible aux champs magnétiques troublés des grandes villes. C. R. Acad. Sc., t. 197, 1933, p. 232.

E. THELLIER — Sur un appareil d'induction pour la mesure des faibles moments magnétiques. C. R. Acad. Sc., t. 200, 1935, p. 736.

E. THELLIER — Aimantation des briques et Inclinaison du champ magnétique terrestre. Ann. de l'Inst. de Phys. du Globe de Paris, t. XIV (à l'impression).

P. CHARCZENKO — Mesures de la susceptibilité magnétique de quelques minéraux et de quelques roches basiques. Ann. Inst. Phys. du Globe de Paris, t. XII, 1934, p. 76.

P. CHARCZENKO, JOURAVSKY et CHOUBERT — Sur le magnétisme rémanent induit des roches éruptives. C. R. Acad. Sc., t. 200, 1935, p. 541.

J. P. ROTHE — Observations magnétiques au Scoresby-Sund pendant l'année polaire 1932-33. Ann. de l'Inst. de Phys. du Globe de Paris, t. XIII, 1935, p. 99.

J. P. ROTHE — Activité magnétique au Scoresby-Sund et activité solaire. Ann. de l'Inst. de Phys. du Globe de Paris, t. XIII, 1935, p. 138.

Jean CHEVRIER — Observations magnétiques en Syrie (II). Ann. de l'Inst. de Phys. du Globe, t. XI, 1933, p. 63.

G. GRENET — La théorie des poudres ferromagnétiques et la susceptibilité des roches. C. R. Acad. Sc., t. 197, 1933, p. 746.

G. GRENET — Un appareil pour déterminer les propriétés magnétiques des roches. Bull. de l'Inst. et Obs. de Phys. du Globe du Puy-de-Dôme, n° 6, 1933, p. 57.

A. LASSERRE — Déclinaison magnétique en Algérie et dans les Territoires du Sud de l'Algérie. Ann. de Phys. du Globe de la France d'Outre-Mer, juin 1933.

J. DEBRACH — Le Magnétisme terrestre au Maroc. Ann. de Phys. du Globe de la France d'Outre-Mer, avril 1935.

J. CHEVRIER — Le Magnétisme terrestre dans les Etats du Levant sous Mandat français. Ann. de Phys. du Globe de la France d'Outre-Mer, avril 1935.

Ch. POISSON — Le Magnétisme terrestre à Madagascar. Ann. de Phys. du Globe de la France d'Outre-Mer, avril 1935.

ROMER — Le Magnétisme terrestre à la Martinique — Ann. de Phys. du Globe de la France d'Outre-Mer, avril 1935.

H. HUBERT — Une carte du XVIIIe siècle donnant la déclinaison magnétique en Afrique. Ann. de Phys. du Globe de la France d'Outre-Mer, avril 1935.

Electricité atmosphérique

Ch. MAURAIN et J. DEVAUX — Etude sur la Conductibilité électrique de l'atmosphère au cours d'un voyage au Groenland. Ann. de l'Inst. Phys. du Globe, t. XI, p. 85.

Ch. MAURAIN et J. DEVAUX — Etude des noyaux de condensation atmosphérique au cours d'un voyage au Groenland. Ann. de l'Inst. de Phys. du Globe, t. XI, p. 85.

Ch. MAURAIN — Electricité atmosphérique dans le Traité de Climatologie biologique et médicale publié sous la direction du Dr. Piery, t. I, p. 66.

Ed. SALLES — Observations du champ électrique au Val-Joyeux pendant l'année 1932. Ann. de l'Inst. de Phys. du Globe de Paris, t. XII, 1934, p. 39.

Ed. SALLES — Modes de mesure de la conductibilité et de l'ionisation de l'atmosphère. La Météorologie, 1932, p. 236.

Ed. SALLES — Appareils pour l'étude de l'électricité atmosphérique — Communication à la Société Météorologique, 1933.

Ed. SALLES — Note sur les phénomènes d'ionisation par collision observés par temps d'orage dans l'atmosphère. C. R. Congrès Soc. Sav. 1933, p. 487.

Ed. SALLES — Observations du champ électrique au Val-Joyeux en 1933. Ann. de l'Inst. de Phys. du Globe de Paris, t. XIII, 1935, p. 39.

ED. SALLES — Radioactivité de l'atmosphère dans le Traité de Climatologie biologique et médicale publié sous la direction du Dr. Piéry, t. I, p. 82.

ED. SALLES — Variation diurne du champ électrique de l'atmosphère au Val-Joyeux. Volume jubilaire de M. Marcel Brillouin, 1935, p. 360.

Ed. SALLES — L'électricité atmosphérique et la Médecine. La Météorologie, Supplément n° 2, Procès-verbal de la réunion du 12 février 1935, p. 36.

Mme Odette THELLIER — Mesures simultanées de divers éléments d'électricité atmosphérique. C. R. Acad. Sc., t. 200, 1935, p. 1124.

Mme Odette THELLIER — Noyaux de condensation et particules en suspension dans l'atmosphère. C. R. Acad. Sc., t. 201, 1935, p. 348.

R. GUIZONNIER — Phase de la composante diurne du gradient de potentiel électrique terrestre. C. R. Acad. Sc., t. 200, 1935, p. 852.

R. GUIZONNIER — Amplitude de la composante semi-diurne du gradient de potentiel électrique terrestre et activité solaire. C. R. Acad. Sc., t. 200, 1935, p. 1235.

Mme BAYARD-DUCLAUX —Influence de l'eau d'imbibition des roches sur leur conductibilité électrique. C. R. Acad. Sc., t. 197, 1933, p. 854.

Mme BAYARD-DUCLAUX — Etude de la mise en circuit d'échantillons de roches pour la mesure de leur conductibilité électrique. C. R. Acad. Sc., 196, p. 1331.

A. DAUVILLIER — Enregistrement photoélectrique des aurores polaires. C. R. Acad. Sc., t. 197, 1933, p. 780.

A. DAUVILLIER — Activité cosmique et activité solaire. Observation du rayon cosmique au Scoresby-Sund pendant l'année polaire. C. R. Acad. Sc., t. 197, 1933, p. 1741.

Paul ROUGERIE — Analyse harmonique de la variation diurne de la Composante N-S des courants telluriques à l'Observatoire du Parc Saint-Maur. C. R. Acad. Sc., t. 199, 1934, p. 964.

Paul ROUGERIE — Relation entre l'activité solaire et l'amplitude diurne des courants telluriques N-S enregistrés à l'Observatoire de l'Ebre. C. R. Acad. Sc., t. 202, 1936, p. 967.

G. GRENET, J. COULOMB et P. BENAC — Le champ électrique et ses variations à la Côte de Landais. 66e Congrès des Soc. Savantes, 1933.

G. GRENET — Sur la mesure du champ électrique terrestre et de ses variations. C. R. Acad. Sc., t. 198, 1934, p. 967.

Melle JARLETON — Relations entre le champ électrique et la radiation solaire. Diplôme d'Etudes Supérieures de l'Université de Clermont-Ferrand.

E. MATHIAS — Sur la réalité du reste d'éclair sphérique. C. R. Acad. Sc., t. 197, 1933, p. 962.

E. MATHIAS — Sur l'orage du 1er juin 1933 à Hanoï, Tonkin. C. R. Acad. Sc., t. 198, 1934, p. 524.

E. MATHIAS — Action de la foudre sur l'homme et sur les animaux (historique). Bull. de Inst. et Obs. de Phys. du Globe du Puy-de-Dôme, 2e supplément au n° 6, 1934.

E. MATHIAS — Sur les foudres globulaires bleues. C. R. Acad. Sc., t. 199, 1934, p. 505.

E. MATHIAS — La notion d'impureté dans les foudres globulaires nues. C. R. Acad. Sc., t. 199, 1934, p. 1083.

E. MATHIAS — La théorie de Dauzère sur la conductibilité de l'air dans les régions exposées à la foudre. C. R. Acad. Sc., t. 201, 1935, p. 314.

E. MATHIAS — La foudre et sa forme globulaire. Exposé critique. Mémorial de l'Office National Météorologique, n° 24, 1935.

C. DAUZERE — L'ionisation de l'air et ses explications. 66e Congrès des Soc. Savantes, 1933.

C. DAUZERE et J. BOUGET — Sur les variations de la conductibilité de l'air dans les grottes. C. R. Acad. Sc., t. 198, 1934, p. 490.

C. DAUZERE — Sur les lieux fréquemment foudroyés dans le département de l'Aveyron. C. R. Acad. Sc., t. 197, 1933, p. 1684.

C. DAUZERE et J. BOUGET — Sur la cause des variations de la conductibilité de l'air dans les grottes. C. R. Acad. Sc., t. 199, 1934, p. 1645.

H. GARRIGUE — Nouvel appareil très portatif pour la mesure des faibles teneurs en radon. Journ. Phys. et Radium, t. 7, 1936, p. 107.

C. DAUZERE — Etude sur la foudre (première partie). Conférence Internationale des Grands Réseaux Electriques à Haute Tension. Session 1935.

ANNEE POLAIRE INTERNATIONALE 1932-1933 — Participation française, T. I. (Introduction, Magnétisme terrestre, Aurores Polaires, Ozone atmosphérique, Rayons cosmiques). Gauthier-Villars, Paris, 1936.

From Dr. NIPPOLDT† was received the following Report on work in Terrestrial Magnetism made in

GERMANY

Das neue »Adolf Schmidt-Observatorium für Erdmagnetismus« in Niemegk wurde am 23. Juli 1930, dem 70sten Geburtstage von Adolf Schmidt, in feierlicher Weise eingeweiht. Es besteht aus einem Hauptgebäude mit Wohnungen für einen Angestellten und einen Arbeiter, nebst Laboratorium, Arbeitszimmern und Gastwohnungen, Werkstätte, elektrischer Zentrale u. s. w., ferner dem halb-unterirdischen Variationshaus für Registrierung der magnetischen Variationen, dem Hause für absolute Messungen, dem für Erdstromregistrierungen und Laboratoriumszwecke umgebauten einstigen Variationshaus von Seddin, einem Häuschen für absolute Messungen besuchender Gelehrter — ebenfalls aus Seddin hertransportiert — und einigen Nebengebäuden. Das Ganze liegt in einem Gelände von 272 ar Grösse, ungefähr 1 km westlich der kleinen Landstadt Niemegk in SW der Provinz Brandenburg, in Luftlinie rund 50 km südwestlich von Potsdam.

Das seit 1908 registrierende Observatorium in Seddin wurde am 1. April 1932 stillgelegt und abgebrochen. Die zahlenmässigen Ergebnisse der ganzen Seddiner Beobachtungsreihe erscheinen zusammengefasst 1934 in den »Ergebnissen der Magnetischen Beobachtungen in Seddin i. J. 1931« *Jul. Springer*, Berlin. Die Jahre 1932 und 33 bieten der Verarbeitung grosse Schwierigkeiten, weil die neu aufgestellten Variometer, die bei dieser Gelegenheit auch noch eingehend umgearbeitet wurden, sich erst allmählich normal einspielten. Zur Sicherheit waren ausser den zwei Normalsätzen von Variometern noch mehrere Hilfssätze aufgestellt, aber gerade dies bedingt vermehrte Reduktionsarbeit. Dazu kam, dass kurz vor Beendigung der Aufstellung der Normalvariometer wegen unerwarteter Feuchtigkeitsschäden die eine Aufstellung wieder beseitigt werden musste, um die Ursache der Schäden durch bauliche Vorsichtsmassnahmen zu beseitigen. Aus diesen Gründen werden die Ergebnisse für 1934 und 35 vor denen von 1932 und 33 erscheinen.

Das Observatorium in Niemegk besitzt ein registrierendes System in X, Y, Z und D und ein zweites registrierendes in D, H, I und Z. Ersteres System liefert auf jeden Bogen gleichzeitig Registrierungen in kleiner und grosser Empfindlichkeit; das D H J-System kann, ohne Störung der 24- stündigen Registrierung seine Variationen auf ein zweites Walzenpaar je nach Wunsch in 2-stündigem oder 8-stündigem Lauf verzeichnen. Der 2-stündige dient für die Entnahme der Variationen zu den absoluten Messungen. Die Zeiten werden durch Lichtsignale auf dem Kurvenbogen gekennzeichnet. Die absoluten Messungen in D und H werden mit dem seit 1896 vorhandenen Theodoliten Wanschaff besorgt, die I-Messungen mit dem seit 1901 normalen Erdinduktor Schulze 1. Es stehen aber ausserdem noch andere Theodolite und Erdinduktoren zur Verfügung, desgleichen Variometersätze.

Die Erdstromanlage wurde gelegentlich des Internationalen Polarjahrs 1932/33 aus Mitteln beschafft, die der Rockefeller Fonds durch gütige Empfehlung der Internationalen Polarkommission bewilligt hatte, wofür auch hier herzlichst gedankt sei. Es wurden zwei je rund 1 km lange Kabelleitungen leicht in Erde verlegt, die eine nach astronomisch West, die andere nach Nord gerichtet. Ausser den dort vergrabenen Erdplatten standen noch zwei weitere zur Verfügung, welche den Erdstrom in magnetisch West und Nord massen. Durch eine Signaluhr konnte automatisch zwischen beiden Systemen gewechselt werden. Diese Erdstromanlage wird z. Zt. nach den seitherigen Erfahrungen umgebaut.

Während des Polarjahrs war ferner eine Schnellregistrierung in Betrieb. Alle Variationen des Polarjahrs wurden in Kopenhagen von Dr. la Cour durch photographische Kopien in das internationale Archiv aufgenommen.

Das Observatorium in Niemegk beteiligte sich lebhaft an den Untersuchungen über die Vorgänge in der *Ionosphäre* und zwar durch eigene, von Herrn Dr. Fanselau veranstaltete Echomessungen als auch durch Überlassung geeigneter Räume an das Institut für Wellenforschung. Die sehr lehrreichen Ergebnisse zeigten, dass vor allem, ehe man an schablonenmässige Dauerregistrierungen gehen kann, noch viel grundlegende theoretische und praktische Fragen zu lösen sind. Hierin bestand die bisherige Hauptarbeit auf diesem Forschungsfeld.

Mit den deutschen Anstalten für Wellentelegraphie, Funkpeilungen, Aeronautik u. s. w. sind in systematischer Zusammenarbeit Richtlinien für die Überwindung der Empfangsstörungen ausgearbeitet worden.

Zusammen mit den magnetischen Observatorien von Maisach bei München und Gross-Raum bei Königsberg i. Preussen und den anderen deutschen Fachleuten wurde in den Jahren 1934 und 1935 eine neue magnetische Aufnahme des Deutschen Reichs durchgeführt und zwar mit Unterleitung der Notgemeinschaft der deutschen Wissenschaft (Deutsche Forschungsgemeinschaft). Es wurde von den Herren W. Kleinschmidt, H. Reich, R. Bock, Fr. Burmeister und Fr. Errulat 522 Stationen nach gleichem Plan vermessen. Insbesondere wurde darauf gesehen, dass alle drei Elemente gleich gut beobachtet waren, in Inklination kam daher ausschliesslich der Erdinduktor zur Anwendung. Um die geographische Verschiedenheit der täglichen Variationen berücksichtigen zu können, waren temporäre magnetische Beobachtungen bei Freiburg in Baden, Ratibor in Oberschlesien und im Taunus-Observatorium bei Frankfurt am Main eingerichtet. Die magnetische Reichsaufnahme wird von nun an eine dauernde Einrichtung, um sie stets auf dem neusten Stand zu halten. Das Magnetische Observatorium Potsdam ist ferner an der Geophysikalischen Aufnahme des Deutschen Reichs beteiligt und an einer Anzahl verwandter Vermessungen zu Land, See und in der Luft.

An internationalen Zusammenarbeiten ist zu erwähnen, dass sowohl für die türkische als auch die bulgarische magnetische Aufnahme je ein magnetischer Theodolit eingehend untersucht und die betreffenden Beobachter in Niemegk ausgebildet wurden. Für das chinesische Observatorium in Zi-ka-wei wurden 2 Variometer von R. Toepfer-Potsdam geeicht. Das Observatorium Pilar (Argentinien) schickte einen Magnetiker zum Studium der Potsdamer Arbeitsmethoden, und griechische und spanische Behörden erbaten die Niemegker Baupläne um sie für ihre eigenen Neubauten zu verwerten. Mit den QHM-Variometern von La Cour-Kopenhagen fanden mehrfach Vergleichsmessungen statt, desgleichen eine Serie Vergleichsmessungen mit den Reiseinstrumenten der Carnegie-Institution in Washington, U. S. A.

Bezüglich der anderen magnetischen Arbeitsstellen Deutschlands ist zu erwähnen, dass Maisach-München eine Vermessung der Bayrischen Rheinpfalz abgeschlossen hat (Burmeister, Akademie der Wissenschaften 1932), sodass der Anschluss an die Reichsaufnahme verhältnismässig einfach war. Gross-Raum gab (Errulat: *Mitt. Geophys. Warte Gross-Raum,* Nr.25, Königsberg, 1935) die Ergebnisse seiner Beobachtungen im Polarjahr heraus und bewerkstelligte die Detailaufnahmen von Ostpreussen und Danzig. An mehreren Stellen widmet man sich dem Zusammenhang zwischen geologischem Bau des Untergrunds und den lokalen magnetischen Anomalien (F. Schuh: »Isanomalenkarte von Mecklenburg«, Rostock, 1934). Von allen diesen Arbeiten kann man sagen, dass sie in vorbildlicher Gemeinsamkeit von allen magnetischen Arbeitszentren betrieben wurden.

GREAT BRITAIN

REPORT OF THE BRITISH NATIONAL COMMITTEE

(1) *Reports of Observatories, etc.*

(a) *Royal Observatory, Greenwich (Abinger).*

The photographic registration of variations of D, H and V has been continued with negligible interruption during the period. The registration on a time-scale twelve times as great as normal was continued on the days specified by the Second International Polar Year Committee until the completion of the programme. The quick-speed records have been prepared for reproduction on a uniform plan.

The annual publication of results has been punctually maintained, the results for 1935 being already in type.

In addition to the routine observation of absolute values of the magnetic elements (several independent observations of each being made, normally, each week day) the work of testing and certifying magnetic instruments is undertaken, and occupies much of the observers' time.

As the result of anomalous observations obtained with a Kew-pattern unifilar magnetometer submitted for re-standardisation a detailed investigation of the question of "distribution constants" and the validity of theory in their practical application has been begun. Some rather important possibilities have been brought out, the chief of which is that departures from the uniform magnetisation assumed in theory may be so large that the values of the constants P and Q obtained from deflections at one set of distances will be markedly different from the values obtained at other distances.

When such a condition exists an inter-comparison made at a particular station is not valid for a station where a different horizontal intensity necessitates the choice of different distances for the deflection experiment.

Further, the results obtained by one and the same instrument will differ systematically according to the distances chosen, by amounts which certainly exceed the accidental error of observation.

In work with a unifilar magnetometer, the value of the horizontal force is obtained by a combination of vibration and deflection experiments. A deflection experiment at one distance, yields the quantity $\frac{H}{m[1+f(r)]}$ where f(r) is a function of the deflection distance, which becomes zero for infinite r and involves the distribution of magnetism in the two magnets. To obtain H it is usual to assume that $f(r) = \frac{P}{r^2} + \frac{Q}{r^4}$, P and Q being the so-called distribution constants, and to obtain deflections at three distances r_1 r_2 r_3, thereby obtaining equations from which P, Q and H can be derived. It is to be observed that the observed quantity at distance r is $\frac{H^1}{m} = \frac{H^1}{m[1+f(r)]}$, and that the standard practice consists, in effect, of observing the values of $\frac{H^1}{m}$ at three distances and then extrapolating to $\frac{1}{r} = 0$.

It appears that for some instruments the extrapolation is justifiable and that for others it is not. The following tables give results for the unifilar magnetometer Casella 181, which was the standard instrument at Abinger prior to the introduction of the Schuster-Smith Coil, and for a unifilar submitted for test, which is here designated Magnetometer X. The quantities tabulated are in each case $H-H^1$, where H^1 is the quantity $\frac{H}{1+f(r)}$, the value of H is taken from coil observations, and m is obtained by combining this value of H with the value of mH derived from vibration experiments.

Casella 181 (mean of 37 sets)

r (cms.)	$\frac{1}{r^2}$ x 10^6	$H-H^1$
22.5	1975	+232γ
25	1600	+199
30	1111	+162

Casella 181 (mean of 37 sets)

r (cms.)	$\frac{1}{r^2}$ x 10^6	H — H'
35	816	+124γ
40	625	+ 97
45	494	+ 82
50	400	+ 68
∞	0	0

Magnetometer X (mean of 73 sets)

r (cms.)	$\frac{1}{r^2}$ x 10^6	H — H'
25	1600	+ 6γ
30	1111	+12
35	816	+24
45	494	+12
∞	0	0

On plotting the values of $H - H^1$ against those of $\frac{1}{r^2}$, it will be seen that for Casella 181 the points lie on a reasonably smooth curve and that the value at $\frac{1}{r^2} = 0$ could quite justifiably be extrapolated from the values for three values of $\frac{1}{r^2}$ by means of the usual quadratic formula. But for Magnetometer X this is clearly not true, and the process of extrapolation usually employed might lead to wildly inaccurate results depending on the distances used. This means that Cassella 181 is a reasonably good instrument and that Magnetometer X is a bad one. But it will be noticed that it is impossible to decide whether a unifilar is good or bad until sets of deflections at various distances are taken and the observed results combined with the value for r = ∞, which must be obtained from a coil standard. This means that before confidence can be placed in the results of observations with a unifilar it must be tested at an observatory where an electromagnetic standard is available. The unifilar magnetometer is, in fact, not an absolute instrument.

(b) *Observatories of the Meteorological Office.*

The observatories at Eskdalemuir and Lerwick have continued their normal programme since the last report. They are now equipped with Copenhagen magnetographs both of the standard and quick-run type. The Copenhagen magnetograph, formerly used by the British Polar Year Expedition at Fort Rae, became the standard instrument at Lerwick in April 1934; a new instrument of the same type was installed at Eskdalemuir in December 1935 and will probably be taken as the standard for that Observatory from January 1936. The quick-run magnetograph installed at Eskdalemuir for the Second Polar Year has been maintained in operation; the similar instrument used at Fort Rae was set up at Lerwick in July 1935 and is in continual operation.

Since January 1934 the standard control instrument for horizontal force at Eskdalemuir has been a Schuster-Smith magnetometer which is an exact copy of, and is standardised against, the original magnetometer of this type at Abinger. In August 1935 using one of the new horizontal force magnetometers (QHM) designed at Copenhagen, Dr. Laursen of the Danish Meteorological Service provisionally determined the difference between the Copenhagen and Eskdalemuir standards of horizontal force to be of the order of two gammas.

A Smith portable magnetometer brought into use at Lerwick in October 1932 has not functioned entirely satisfactorily and is at present undergoing comparison tests at Eskdalemuir. In the meantime the Kew pattern magnetometer continues to be used as standard for determination of horizontal force at Lerwick. Since June 1935 a dip inductor, standardised against the Dye vertical force magnetometer at Abinger and presently on loan from the Astronomer Royal, Greenwich, has replaced the dip circle for measuring inclination.

Enquiry has been made into the variation from year to year of the P and Q distribution coefficients as determined in the course of the absolute observations at Eskdalemuir and Lerwick. It has been found that since 1923, when the Lerwick series commences, the Lerwick and Eskdalemuir values show a rather unexpected parallelism. So far this has not been definitely traced to any circumstance likely to be common to the two observatories.

The programme of routine work at Lerwick includes an auroral watch on all suitable occasions. The Observatory is equipped with an auroral camera but the number of occasions suitable for photography has been limited, particularly in recent years.

The large horizontal coil and galvanometer system at Eskdalemuir for recording rates of change of the vertical component of the earth's field has been maintained in working order and occasional records have been made in co-operation with the National Physical Laboratory.

The magnetic work at Valentia Observatory is confined to weekly absolute observations of horizontal force, declination and inclination. These have been continued uninterruptedly.

(c) *Stonyhurst College Observatory.*

Regular determinations of the magnetic elements were commenced at Stonyhurst in 1863, and from that time it has been the practice to make absolute determinations of the Horizontal force and Inclination once each month, and of the Declination once each week.

In 1866 a set of photo-magnetographs of the Kew Observatory pattern was installed, giving continuous records of the Declination, Horizontal and Vertical Force, which are still in service. Time marks are made on the records by a Synchronome Mean Time clock operating a relay which cuts off the light for two minutes every two hours. The clock error is determined daily, and is never allowed to exceed a few seconds.

The readings of the Vertical Force Balance are not found to be sufficiently consistent to allow of numerical values being quoted, and little use is made of them. The scale value of the Declination instrument is 11.′28 per cm. of ordinate, and the Horizontal Force is adjusted to be as nearly as possible .00050 C.G.S. Units per cm. of ordinate, and is determined by the method of deflections two or three times a year. The base line values are determined from the curve ordinates at the time of the absolute measures.

Four daily readings are measured on the curves of Declination and Horizontal Force — the Maximum and Minimum, and at 04 and 16 hours G.M.T. — and from these readings on the five quietest days of the month, mean values of these elements for the month are deduced. It has been found from a series of comparisons that mean values derived as above approximate closely to those derived from hourly measures, which, with the limited staff, it has not been possible to undertake. The monthly values of the Vertical and Total Force are deduced from the mean value of the Horizontal Force and the single observation of the Dip.

Mean values for the year of all the elements are communicated to the Astronomer Royal, for incorporation in The Observatories' Year Book, and the Numerical Magnetic Character of each day is supplied to the International Organisation at De Bilt. A fuller summary of results is given in the Annual Report of the Observatory, which is distributed to most of the observatories and principal scientific institutes throughout the world.

(d) *Ordnance Survey.*

During the period under review no routine observations at new stations or repeat stations have been made by the Ordnance Survey. Attention is being directed to the problem of more intensive magnetic surveys, particularly of Declination, covering restricted areas. To this end a new instrument, called a magneto-theodolite, has been designed at the Ordnance Survey and a pair have been constructed for that Office by the Cambridge Instrument Company in collaboration with Messrs. E. R. Watts and Sons. The practical applications of the instrument in the surveying and engineering professions have also been discussed with outside bodies, some of whom are testing the instrument in collaboration with the Ordnance Survey.

(e) *Auroral Observations at Kirkwall, Orkney.*

Mr. G. W. Reid has continued the systematic observation of auroral phenomena at Kirkwall. The details observed and recorded include position of auroral forms of different kinds, time of occurrence, principal changes occurring during a display, period of pulsating aurorae, etc.

This series of observations has now extended over six years, and includes every night except those on which the light of the northern sky in summer renders observation useless.

(2) *New Instruments.*

(a) *The Ordnance Survey Magneto-Theodolite.*

The instrument is an eccentrically mounted theodolite with a Smith Fluid Suspension chamber containing a magnet system occupying the vertical axis of rotation.

The introduction by Sir Frank Smith in 1925 of this fluid suspension for magnets was the beginning of a new type of field magnetic instrument. The first of its kind was a portable form of the so-called Schuster-Smith Magnetometer. It is based upon a principle suggested by the late Sir Arthur Schuster, and was made for the Ordnance Survey by the Cambridge Instrument Company. This magnetometer and its fluid container and magnet system are described in the Ordnance Survey Publication "A Portable Magnetometer of the Null Type" (H. M. Stationery Office, — 1930 price 1/-). Since 1928, the magnetometer has been regularly used on the magnetic surveys of Great Britain and copies of it have been manufactured for other countries.

The coil magnetometer, although primarily designed to measure Horizontal Force, constitutes a means of connecting accurately any bearing with the magnetic meridian and it has been used to measure D as well as H. For rapid Declination surveys, however, it has several disadvantages:— its weight, its bulk and the necessity of removing the container and magnet system from the line of sight of the telescope before the distant object of other azimuth mark can be sighted on. The magnet system of necessity occupies the vertical axis of rotation of the instrument and so the telescope has to be mounted in an awkward outside position pointing at this axis.

In the new magneto-theodolite the difficulties are overcome by mounting the telescope to one side of the container and the change over from theodolite operation to magnetometer operation or vice-versa takes place in about one second by throwing into the line of sight within the body of the telescope a penta-prism which reflects through 90° rays from the glass cube forming part of the magnet system. Auto-Collimation takes place through a second objective fixed in this broken light path, facing the window of the container. The prism is raised and lowered in a tube at right angles to the telescope tube by means of a rack and pinion. The telescope itself can be completely traversed in a vertical plane.

In making rapid Declination surveys the instruments are to work essentially in pairs, preferably at intervisible stations. Simultaneous observations of their respective magnetic meridians by the two observers, followed by observations of the bearing from instrument to instrument, will determine relative values of D at the two points without reference to simultaneous values at a Magnetic Observatory. This is one of the advantages of the method. After completion of the observations at two stations, the forward observer remains and the backward observer moves to another forward station. In this way a Declination survey along a line of points is made, closing on the initial station or on some station where D is known. The accumulated error in D can then be eliminated by an appropriate distribution of corrections throughout the line. The practical details of observing programmes have not yet all been worked out.

The instruments have been tested side by side and it has been found that with new pivots the freedom from friction at the jewel is such as to allow the magnet system to follow unaided the small fluctuations in D on a quiet day within 15″. That is to say, if the two magnet systems are left quite undisturbed and their movements are followed by two observers, these movements have a probable difference, less than 15″. The constant of each instrument, or difference between apparent D and true D, depending principally upon the angle between the magnetic axis of the magnet system and the collimating face of the glass cube, is not absolutely constant and must be checked from time to time. To do it absolutely a visit to a Magnetic Observatory must be made but the difference between the constants of the two instruments can be determined at any time and place.

(b) *A new type of Magnetograph.*

A magnetograph, embodying a new principle, has been designed by Dr. Harrison, at the Admiralty Signal School, Portsmouth.

It is well known that the resistance of ferromagnetic materials to alternating current is a function of the frequency of the A. C. and of the permeability of the material. With some of the new nickel iron alloys it has been found that this resistance is also a function of the longitudinal magnetic field when the material is in wire form and that even at audio frequencies the change of effective resistance with applied field is large with small fields (*Nature*, 8th June 1935). This change is of such a magnitude that for a 12″ 26 S.W.G. wire a change of 0.4 gauss produces at 20 % change in resistance.

This peculiar property has been used in the production of the new type of magnetograph. A wire of nickel iron alloy approximately 12″ in length is connected in one arm of a wheatstone bridge circuit which is fed with A. C. from a valve oscillator. The wire is mounted vertically or horizontally according to whether it is desired to record changes in the earth's vertical or horizontal field. The bridge is balanced and the out of balance current due to change in impedance of the nickel iron bridge arm is detected on a new type of detector system which is capable of giving on a chart right and left deflections from an A. C. input instead of the usual zero. An increase in intensity deflects the recorder in one direction and a decrease in the other. By using three wires, mutually at right angles to one another, one of the wires being vertical, it is possible to record the variations in the vertical and two horizontal components of the Earth's field on the same instrument simultaneously.

The instrument is at present arranged as a magnetograph for measuring variations in the Earth's vertical magnetic field and under steady temperature conditions, a change of 5γ in V causes a movement of 1 mm. on the Chart.

There seems no reason why this sensitivity should not be increased fivefold.

It has been arranged to try the magnetograph for a period at the Magnetic Observatory, Abinger.

(3) *The R. R. S. "Research".*

The construction of a non-magnetic ship, to continue the ocean magnetic survey work formerly undertaken by the *Carnegie*, has been approved by the Admiralty. The designs of the new ship, to be known as the R. R. S. *Research* have been prepared and tenders for the construction have been invited. The ship will be somewhat larger than the *Carnegie*, with a displacement of 650 tons. She will have a brigantine rig and be provided with a single screw Diesel engine with sufficient oil fuel to give a radius of action of about 2,000 miles at 6 knots. The cables will be of bronze, instead of hemp rope, as in the *Carnegie,* and to some extent brass or bronze will prove more satisfactory. The ship will have a total complement of 31 persons and will carry about 40 tons of fresh water.

Magnetic declination will be determined with a marine collimating compass; the horizontal intensity of the Earth's Field will be determined with a sea-deflector, and the dip will be determined with a marine earth-inductor, driven at a constant speed by a tuning fork controlled rotary converter, the drive being transmitted by an articulated shaft. The sea-deflector will be mounted in a forward observatory, communicating with the standard Compass: the earth inductor will be mounted in an after observatory. These observatories will not be provided, as in the *Carnegie,* with glass domes. A full instrumental equipment for land observations will be provided. Contracts for several of the instruments have been placed and specifications have been prepared for the others.

The designs of the instruments for sea observations have been based on those of the instruments used on the *Carnegie.* The Carnegie Institution of Washington has readily placed all information at the disposal of the Admiralty and has generously loaned Mr. W. J. Peters to the Admiralty for advice and assistance in all matters connected with the design of the ship and its equipment.

The *Research* will be equipped also with instruments for the study of atmospheric electricity and with echo-sounding gear for determining the ocean depths. She will also undertake some oceanographical work.

The area in which magnetic data are most uncertain is the southern portion of the Indian Ocean. The *Carnegie* made relatively few observations in the Indian Ocean; the cruise on which she was engaged when she blew up was to have included the Indian Ocean. Moreover, there has been a more rapid change during recent years in the secular variation of the magnetic declination in that area than elsewhere. It is probable therefore that the first cruise of the *Research* will include the Indian Ocean.

(4) *Miscellaneous Researches.*

Papers published during the period under review include: Terrestrial Magnetism — The Magnetic Variations of Short Duration by A. H. R. Goldie in the "Problems of Modern Meteorology" series, *Lond. Q. J. R. Meteor. Soc.* 59, No. 248 (1933).

The following papers have been published by J. M. Stagg:

The Diurnal Variation of Magnetic Disturbance in High Latitudes. *Proc. R. S.* A. 149, pp. 298-311 (1935).

Numerical Character Figures of Magnetic Disturbance in relation to Geomagnetic Latitude. *Terr. Mag.*, 40, pp. 255-262 (1935).

Aspects of the Current System producing Magnetic Disturbance. *Proc. R. S.* A. 152, pp. 277-298 (1935).

Some General Characteristics of Aurorae at Fort Rae 1932-33. London. *British National Polar Year Committee*, pp. 1-6 (1935).

In addition, Mr. Stagg has been more or less continuously occupied with the reduction of the magnetic, auroral and atmospheric electrical data from the British Polar Year Station at Fort Rae, N. W. Canada, since the return of the expedition to this country at the end of 1933. Apart from the measurements of the large quantity of double station auroral photographs, this work is now completed and the discussion ready in a form suitable for publication. It is hoped to have the material published in the near future.

Measurement of the auroral photographs from Fort Rae has also been carried on and details of height, azimuth and distance have been computed on an average of 12 to 15 points each from over 600 pairs of photographs. Mr. Stagg, in collaboration with Mr. Paton of Edinburgh University, hopes soon to begin a study of the results of these computations to see how the characteristics of aurorae in N. W. Canada compare with those in Norway.

S. Chapman has continued his researches on the lunar daily magnetic variation at various stations, and, with his pupils or collaborators has completed such investigations for the horizontal magnetic force at Greenwich, for all three elements at Cheltenham, and for the declination at Sitka; these await publication. He is engaged on similar reductions for the declination at Batavia and for all three elements at Helwan (the latter on behalf of the Egyptian Government). He has also made and published many determinations of the lunar atmospheric tide at various stations. In addition he has published the following papers on terrestrial magnetism and related subjects:

The effect of a solar eclipse on the earth's magnetic force. *Terr. Mag.*, 38, pp. 173-183 (1933).

The mechanical-optical method of reduction of pairs of auroral plates. *Terr. Mag.*, 39, pp. 299-303 (1934).

The electrical current systems of magnetic storms, *Terr. Mag.*, 40, pp. 349-370 (1935).

Space-gradients of the earth's magnetic field. *Terr. Mag.*, 41, pp. 127-136 (1936).

(With Professor E. V. Appleton) Report on ionization changes during a solar eclipse. *Proc. Inst. Radio. Eng.* 23, pp. 658-669 (1935).

He has also written a small book, "The Earth's Magnetism" *(Methuen and Co., Ltd.)*, and with Professor J. Bartels has in preparation a treatise on geomagnetism.

Dr. T. G. Cowling has developed a theory of the magnetic field of sunspots *(M. N., R. A. S.* 94, pp. 39-48, 1934), which has a bearing on the theory of the earth's magnetic field.

(5) *Radio Measurements of Upper-Atmospheric Ionisation and Magnetic Activity.*

(1) The radio observations under review have been carried out by British workers as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research. They consist of daily measurements of the maximum ionisation densities of the various regions of the ionosphere at

(a) Radio Research Station, Slough, (Lat. 51° 30′ N. Long. 0° 34′ W.) from 1932 up to the present time,

and at

(b) Tromsø, Northern Norway, (Lat. 69° 39′ N. Long 18° 56′ E.) during the International Polar Year 1932-33.

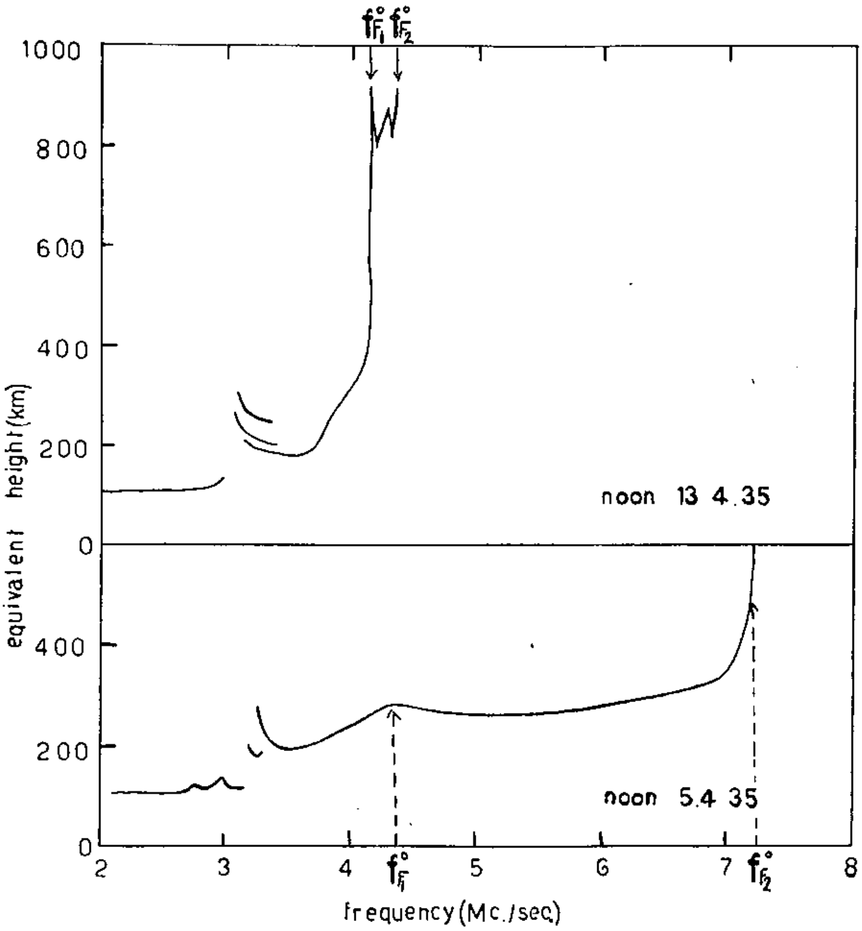
(2) It is known that the ionosphere may be divided into two main regions, the lower, Region E, at a height of about 100 km., and an upper and more intensely ionised Region F at an equivalent height of about 200 to 250 km. The latter develops a well-defined ledge on its lower boundary when the altitude of the sun is high. When it is necessary to distinguish between this ledge and the main region, we refer to them as Regions F_1 and F_2 respectively.

(3) The measurements of the ionisation density of Region F_2 made at Slough at noon during the period August 1932-August 1933 have been first compared graphically with the Daily Magnetic Character Figures from the Abinger Observatory supplied by the Astronomer Royal. It was at once found that intense magnetic storms were usually accompanied by marked reduction in the critical frequency of the Region in question, though there were noted a number of cases in which the critical frequency was actually greatly increased while a storm was in progress.

The matter was investigated further by the evaluation of the correlation factor for the noon critical frequency of Region F_2 and the magnetic character figure for the preceding day. This was found to be –0.397. It was further noted that the most marked reductions of critical frequency, and therefore of maximum electronic content, occurred during the spring months of 1933 when a very marked 27-day recurrence tendency was apparent in both the radio and magnetic data. In the evaluation of the correlation factor, the daily departures of the critical frequency from the appropriate value on a smooth curve drawn through the monthly means were used.

For the years 1934 and 1935, corresponding investigations have been made for both Regions F_1 and F_2. The same procedure as already described was used, yielding values for the correlation factors, for the year 1934, (a) with Region F_2 of −0.016 and (b) with Region F_1 of -0.042. These values are slightly lower than was to be expected from a consideration of the Polar Year results. This may have been due to the smaller number of big storms in 1934, and also to the absence of the well-defined 27-day recurrence period characteristic of the spring months of 1933. Using the 1935 results, values of -0.200 for Region F_2 and −0.064 for Region F_1 were found for the correlation factors.

Since magnetic activity is, in the latitude of Slough, most pronounced just before midnight, an examination of the midnight values of Region F_2 critical frequency with magnetic activity has been made for the years 1934 and 1935, correlation factors of −0.247 and −0,357 having been obtained. On detailed



investigation it has been found that when there is a small amount of magnetic activity the ionisation is above normal, but that when the activity is more severe, the critical frequency is much depressed. These results are in agreement with those obtained using the noon ionisation as a daily index figure except that there is now no tendency for big magnetic storms to increase the ionisation. A satisfactory method of differentiating between storms which increase and decrease the ionisation densities during the daytime has not yet been reached.

(4) The ionospheric abnormalities which accompany magnetic activity can best be illustrated by comparing the curves relating equivalent height of reflection with frequency on quiet and disturbed days. Two such curves for the ordinary magnetic component are shown in the accompanying figure.

In this connection it may be noted that, with disturbed magnetic conditions, the following radio phenomena are usually experienced:—

(a) The critical frequency of Region F_2 is low and poorly defined on the equivalent height/frequency curve. The curve may also show a "spur" near the critical frequency corresponding to Region F_2.

(b) Group retardation phenomena, more marked than normal, are associated with the penetration of Region F_1.

(c) The Region F_1 critical frequency is not altered nearly so markedly as that of Region F_2 but it is usually slightly reduced.

(d) The minimum equivalent height of Region F_2 is very markedly raised.

(e) The radio echo amplitude is low for all frequencies employed (1.5 to 8 Mc. per sec.).

(5) An examination of the observations made at Tromsø leads to conclusions of similar character. The correlation factor for the noon values of Region F_2 critical frequency and the magnetic character figures supplied by Director Harang of Nordlysobservatoriet has been found to be -0.341 agreeing with the inverse correlations mentioned above for the Slough data.

At both Tromsø and Slough a very striking feature of periods of intense magnetic disturbance is the extremely low ionospheric reflection coefficients. At Slough, except on one occasion, the echo intensity was never imperceptible for a period of hours' duration, but at Tromsø this condition prevailed during every severe magnetic disturbance. Thus, although the correlation factors for the two stations given above are comparable in value, the effect of a magnetic storm on upper-atmospheric ionisation is really more pronounced at Tromsø than at Slough since all days when the echo intensity was imperceptible have had to be omitted from the examination.

The low values of reflection coefficient accompanying magnetic storms have been attributed by Appleton, Naismith and Builder to increased ionisation at low levels in the atmosphere where the consequent absorption of radio waves is great (*Nature,* Vol. 132, p. 340, 1933).

(6) At Tromsø it was found that during periods of small magnetic activity and also for a brief interval during the onset of a severe storm, abnormal reflections were obtained from Region E when the electric wave frequency used was greater than the normal penetration value for undisturbed conditions. These results confirm the connection between magnetic activity and abnormal Region E reflection noted by Appleton and Naismith in England in 1932 (*Proc. R. S.,* Ser. A., Vol. 137, p. 36, 1932).

(7) An increase of ionisation density as an accompaniment of magnetic activity would receive a ready explanation in terms of current theories of the production of magnetic storms by the injection in the upper atmosphere of ionising particles from the sun, but the most striking result of the radio observations, namely, the reduction in the maximum electronic content of Region F_2 in disturbed conditions seems more difficult to explain. It has, however, been pointed out by Appleton and Ingram (*Nature,* Vol. 136, p. 548, 1935) in this connection that if the agency responsible for magnetic disturbance heats the upper atmosphere, so that it expands, the *maximum* electron density might be expected to be abnormally low.

(6) *Atmospheric Electricity.*

(a) *Kew Observatory.*

Since 1933 the principal development in the work in Atmospheric Electricity at Kew Observatory has been the introduction of balloon soundings for finding the sign of the potential gradient in and above the clouds, especially during thunderstorms. As the sign of the potential gradient is of more significance than the magnitude, it suffices to use pole-finding paper instead of an electrometer. Pressure, humidity and the sign of potential gradient are recorded simultaneously; pressure and humidity are inscribed on a smoked metal disk whilst the sign of potential gradient is indicated by lines traced by iron points on paper soaked with potassium ferrocyanide. The potential difference which is effective is that between the apparatus and the end of a tail which may conveniently be made 10 metres long during thunderstorms, 100 metres long in ordinary rainy weather. Up to the end of March 1936 42 soundings had been attempted. The instruments were recovered on 32 occasions and 20 yielded legible records. In one violent thunderstorm nine balloons were released and six records were obtained. It is hoped that by this investigation information of fundamental importance with regard to the generation of electricity in the clouds will be obtained.

Apparatus for recording the charge on rain has been in regular operation since the beginning of 1935. The records obtained in the first year showed that the total positive and negative charges brought down by rain were nearly equal; showers were responsible for most of the negative electricity whilst continuous rain and thunderstorms were both associated with a slight excess of positive electricity.

The point-discharge recorder, an account of which was given by Dr. Whipple at the Lisbon meeting, is maintained in regular operation and a memoir dealing with the results obtained from 2½ year's records has been published recently. Arrangements have been made to obtain records of the discharge from a point on a mast about 0.8 km. from the Observatory, it being anticipated that the comparison between the variations of point-discharge at two points at this distance apart will yield useful information about the electric field below thunderstorms. The investigation of electrical conditions in disturbed weather has also been facilitated by the installation of an insensitive but quick-acting potential gradient recorder in which a short period Dolozalek electrometer is used in conjunction with a very efficient polonium collector. At the meeting in London of the International Union for Scientific Radio Telegraphy in 1934 it was agreed that 5 mm per minute should be adopted as the standard scale for records of disturbed electrical conditions. This scale has been adopted at Kew Observatory for the records of point-discharge, electricity on rain and potential gradient. It is found convenient to use drums rotating once in two hours, i. e. with circumference 60 cm.

The Kelvin electrograph is still used for providing continuous records of potential gradient. Polonium collectors (to be renewed every six months) were substituted for the water-dropper in 1932. The electrograph is now standardized so that published readings give the potential gradient at a side in the observatory paddock. Attention may be called to a memoir by Mr. Scrase (*Geophysical Memoir.,* Vol. VII, No. 60, 1934), in which reduction factors to be applied to earlier observations are set out. Observations in atmospheric electricity were inaugurated at Kew Observatory as long ago as 1843. They are associated with the great names of Sir Francis Ronalds and Lord Kelvin. About the end of the nineteenth century, regular observations standardized so as to make possible comparisons of potential gradient at different epochs were commenced. A homogeneous series of readings of potential gradient from 1910 onwards is now available. Mr. Scrase's memoir shews that interesting comparisons with earlier data are also possible.

The variation of potential gradient with height near the ground has been investigated by a differential method employing a double stretched wire system. It was found that on the average there was a decrease in the potential gradient of about three per cent in 10 m.; the change was more uniform in turbulent air than in comparatively stagnant air. The volume charge was extremely small except in still air when a change of the order of + 0.1 E. S. U. per m³ was observed between 5 and 10 m.

A long series of observations of the numbers of charged and uncharged Aitken nuclei has been carried out. The analysis of the observations indicates that the ratio of the numbers depends on the relative humidity of the air, the proportion of uncharged nuclei being decreased when the humidity exceeds 80 per cent. The effect is presumably due to an increase of size of the nuclei.

During the whole of the year 1933 apparatus for recording continuously the conductivity of the air and the number of small ions was in operation. A study of the results of the records is in progress.

Routine observations of the fine weather air-earth current, positive conductivity and potential gradient at the surface of the ground by means of the Wilson test-plate apparatus in the underground laboratory have been continued. Revised monthly means derived from the Wilson observations, which have been made regularly on fine afternoons since 1911, are included in *Geophysical Memoir*, No. 60, Vol. VII, 1934.

Bibliography

The Observatories' Year Book of the Meteorological Office includes tables shewing for Kew, Eskdalemuir and Lerwick:

(a) Potential gradient at four hours each day.
(b) The electrical character of the day and the duration of negative gradient.
(c) The diurnal variation of potential gradient on quiet days.

In addition the values of air-earth current and conductivity are given for Kew Observatory for certain days.

Geophysical Memoirs, Vol. VII:

No. 60 (1934). F. J. Scrase. — Observations of atmospheric electricity: a survey of results obtained from 1843-1931.
No. 64 (1935). F. J. Scrase. — The charged and uncharged nuclei in the atmosphere and their part in atmospheric ionisation.
No. 67 (1935). F. J. Scrase. — Some measurements of the

variation of potential gradient with height near the ground at Kew Observatory.
No. 68 (1936). F. J. Whipple and F. J. Scrase. — Point-discharge in the electrical field of the earth.

R. Met. Soc., Q. J., Vol. LXI:
No. 261 (1935), pp. 367-379. F. J. Scrase. — The sampling errors of the Aitken nucleus counter.

(b) *Point-discharge Recorder, Royal Observatory, Greenwich.*

The continuous photographic record of current discharged at a point 30 feet above the ground was begun at the Royal Observatory on 1935 January 1. The point is a steel needle-point, renewed at regular intervals. The current passes to earth through two galvanometers connected in series. The sensitivity of one is about twenty times that of the other. The two traces appear one immediately below the other, so that movements may be compared and the appropriate trace may be selected for measurement, with great ease.

The scale of the sensitive trace is 1 cm. = 0.070 micro-ampère; that of the less sensitive trace is 1 cm. = 1.37 micro-ampère; while the time-scale is 4 mm. to the minute. The recording cylinder is revolved by synchronous motor, and this gives ideal regularity with corresponding simplicity in identifying definite instants of time.

The integrated net outflow shown by the records made during 1935 is not yet available. One feature of interest is a small steady current shown on the sensitive trace beginning frequently an hour or so before midnight, and lasting as a general rule for some hours into daylight. The nature and origin of this current is being investigated.

Interesting traces have been obtained on several occasions when thunderstorms have passed at a distance from the Observatory. The sensitive galvanometer registered measurable instantaneous currents — both signs, but chiefly positive — coinciding with the occurrence of lightning flashes at least five miles away.

(c) *Solar Physics Observatory, Cambridge.*

The main line of investigation in the field is still the potential gradient of thunderclouds using the capillary electrometer technique initiated by C. T. R. Wilson. Attention has been concentrated on recording the electrostatic field at the earth's surface during and immediately after a lightning discharge. Observations can be made on flashes at all distances up to about 40 kms.; the time limit of resolution is about 0.01 second. The effects of the separate strokes making up a lightning discharge can be readily separated in many cases.

Several connected problems have also been investigated. A number of balloons carrying films in metal containers were sent up into thunderclouds in a search for penetrating radiation of considerable intensity. The results were negative. (W. A. Macky, *Proc. Cam. Phil. Soc.* XXX, 70, 1933).

A further attempt to detect penetrating radiation associated with thunderstorms was made using a Wilson cloud chamber in which the expansion was automatically released by the field-change of a moderately distant lightning discharge. While the results were not very conclusive, more penetrating particles were captured in such expansions than in similar expansions made at random. (E. C. Halliday, *Proc. Camb. Phil. Soc.* XXX, 206, 1934).

A series of experiments carried out in the Cavendish Laboratory has shown that a large drop of water falling through ionised air or through a cloud of charged particles, in an electric field, acquires a charge in accordance with the theory propounded by C. T. R. Wilson as a possible mechanism for thunderclouds. (J. P. Gott, *Roy. Soc. Proc.* A, 142, 148, 1933 and 151, 665, 1935).

J. A. Ratcliffe and a team of workers from the Cavendish Laboratory have been engaged in a systematic attack on various problems of the ionosphere and a number of papers have been published.

(d) *University College, Dublin.*

During the last three years, observations on atmospheric electricity have been continued under the direction of Prof. J. J. Nolan at the station at Glencree, Co. Wicklow, which is maintained by University College, Dublin.

Observations have been made, by C. T. R. Wilson's exposed-plate method, of the field at the earth's surface and of the current into the earth. Simultaneous observations of the concentrations of positive and negative small ions were made. A new form of apparatus for counting small ions has been in use. A considerable number of determinations of the mobilities of small ions have been made with this apparatus.

An investigation into the loss of nuclei from air-streams passing through tubing has led to a method for the determination of the diffusion coefficients and velocities of fall of condensation nuclei. The results reported so far must be regarded as tentative, and the work is still in progress.

Certain results of a negative character may be mentioned. Investigations by ion-counters and by Kolhörster apparatus at two places (Sandyford, Co. Dublin and Grange Con, Co. Wicklow) reported to be frequently struck by lightning, have revealed no detectable excess of atmospheric ionisation or of ionising radiation at either place.

(c) *Miscellaneous Investigations.*

"The Theory of the Combination Coefficients for Large Ions" has been discussed by Dr. W. R. Harper of the University of Bristol,*Phil. Mag.* XVIII (1934) p. 97, XX (1935) p. 740. Formulae have been derived from the kinetic theory of gases both for the coefficients determining the rate of combination of uncharged nuclei with small ions and for those determining the rate of combination of charged nuclei (i.e. large ions) with small ions of opposite sign. The value determined by Nolan and O'Brolchain for the coefficients appropriate for certain conditions in Dublin are in accordance with Harper's theory.

The fundamental problem of the nature of nuclei (and therefore of large ions) has been studied experimentally by J. H. Coste and H. L. Wright *(Phil. Mag.* XX (1935), p. 209), who find that the nuclei produced when combustion is taking place are probably formed by the combination of the constituents of the air into nitrous acid. The authors believe that although sea water is the chief constituent of nuclei in nature, most of the nuclei produced by the fires associated with human activity are droplets of nitrous acid.

HOLLAND

RAPPORT SUR LES TRAVAUX MAGNÉTIQUES 1933-1936

Par G. van DIJK

L'Observatoire magnétique de De Bilt a régulièrement continué les enregistrements magnétiques avec deux jeux de variomètres: un jeu enregistre les variations de la déclinaison de l'intensité horizontale et de l'intensité verticale à l'aide de lumière intermittente, l'autre jeu enregistre les variations de trois composantes astronomiques nord-sud, est-ouest et verticale à l'aide de lumière permanente; vitesse de déroulement du papier 15 mm par heure.

Dans le pavillon des observations abolues on a déterminé comme auparavant trois fois par mois la déclinaison, l'intensité horizontale et l'inclinaison. Les observations ont été publiées dans l'*Annuaire* de l'Institut Météorologique Royal des Pays-Bas, B. Magnétisme Terrestre; l'annuaire de 1935 est sous presse et paraîtra en Octobre.

Dans le mois de mars 1934 on a disposé derrière les variomètres des composantes astronomiques un variomètre Godhavn du Dr. la Cour; dans le mois de mars 1935 on a remplacé le variomètre de l'intensité verticale de Schulze dans l'appartement à enregistrement avec lumière intermittente par un variomètre Godhavn. Les deux variomètres Godhavn revenus de l'expédition néerlandaise à Angmagssalik, ont été munis d'un fort amortissement en cuivre; ils sont complètement compensés contre les variations de la température, qui d'ailleurs ne se montent qu'à 4 degrés durant l'année (minimum au printemps 9°, maximum en automne 13°). Le comportement de ces variomètres a été excellent.

Dans le printemps de 1936 on a déterminé l'intensité horizontale à l'aide de 3 magnétomètres QHM envoyés par l'Institut Météorologique de Copenhague. Les trois magnétomètres ont montré une concordance parfaite, la différence avec le théodolite Edelmann de l'Observatoire de De Bilt se monte à 9γ.

La station polaire à Angmagssalik a continué les enregistrements magnétiques encore une année après l'Année Polaire jusqu'au mois d'Août 1934 sous la direction du Dr. van Zuylen, chef de l'expédition.

Les observations magnétiques faites à Angmagssalik ont été réduites autant que le temps du personnel de l'Institut de De Bilt, disponible à ce travail, le permettait. On a reproduit sur films et envoyé au Président de la Commission de l'Année Polaire Internationale les enregistrements à marche ordinaire durant l'Année Polaire et l'année suivante, on a reproduit sur films les photographies de l'aurore polaire avec une explication, on a décrit et dessiné les observations aurorales visuelles etc. conformément aux vœux de la Commission de l'Année Polaire. On espère publier l'année prochaine les observations magnétiques faites à Angmagssalik.

La publication des tableaux trimestriels des caractères magnétiques, rédigés par l'Institut Météorologique des Pays-Bas, à savoir «Caractère magnétique de chaque jour» et «Caractère magnétique numérique des jours», a été continuée régulièrement. Une étude, intitulée «Measures of Terrestrial Magnetic Activity» a été présentée à la Commission de Magnétisme terrestre et d'Electricité atmosphérique de l'O. M. I. lors de sa séance à Varsovie en septembre 1935.

A la prière du Président de la Commission de l'Année Polaire l'Institut de De Bilt s'est chargé de prendre soin de la rédaction et de l'impression des caractères magnétiques des stations en opération pendant l'Année Polaire et également par rapport avec une proposition adoptée à Varsovie de collectionner et d'arranger les caractères magnétiques des observatoires avant l'année 1906.

A présent les observations magnétiques à De Bilt sont sérieusement menacées par les projets de la Compagnie des Chemins de fer néerlandais, d'électrifier plusieurs lignes dans le centre du pays. D'après des enregistrements de l'intensité verticale exécutés à quelques endroits dans le voisinage des chemins de fer existants dans l'ouest du pays, on peut s'attendre à ce que les perturbations des observations magnétiques à De Bilt à cause de courants vagabonds, seront très grandes.

Il est fort souhaitable que le danger qui menace les observations magnétiques aux Pays-Bas, soit paré et que dans l'avenir ces observations puissent être continuées comme auparavant sans interruption et sans perturbations.

Septembre 1936.

JAPAN

NATIONAL REPORT OF THE JAPANESE COMMITTEE OF TERRESTRIAL MAGNETISM AND ELECTRICITY

By A. TANAKADATE

The four standing magnetic observatories, Toyohara, Kakioka, Simoda and Aso, the first three with quick running magnetographs as well as the earth current, are continuing their regular works as they were during the Second Polar Year. The four subsidiary stations, Oodamari in Karahuto, Zinsen in Tyôsen, Daihoku in Taiwan and Palau in Carolina Islands are taking daily observations on declination only just for the purpose of checking bearings in charts.

A new magnetic survey of Taiwan (Formosa) is now finished and the results are ready for press. 100 stations were taken, at 26 of which absolute measurements of H were made and the rest are relative determinations with reference to those stations.

A new magnetic observatory at Miyako is now being built and will be working next year.

A small wooden ship of 200 tons is designed for making magnetic observations on sea. This is to work in conjunction with a larger iron ship of 1100 tons destined for geophysical and other researches. The observers will be lodged on board of this ship and will take observations on quiet days on the small wooden ship at a sufficient distance from the iron ship. The idea was suggested to Dr. Bauer when the *Carnegie* was going to be built. The two ships will be ready toward the end of the next summer, and we hope the trial may suggest certain advantages for future extension of the ocean magnetic works.

As to theoretical works, two endeavours, one by Mr. M. Hasegawa, Rigakusi, and the other by Mr. K. Terada, Rigakusi, may be mentioned. The former is studying the types of the diurnal magnetic variations and their distribution over the earth and the progressive march of the type round the earth; the corresponding system of currents in the air and earth are calculated. Two preliminary summaries are in the *Proceedings of the Imperial Academy,* Vol. XII. The latter has attempted to calculate the horizontal current in the atmosphere by taking the circulation of magnetic force, assuming the vertical variation of H to be that of the first term of the harmonic expansion and taking the observed variations of Z on the earth surface. Two papers in Japanese are now put in English in one paper in the *Geophysical Magazine,* Vol. X. The result calculated from the old data of Ad. Schmidt of 1885 and that calculated from the data of Dyson and Furner of 1922 agree in essential features.

The observations carried during the total solar eclipse June 19th, 1936, are being reduced: their preliminary reports are communicated in separate brochures.

Addenda. Three QHM have just arrived from Dr. Fleming, and they are sent to Kakioka where comparisons will be made.

OBSERVATIONS OF TERRESTRIAL MAGNETISM, ATMOSPHERIC ELECTRICITY AND EARTH-CURRENTS BY THE CENTRAL METEOROLOGICAL OBSERVATORY OF JAPAN

By T. OKADA

The Central Meteorological Observatory, Tokyo, is making systematic observations of terrestrial magnetism, atmospheric electricity and earth-currents at the Kakioka and Toyohara magnetic observatories attached to it.

1. *The Kakioka Magnetic Observatory.*

Kakioka is a small town lying at a distance of 70 km to the north-west of Tokyo, and the Magnetic Observatory is situated at the outskirt of the town. The geographical coordinates of the Observatory are: —

Longitude: 140° 11′ 21″ E
Latitude: 36° 13′ 51″ N
Height: 28.2 m. above sea-level.

The main building of the Kakioka Observatory is a reinforced concrete building, 23.1 m. long and 11.2 m wide. The building has seven rooms beside a kitchen and a bath room. In the seismometer room are installed a set of Wiechert's horizontal and vertical seismographs and a strong motion seismograph. In the clock room is working Riefler's normal astronomical clock, No. 460, and a secondary clock, No. 491. The absolute house is built of white bricks, and is 7.3 m. long and 3.6 m. wide. There Ad. Schmidt's normal magnetic theodolite No. 5, constructed by the Askania Werke, Berlin, is installed. The variation house is also built of white bricks free from ferric components. There Ad. Schmidt's variometers are constantly working.

At the Observatory the variations of the three elements are constantly recorded by a set of Ad. Schmidt's magnetographs constructed by Askania Werke in Berlin, and a set of absolute measurements is made once a week with Ad. Schmidt's normal theodolite and earth inductor also constructed by the same German firm. The Kakioka Observatory is under the charge of Mr. S. Imamiti.

The provisional mean values of the three magnetic components at Kakioka for each month and the year 1935 are as follows: —

The mean values of the magnetic elements
at Kakioka, 1935.

Element	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
D. 5°	+48′.3	48′.5	48′.7	48′.7	48′.9	49′.6	49′.4	49′.8	50′.4	50′.4	50′.1	50′.6	49′.5W
H. 29000γ	+714	719	711	717	729	729	734	724	709	711	724	710	719
V. 34000γ	+813	799	800	827	836	837	830	826	819	834	826	824	822

At Kakioka the atmospheric electric potential gradient is continuously recorded by a quadrant electrometer of the Benndorf pattern. As the collector a Lord Kelvin's water dropping apparatus is used. The electric conductivity of air is observed with Gerdien's apparatus. The variations of earth-current are also recorded by the galvanometric method. The electrodes in use at Kakioka are copper plates of one metre square, each coated by a thick layer of oak-charcoal powder. They are buried at a depth of three metres below the surface of ground.

2. *The Toyohara Magnetic Observatory.*

Toyohara is a town in South Sakhalien. The Magnetic Observatory stands in the eastern outskirt of the town, and has the geographical coordinates: —

Longitude:	142° 45′ E
Latitude:	46° 58′ N
Height:	61.5 m. above sea-level.

The main building of the Observatory is a two storied wooden house, 6.6 metres wide and 8.4 metres long. In the ground floor there is a computation room, a dining room and two dark rooms, one for recording the variation of earth-current and the other for photography, beside a lobby, a kitchen and a bath room. In the first floor there is a reception room, a room for the recording instrument for atmospheric electric observation and three private rooms for observers. The variation house is built of wood, and is 10.4 metres long and 7.3 metres wide, a lobby dividing it into two rooms. The eastern room is again divided into two parts. In one of them is placed a set of recording apparatus while in the other a set of Eschenhagen's variometers. In the western room is working a horizontal force variometer and a quick running recorder constructed in the work shop of the Central Meteorological Observatory, Tokyo. In order to keep the daily range of the temperature in the rooms of the variation house to be negligibly small, the space between the double walls of the house is filled with saw-dust. The absolute house is also built of wood, and is 7.5 m. long and 4.7 m. wide. The building has two rooms. In one of them is placed a magnetic theodolite of the Indian Survey pattern, and in the other are placed an earth-inductor and a galvanometer. An azimuth mark for declination observation is put at a distance of about 600 m. to the east of the building. The magnetic theodolite was made by Cooke, Troughton and Simms, Ltd., London, and was carefully certificated in the Greenwich Observatory. The earth-inductor was made by Edelmann, Munich. The variometers were constructed by Otto Töpfer and Sohn, Potsdam.

The variations of the three components of the magnetic elements are continuously recorded, and the absolute measurements of the elements are taken once a week. Records of earth-currents, atmospheric electric potential and the electric conductivity of air are also made. The Toyohara Magnetic Observatory is under the charge of Mr. M. Hirayama. The results of the magnetic and electric observations made at Toyohara during the Second Polar Year 1932-1933 have been published in the *Bulletin* of the Central Meteorological Observatory of Japan, Vol. V, No. 2, 1936. The provisional mean values of the magnetic elements for each month and the year, 1935, are as follows: —

The mean values of the magnetic elements
at Toyohara, 1935.

Element	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
D. 9°	+1′.9	2′.0	1′.9	2′.6	2′.8	3′.3	3′.5	3′.8	5′.0	5′.2	5′.0	5′.3	3′.5W
H. 25000γ	+032	027	024	029	039	036	034	035	020	015	029	032	029
V. 44000γ	+607	612	609	606	612	612	602	601	591	606	617	630	609

At Toyohara the atmospheric electric potential gradient is also continuously recorded by means of a Benndorf's electrometer and a radio-thorium collector. The electric conductivity of air is observed with a Gerdien's apparatus. The variation of earth-current is recorded by galvanometric method just in the same way as at Kakioka.

3. *The Magnetic Survey of Formosa.*

For finding the eventual variation in the distribution of the terrestrial magnetism in Formosa, due to the great earthquake on April 21, 1935, the Central Meteorological Observatory, Tokyo, has undertaken a complete magnetic survey of the islands at the request of the Government General of Formosa. The party engaged in the work consists of three experts, T. Kubo of the Imperial Marine Observatory, Kobe, H. Hatakeyama of the Central Meteorological Observatory, Tokyo, and R. Yosimatu of the Kakioka Magnetic Observatory, Kakioka. In the magnetic survey the following instruments are used: a set of the magnetometers of the Indian Survey pattern made by Cooke, Troughton, and Simms, London, and a dip circle made by Watson, London. A set of Ad. Schmidt's Local variometers was also used to find the local anomaly in the distribution of the terrestrial magnetism. The points at which the observations were taken are 100 in number. The complete sets of the magnetic observations were taken at 26 of these stations with the magnetometers, and the variations in declination and horizontal force were observed at the remaining 74 stations by the local variometers. All of these observations have been reduced to the values at sea-level for the beginning of 1936. Using the results of observations at these 26 stations the following empirical expressions have been obtained: —

$$H = 36402.7 - 5.366\Delta\varphi - 2.602\Delta\lambda + 0.00043\Delta\varphi^2 + 0.00133\Delta\varphi\Delta\lambda - 0.00227\Delta\lambda^2$$

$$I = 32^\circ\ 41.'88 + 1.'820\Delta\varphi - 0.'064\Delta\lambda + 0.'00011\Delta\varphi^2 - 0.'00134\Delta\varphi\Delta\lambda + 0.'00011\Delta\lambda^2$$

$$\delta = 1^\circ\ 23.'00 + 0.'295\Delta\varphi + 0.'014\Delta\lambda + 0.'00015\Delta\varphi^2 + 0.'00022\Delta\varphi\,\Delta\lambda - 0.'00085\Delta\lambda^2$$

$$Z = 23384.6 + 23.831\Delta\varphi - 2.325\Delta\lambda - 0.00194\Delta\varphi^2 - 0.00281\Delta\varphi\Delta\lambda + 0.00415\Delta\lambda^2$$

where $\Delta\varphi = (\varphi - 23^\circ\ 30.'0)$ and $\Delta\lambda = (\lambda - 121^\circ)$

NORWAY

REPORT ON MY GEOPHYSICAL WORK IN THE PERIOD 1932-1936, FROM THE MEETING IN LISBON TO THE MEETING IN EDINBURGH

By CARL STÖRMER

The geophysical work done in the period 1932 to 1936 falls along two different lines: A. Observational work on aurora and on stratospheric clouds, and B. Theoretical work on electron orbits with application to aurorae and to cosmic rays.

A. *Observational work on aurora and on stratospheric clouds.* During the period in question 10 aurora stations in southern Norway have been in action. Each station had the necessary equipment for photographing the aurora or stratospheric clouds and could be connected to 1, 2 or 3 other stations by means of the state telephone lines.

In the years 1933, 1934, 1935, 1936 aurorae were photographed on 56 nights. The following table gives the number of *successful* pictures taken from *one* station only (I), the number of successful sets taken simultaneously from two stations connected by telephone (II), from three stations (III) and from four (IV):

Year	I	II	III	IV
1933	380	416	113	8
1934	165	75	68	6
1935	434	219	82	39
1936 (till June)	188	141	126	8
sum	1167	851	389	61

Some spectra have also been taken; they will be mentioned in a paper under preparation.

Of this extensive material only a small fraction has hitherto been measured and calculated. The work, however, is now going on in the new Institute for theoretical Astrophysics, where rooms and other facilities have given much better conditions for work than in earlier years.

The following papers in connection with aurora have been published:

1. Die wichtigsten Ergebnisse der Nordlichtforschung. Elektrische Nachrichtendienst, Bd. 10, 1933.
2. Über eine Nordlichtexpedition nach Trondheim im März 1933, Gerlands Beiträge z. Geophysik, Bd. 41, 1934.
3. Ergebnisse der Nordlicht-Photographie im südlichen Norwegen im Internationalen Polarjahr 1932-1933. Archiv für Polarforschung, Jahrg. 4.
4. Measurements of Aurora with very long base lines. Geofys. Publ., XI, 3.
5. Remarkable Aurora forms from southern Norway: I. Feeble homogenous Arcs of great Altitude. Geofys. Publ., XI, 5.

As to the stratospheric clouds, they have been photographed from the same stations as the aurora. I give only the papers published since the beginning of 1933:

1. Höhe und Lage von leuchtenden Nachtwolken beobachtet in Norwegen im Jahre 1932. Meteorol. Zeitschr., 1933.
2. Height and Velocity of Luminous Night-Clouds observed in Norway 1932. University Observatory Publications, Oslo, No. 6, 1933.
3. Nuages dans la stratosphère. Comptes-Rendus, Paris, t. 196, p. 1824, June 1933.
4. Höhenmessungen von Stratosphärenwolken. Beiträge zur Physik der freien Atmosphäre, Bd. 21, 1933.
5. Luminous Night-Clouds. Nature, Vol. 134, p. 219.
6. Luminous Night-Clouds over Norway in 1933 and 1934. Nature, Vol. 135, p. 103.
7. Measurements of Luminous Night-Clouds in Norway 1933 and 1934. Astrophysica Norvegica, Vol. I, 3.

The very extensive material of photographs of Mother of Pearl Clouds from later years consisting of some hundred pairs for measuring height and velocity, are being measured now.

B. *Theoretical work on electron orbits with application to aurora and to cosmic rays.*

As the problem of the motion of an electron in the field of a magnetic dipole, so interesting for the theory of aurora, in the latest years has required new interest on account of its application to the theory of cosmic rays, a long series of numerical calculations have been started continuing those of 1904-1910. About 26000 norwegian crowns have been granted from norwegian scientific funds for this work.

In the period 1933 till now the following papers have been published by the author:

1. Über die Bahnen von Elektronen im axialsymmetrischen elektrischen und magnetischen Felde. Annalen der Physik, Bd. 16, 1933.
2. Angenäherte Integration der Bewegungsgleichungen von Elektronen im Felde eines magnetischen Dipols. Zeitschrift für Astrophysik, Bd. 6, 1933.
3. On the trajectories of electric particles in the field of a magnetic dipole with application to the theory of cosmic radiation I, II, III, IV and V. University Observatory Publications, Oslo, Nos. 10 and 12, and Astrophysica Norvegica, Oslo, Vol. I, Nos. 1 & 4, and Vol. II, No. 1, 1933-1936.
4. Critical Remarks on a Paper by G. Lemaitre and M. S. Vallarta on Cosmic Radiation. Phys. Review, Vol. 45, p. 835.

The numerical integrations are still going on, and new papers are ready for publication.

August, 10th, 1936.

SHORT REPORT ON GEOPHYSICAL RESEARCHES AT THE AURORAL OBSERVATORY, TROMSØ

By LEIV HARANG

Earth-Magnetism

The registrations of the three components D, H, and V have been continued and absolute determinations have been made at regular intervals for checking the base lines. The hourly values have been published in the series *Publikasjoner fra Det Norske Institutt for Kosmisk Fysikk,* up to the year 1935.

On the islands of Jan Mayen and Bjørnøya (Bear Island) the registrations of D, H and V by two sets of "Variomètre de Copenhague" have been continued.

Aurorae

(a) *Parallactic photography.*

Parallactic photos have regularly been taken of auroral forms which seemed to be of more unusual character. A great number of photos have been taken during the last three winters, of which a number taken of sunlit and redcoloured aurorae have been measured out.

(b) *Spectrography.*

Exposures of spectra in the region of longer waves through spectrographs of medium dispersion have been continued. The times of exposures were several months. A report on the results is given in prof. Vegard's memorandum on researches in the auroral spectrum.

For precision measurements of the wave-lengths the green and red auroral lines have been photographed through Fabry-Pérot interferometers. The observations of the red auroral line is being continued.

Ionosphere

By means of a pulse transmitter and a receiver supplied with cathode ray oscillographs the ionized layers of the upper atmosphere have been observed daily from April 1935. Special attention has been paid to the following two groups of observations: (a) Determination of the noon values of the critical frequencies. (b) Variations of the electron densities of the layers during magnetic storms and aurorae. The results are discussed in a special report. (See below).

Atmospheric Ozone

From July 1935 measurements of the atmospheric ozone by means of a Dobson spectrograph have been continued by Mr. E. Tønsberg. During the dark period in winter the spectra of the sun were supplied and replaced by spectra of the moon taken by a quartz-spectrograph and of stars (α Lyrae and γ Cassiopeiae) taken by a Chalonge spectrograph. A report on the results obtained was given on "The International Conference on Questions relating to Atmospheric Ozone, 1936", and printed in the papers of the Royal Meteorological Society of London.

INVESTIGATIONS ON THE AURORAE AND THE IONOSPHERE AT THE AURORAL OBSERVATORY, TROMSØ ($\varphi = 69°40'$ N, $\lambda = 18°57'$ E. Gr.)

By LEIV HARANG

1. *Aurorae.*

Simultaneous parallactic photos of aurorae have been taken at regular intervals during the last winter seasons from the Observatory and our second station Tenness, lying 43.2 km to the south. During the last winter a series of parallactic photos of more than 700 pairs taken on the evenings from March 15 to 23, 1936, are especially interesting as the aurorae appearing in a number of cases were lying in the sunlit atmosphere.

The heights of the sunlit aurorae may give valuable informations about the vertical movements of the atmosphere from the dark to the sunlit part, which one must expect on account of the temperature variations.

On October 27, 1935, parallactic photos of an auroral arc of a length more than 800 km was taken, the one half of the arc was lying in the sunlit atmosphere the other half in the dark. The heights of the lower border of this arc increased continuously from the uniform height of 100 km in the dark atmosphere, which is the usual height of auroral arcs lying in the dark atmosphere, to the unusual great height of 140 km in the sunlit atmosphere. Assuming the electrically charged particles producing the aurorae to have the same penetrating power along the arc, the variation of height from the dark to the sunlit atmosphere indicates the position of an isobaric surface in the atmosphere. The continuous increase of the heights of this isobaric surface from the dark to the sunlit atmosphere is to be regarded as an effect of the termal expansion of the atmosphere in 100 km's height due to the temperature increase*).

In the material from March 1936, this effect of the sunrays on the heights of arcs and bands lying partly in the dark and the sunlit atmosphere, has been confirmed in a number of cases. A preliminary report of these height-measurements is given in a paper in Beiträge zur Geophysik**).

Besides of sunlit aurorae, parallactic photos of a number of arcs and bands having a more or less pronounced red colouring at the bottom edge have been taken. In accordance with

*) Terr. Mag., Vol. 41, p. 143 (1936).
**) Beitr. z. Geophysik, 48, 1-12 (1936).

previous height determinations*) the red colouring was accompanied by a decrease of the heights of the individual auroral forms, indicating an increase of the penetrating power of the electrically charged particles producing the red coloured aurorae. A spectrum taken of these red coloured arcs and bands show an increase of the intensity of the red oxygen doublet 6300 and 6360 Å ($1D_2 - 3P_2$) and ($1D_2 - 3P_1$).

Besides spectra taken more occasionally of individual auroral forms, special attention has been paid to trials to obtain interferometric pictures by means of Fabry-Pérot interferometers of the red auroral line 6300 Å. A first picture was obtained in January 1934**). During the last winter we have succeeded in obtaining a number of pictures which will allow a more precise determination of the wavelength.

2. *Ionosphere.*

Observations of the ionosphere by means of radio echoes were commenced in April 1935 and now form a part of the programme of observations. The Breit and Tuve pulse method is used. The apparatus consists of a small pulse transmitter and a receiver supplied with cathode ray oscillographs for recording the echoes appearing. The transmitter and the receiver are placed in the same room and the transmitting and receiving of the signals are performed on two crossed dipoles. Special attention has been paid to the following observations.

a. *Measurements of the critical frequencies at noon of the ionized layers.*

The critical frequencies, *i. e.* the limiting frequency at which the waves penetrate a layer, is recorded at local noon by recording the echoes appearing in a frequency interval of 1-10 Mgc/sec. As a supplement the same observations are usually repeated at 10h, 14h and 18h local time. Investigations by radio methods have shown that the ionosphere consists of two main divisions, the Kennelly-Heaviside-layer (or E-layer) in 110 km and the Appleton-layer (or F-layer) in 230 km height. Besides these two main divisions, the F-layer shows during the day, and in high latitudes as in Tromsø only during the four summer months, a ledge in the ionisation curve at the lower boundary, the F_1-layer, whereas the main layer is named as the F_2-layer.

In fig. 1 the critical frequencies (ordinary component only), of the E-, F_1- and F_2-layers measured at local noon from April 1935 to July 1936 is shown. During undisturbed conditions no E-echoes up to 1 Mgc/sec. is obtained in the months December-January when the sun is below the horizon, whereas the F_2-

*) Beitr. z. Geophysik, 37, 109 (1932).
**) Harang and Vegard: Nature, 135, 542 (1935).

layer during winter time shows a strong increase of the critical frequencies, *i. e.* the maximum electron density of the layer.

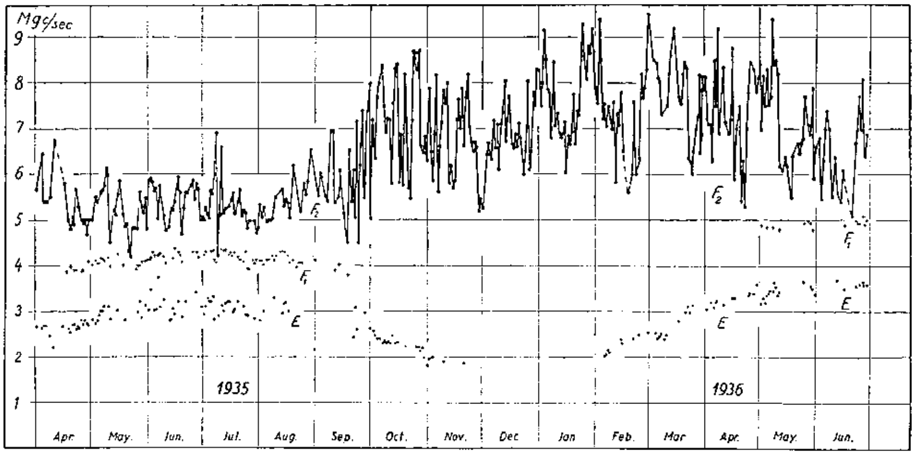


Fig. 1. — The critical frequencies of the E-, F_1- and F_2-layers, ordinary component only.

This increase of the critical frequencies during winter time is in accordance with earlier observations in Slough (England) and Deal and Washington (U.S.A.).

The noon values of the critical frequencies from spring and summer 1936 show a considerable increase for all three layers when compared with the same months in 1935. The following table shows the increase of the mean monthly values of the critical frequencies for three months from 1935 to 1936.

Table 1.

	1935			1936					
	E	F_1	F_2	E	F_1	F_2	Δ E	ΔF_1	ΔF_2
	Mgc/sec	Mgc/sec	Mgc/sec	Mgc/sec	Mgc/sec	Mgc/sec	Mgc/sec	Mgc/sec	Mgc/sec
April	2.63	3.94	5.30	3.25		7.40	+ 0.62		+ 2.10
May	2.95	4.06	5.31	3.43	4.89	7.19	+ 0.48	+ 0.83	+ 1.88
June	3.17	4.23	5.48	3.61	4.96	6.61	+ 0.44	+ 0.73	+ 1.13

Now the solar acitivity measured by the sunspot activity or the Earth's magnetic activity shows a considerable increase from 1935 to 1936. The simultaneous increase of the critical frequencies for all three layers from 1935 to 1936 shows that the ionizing agency producing the day-time ionisation in the highest layers must show a parallel increase. Observations during solar eclipses show that at least for the E- and F_1-layers, the ionizing agency most probably is the ultraviolet part of the solar spectrum. The considerable annual increase of the critical frequencies indicates that this part of the solar spectrum lying in the region of the ionisation potentials of the oxygen and nitrogen molecules, which correspond to 766 and 730 Å, must show a simultaneous increase in the intensity. It will be of special interest to investigate if the considerable annual increase of the critical frequencies also appears in lower latitudes, or, whether it is more pronounced in the vicinity of the auroral zone. The latter would indicate that besides the ultraviolet part of the solar spectrum, also charged particles emitted from the Sun may be of importance for the production of the day-time ionisation.

b. *The effect of the aurorae and the Earth magnetic storms on the ionized layers.*

The Observatory, lying in the vicinity of the auroral zone, is especially suited for studying the influence of the Earth magnetic storms on the ionized layers. Previous investigations have shown that the effect of aurorae and Earth magnetic storms may be summarized as follows:*).

Magnetic storms and aurorae of low intensity produce a strong ionisation in the niveau of the E-layer (100-150 km). This strong E-ionisation usually screens off the higher F-layers from observations.

Intense magnetic storms and aurorae are usually accompanied by a complete cessation of all echoes in the frequency interval used, 1-10 Mgc/sec. This is explained by the absorbing effect of an ionized layer *below* the usual layers. On account of the higher density of the air, the collisional friction will be considerable and the signals on the wavelengths used will be absorbed.

In order to investigate more quantitatively the effect of the Earth magnetic storms on the ionized layers, special attention has been paid to *small* Earth magnetic disturbances, during which the echoes still may be obtained. By determining the critical frequencies at short intervals, usually every half an hour or less, during 24 or 36 hours, one may follow continuously the change of the maximum electron-density computed from the critical frequencies during the Earth magnetic perturbations.

According to the magneto-ionic theory for the propagation of radiowaves under the influence of the Earth's magnetic field developed by Appleton, the maximum electron-density N of a layer is determined from the critical frequency doublet f_1 and f_2 from the following equations:

*) Appleton, Naismith and Builder: Nature, 132, 340 (1933).

$$N = (3\pi m/2e^2)\, f_1^2 \qquad \text{(ordinary ray)} \qquad (1)$$

$$N = (3\pi m/2e^2)\, (f_2^2 - f_H f_2) \qquad \text{(extraordinary ray)} \qquad (2)$$

where *m* and *e* are the mass and charge of the electron and f_H is the gyro-frequency of the free electron in the Earth's magnetic field, for Tromsø we have $f_H = 1.39$ Mgc/sec.

In figs. 2 and 3 is shown the variation of the maximum electron-density on a number of days with small Earth magnetic disturbances. The electron-densities have been calculated using the formulas (1) and (2), and the values for the ordinary

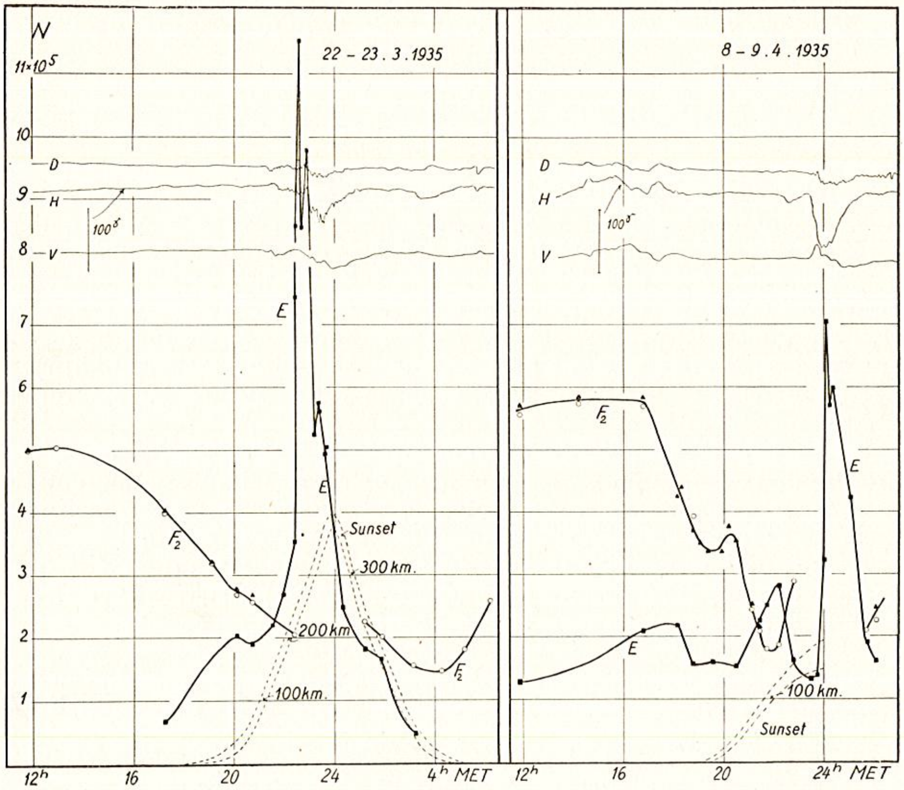


Fig. 2. — The maximum electron-densities *N* of the F_2- and E-layers, calculated from the critical frequencies measured. ○ and ▲ correspond to the ordinary and extraordinary component of the critical frequencies of the F_2-layer, ■ to the ordinary component of the critical frequency of the E-layer.

The broken curves indicate the heights of the sunrays entering the atmosphere during the observations, with and without taking the effect of refraction into account.

The figure illustrates the sudden increase of the E-ionisation during the small Earth magnetic disturbance.

Fig. 3. — The figure illustrates the sudden increase of the E-ionisation during the small Earth magnetic disturbance.

The equivalent heights of the points of reflexion in the F_2-layer for a number of frequencies are indicated below. After the Earth magnetic disturbance the heights of the F_2-layer show abnormal great values, the layer has been expanded during the disturbance and is sinking down in the early morning hours.

and extraordinary ray are indicated by O and ▲ in the figures*).

As previously mentioned the increased ionisation of the E-layer during Earth magnetic disturbances usually screens off the higher layers and makes impossible direct measurements of the ionisation of the F-layers during disturbances. The influence of the Earth magnetic storms on these layers is shown in an indirect way. As shown by Schafer and Goodall**) and by Appleton and Ingram***) there is a negative correlation between the Earth magnetic disturbances and the critical frequencies of the F_1- and F_2-layers. During periods of Earth magnetic activity the critical frequencies of the F-layers shows a reduction of the normal values. According to Appleton this is to be explained as a temperature effect; during periods of Earth magnetic activity the layer will expand, which causes a reduction of the maximum electron-density.

A statistical treatment of the noon values of the critical frequencies from a highly disturbed place as Tromsø shows this effect distinctly. From the smoothed annual curve of the noon values of the F_1- and F_2-critical frequencies, the daily departure was computed. The Earth magnetic activity from the observatory's records was determined for each day from noon to the following noon by measuring the hourly departures from the undisturbed values of the field, and the diurnal sum computed. The correlation coefficient was computed between the departure of the critical frequency at noon and the Earth magnetic activity during the following 24 hours (column D), the preceeding 24 hours (column C) and the Earth magnetic

Table 2.

F_2-layer.

	A	B	C	D
May-June	—0.354	—0.517	—0.642	—0.444
July-August	—0.293	—0.213	—0.427	—0.224
September-October	—0.020	—0.259	—0.520	+0.019
November-December	—0.162	—0.257	—0.337	—0.122
January-February	—0.125	—0.317	—0.599	—0.266
March	—0.401	—0.574	—0.655	—0.472
	F_1-layer.			
June-July	—0.001	—0.190	—0.353	—0.091

*) A number of diurnal curves showing the variation of the electron-densities of the E- and F_2-layers during quiet and disturbed days are published in Beitr. z. Geophysik, 46, 438 (1936).

) Proc. Inst. Radio Eng., 23, 670 (1935). *) Nature, 136, 548 (1935).

activity during the 24 hours respectively one and two days before the critical frequency determination (columns B and A). Table 2 shows that the greatest negative correlation coefficient is between the departures of the critical frequency and the Earth magnetic activity during the *preceeding* 24 hours, thus indicating that the decrease of the critical frequencies of the F_1- and F_2-layers is a *post*-effect of the Earth magnetic disturbances. This confirms the point of view of the heating effect of the Earth magnetic storms on the highest layers.

More directly we may see the opposite variation of the critical frequencies of the F_2-layer and the Earth magnetic activity from fig. 4, where the decrease of the critical frequencies during periods of strong magnetic activity during the months of February and March 1936 is evident.

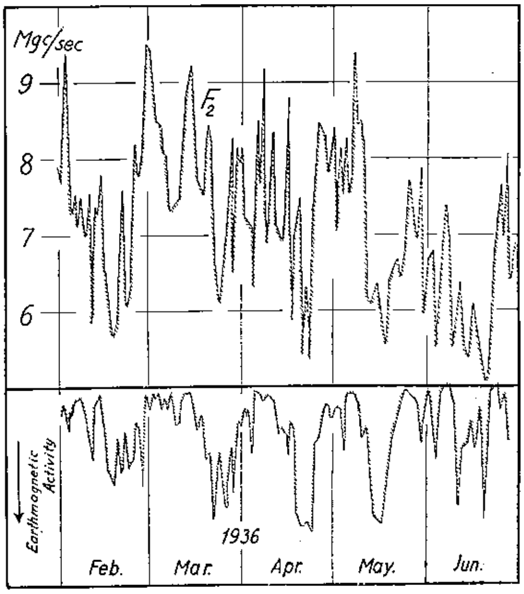


Fig. 4. — Variation of the critical frequencies (ordinary component) of the F_2-layer and the Earth's magnetic activity in arbitrary units determined from the Observatory's records.
Disturbed periods are accompanied by a decrease of the critical frequencies.

We also have an indication of the expansion of the F_2-layer during Earth magnetic disturbances in the variation of heights of the reflection point in the F_2-layer during the hours *after* a disturbance. In a number of cases we have noticed that the F_2-layer when coming in after an Earth magnetic disturbance shows abnormal great heights, which rapidly decrease with the time. This effect is illustrated in fig. 4.

REPORT REGARDING THE WORK AT THE MAGNETIC BUREAU, BERGEN

By B. TRUMPY

Since 1916 a magnetic station at Dombås (φ = 62° 04.′ 7 N; λ = 9° 05.′ 8 E) has been run, and the three elements D, H and V have been permanently registered. It has from the start been intended to use the material collected at this station for the study of the *variations,* so that little stress has been laid on the absolute observations. In fact, absolute measurements have been made only to produce data to be used for the calculation of the scale values for the intensity curves.

When "*Det Magnetiske Byrå*" at Bergen was started in 1929 the working up of the Dombås material was immediately begun and has been continued the whole time. In the course of the present year the prepared tables will be published in the series *Publikasjoner fra Det Norske Institutt for Kosmisk Fysikk.* In the "Report Regarding the Work at the Magnetic Bureau", Bergen — written by O. Krogness in Bulletin No. 9, 1934, (p. 86), — the leading principles of the treatment of the material and the form of the intended publication have been sketched and the practical carrying out of the plan and the methods used for the reduction shall be treated in detail in the publication, mentioned above.

On account of the extent of the material collected at Dombås, it is out of question to print hourly values and we have therefore had to limit the printed data to two sets of tables:

1. giving monthly values for the quiet diurnal variation;
2. giving monthly mean values for the diurnal variation of the "*storminess*".

Beside this we give data for "*absolute storminess*" as expression for the magnetic character of each day. Such tables are given for the entire period 1916-33.

In the mentioned publication from Dombås no discussion of the obtained results will be given. The results show, however, that the material given is very promising as a foundation for a detailed study of the nature of the variation. This is the case for the quiet diurnal variation as well as that of storminess. Such studies have been taken up at the Bureau, and the results are to appear in special papers.

A systematic and homogeneous magnetic survey of Norway including about 100 stations distributed over the whole country has been planned. This work will be carried out as soon as possible.

POLAND

TRAVAUX DE L'OBSERVATOIRE MAGNÉTIQUE DE SWIDER 1933-1936

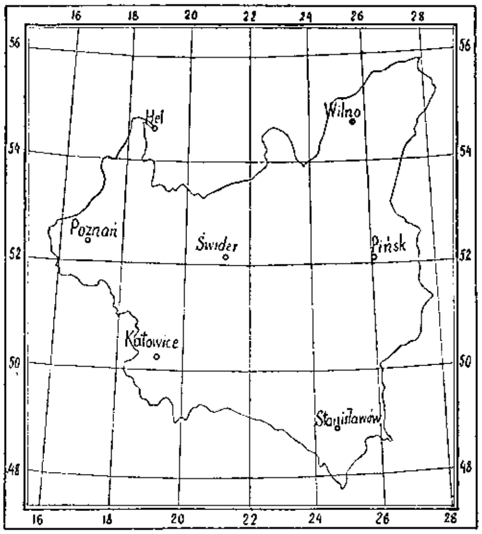
Par St. KALINOWSKI

I. *Magnétisme Terrestre.*

Le travail courant de l'Observatoire a été continué suivant le programme des années précédentes. Les mesures absolues ont été exécutées dans les intervalles fixes. Les enregistreurs ont travaillé régulièrement excepté quelques interruptions de courte durée liées avec le fonctionnement des lampes. Aux termes habituels nos données ont été communiquées au Secrétariat de l'Organisation Météorologique Internationale à De Bilt et se trouvent dans ses publications («Caractère magnétique de chaque jour des mois» et «Caractère magnétique numérique des jours»).

En 1934 fut publié le No. 6 des *Travaux de l'Observatoire Magnétique de Swider* contenant les résultats de toutes les observations magnétiques effectuées à Swider dès 1930 à 1933. En 1935 parut le No. 7 des *Travaux* avec une carte d'isogones de la Pologne pour l'an 1935. Cette édition, utile à tous ceux qui ont à faire à la déclinaison magnétique, contient les tableaux qui permettent de trouver d'après les valeurs moyennes annuelles et mensuelles de la déclinaison sa valeur pour un jour donné et pour une heure donnée. En 1936 fut publié le No. 8 des *Travaux* renfermant les résultats de nos observations de la composante horizontale et de la composante verticale effectuées à l'Observatoire au cours des années 1921-1929. Ce dernier volume constitue un supplément au No. 4 des *Travaux* qui ne contenait que les données sur la déclinaison pour la même époque. Les résultats de nos observations à Swider de 1934-1935 restent ainsi seuls inédits. La publication de ces données va paraître, on peut l'espérer, vers la fin de l'année courante.

Considérant la question de la marche séculaire des élements magnétiques et sa dépendance de la position géographique comme question d'une importance exceptionnelle, notre Observatoire avait exécuté les mesures systématiques dans six points (stations séculaires) situés dans diverses parties de la Pologne. Ces six lieux sont comme il suit: Hel, Poznan, Katovice, Wilno, Pinsk, Stanislawów. La figure ci-contre montre les positions. Compris par soi-même, l'Observatoire de Swider est notre septième station séculaire. L'inconvénient des mesures dans les six points nommés provenait jusqu'à présent de la nécessité de placer les instruments sur des trépieds portables. Maintenant nous sommes en train d'installer les piliers spéciaux



Stations séculaires de la Pologne.

dans les six points nommés provenait jusqu'à présent de la nécessité de placer les instruments sur des trépieds portables. Maintenant nous sommes en train d'installer les piliers spéciaux dans ces six stations. Nous allons publier prochainement nos conclusions préliminaires sur la marche séculaire.

Un autre problème de grande importance dont notre Observatoire s'occupe à présent c'est l'étude des anomalies magnétiques qui ont été constatées par le levé magnétique de la Pologne. Les résultats de cette étude vont faire l'objet des publications spéciales.

Il faut ajouter enfin que le levé magnétique du IIe ordre de la Pologne est déjà commencé. La distance entre les stations ne dépassera pas 18 km. Notre nouveau réseau sera plus de quatre fois plus serré que le réseau du premier levé. Il est difficile de déterminer d'avance la durée de ce nouveau travail. Elle va naturellement dépendre des moyens dont l'Observatoire pourra disposer.

II. *Electricité Terrestre*.

Lorsque le travail de l'Observatoire de Swider dans le domaine du magnétisme terrestre fut définitivement organisé et il ne restait que d'exécuter le plan fixé, il me vint l'idée d'élargir ce travail en embrassant quelques autres branches de la Physique du Globe, de transformer ainsi peu à peu notre Observatoire Magnétique en un Observatoire Géophysique.

En premier lieu, je me mis à organiser l'étude de l'électricité terrestre. Grâce au subside de notre Ministère de l'Instruction Publique fut construit un petit pavillon en briques blanches destiné aux mesures électriques. Les défauts de construction causèrent que le pavillon se montra humide et il fallait le reconstruire fondamentalement. C'est seulement en 1929 qu'il nous est devenu possible de commencer l'enregistrement des variations du potentiel électrique à l'aide de deux électromètres Benndorf de différente sensibilité. Les moyens nécessaires pour l'achat de ces instruments nous ont été offerts par le Fonds de la Culture Nationale. Le secours du Fonds nommé nous a permis de nous procurer encore deux pièces de ces électromètres qui étaient destinés à l'enregistrement de la conductivité de l'air et de l'électricité des précipitations. A regret nous n'avons pas réussi jusqu'à présent de trouver les moyens pour mener au bout l'installation complète pour les deux derniers problèmes. Il faut attendre une conjoncture plus favorable.

Quant aux observations du potentiel électrique, la détermination du coefficient de réduction nous présentait quelques difficultés. Nous avons résolu ce problème en employant deux méthodes: la méthode directe des observations absolues et la méthode de laboratoire au moyen d'un modèle du pavillon et du terrain qui l'entoure. Les détails et les résultats déjà obtenus, vont être le sujet d'une publication spéciale.

SWEDEN

REPORT ON WORK IN TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY IN SWEDEN SINCE THE LISBON ASSEMBLY

By HARALD NORINDER

Biographical notes

Since the Lisbon Assembly in 1933 the Section of Terrestrial Magnetism and Atmospheric Electricity has lost one of its distinguished members, Dr. Vilhelm Carlheim Gyllensköld, who died in Stockholm on December 13, 1934.

As a member of the Swedish National Committee for Geodesy and Geophysics and of the International Commission of Terrestrial Magnetism and Atmospheric Electricity Dr. Gyllensköld attended most of the geophysical conferences held during the latest decades. From 1927 he was Vice-President of the Association of Terrestrial Magnetism and Atmospheric Electricity of the international Union, and he presided at the Session during the Stockholm meeting in 1930.

Since the Lisbon Assembly the Section of Terrestrial Magnetism and Atmospheric Electricity has lost another of its members, Dr. Bruno Rolf, Statens Meteorologisk-Hydrografiska Anstalt, Stockholm. Dr. Rolf, died in Stockholm om May 4th 1934.

With the death of Dr. Rolf the Section has lost one of its members who since many years was active in geophysical investigations and especially in terrestrial magnetism in connection with the Abisko station.

Progress of work in Terrestrial Magnetism and Atmospheric Electricity in 1934-1936

As is to be seen from the enclosed Special Reports continuous magnetic observations have been carried out in Sweden, since the Lisbon Assembly, on the following localities. *The magnetic observatory at Lovö, Stockholm. The observatory at Abisko.*

Survey work has been carried out by the Geological Survey of Sweden (Sveriges Geologiska Undersökning) and by the Hydrographic Office of Sweden (Kungl. Sjökarteverket).

Special investigations into atmospheric electricity have been carried out in Sweden since the foregoing assembly.

The reduction and the discussions of observational data from the Swedish Polar Year station at Sveagruvan, Spitzbergen are under preparation for publication. Detailed information of the present state of the compilation for publication is given in an enclosed Special Report.

SPECIAL REPORTS

MAGNETIC WORK, CARRIED OUT BY THE HYDROGRAPHIC SERVICE OF SWEDEN (KUNGL. SJÖKARTEVERKET) IN 1934 AND 1935

By E. BOUVENG

Survey work. — In 1934, the magnetic declination was determined at 72 sea stations. Re-measurements of D, I and H, have been made at 12 land stations.

The net of main repeat-stations, measured in the years 1928 -1930, is prepared to be re-measured in 1936-1937.

The magnetic observatory at Lovö (Stockholm). — Since the report in 1933, the observatory has continued with the registering of D, H and Z, including as well "normal" registering, as "rapid registering" with the la Cour variometers.

Intercomparison of magnetic standards. — The standards of the field instruments of the Kungl. Sjökarteverket were compared with the Finnish instruments at Signilskär in 1934.

The standards of the Swedish observatory-instruments were in 1935 compared, as regards H and I, with the Danish instruments by measurements in the magnetic observatory at Rude Skov (Copenhagen).

On several occasions, the Danish, Finnish, and Swedish H-standards have been inter-compared with aid of the "QHM-magnetometer" of la Cour.

Publications

Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Lovö (Stockholm) im Jahre 1930.

Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Lovö (Stockholm) im Jahre 1931.

Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Lovö (Stockholm) im Jahre 1932 (being printed).

"A magnetic survey of Sweden made by the Hydrographic Service in the years 1928-1930" by G. S. Ljungdahl, K. Sjökarteverket, Jordmagn. Publikationer Nr. 9.

"Punktbeskrivningar till de åren 1928, 1929 och 1930 uppmätta jordmagnetiska sekulärstationerna" av G. S. Ljungdahl, K. Sjökarteverket, Bilaga till Jordmagn. Publ. Nr. 9.

"Earth magnetic researches along the coasts of Sweden". Part I-Magnetic declination at the epoch July 1, 1929, by G. S. Ljungdahl, K. Sjökarteverket, Jordmagn. Publ. Nr. 10 (being printed).

"Determinations of the magnetic declination at sea on a motorboat" by G. S. Ljungdahl, Terr. Mag., 1935, pp. 139-146.

STUDIES OF COSMIC ULTRA-RADIATION IN NORTHERN SWEDEN

By AXEL CORLIN

As a member of an international group embracing exactly similar apparatuses as those erected at Königsberg and Potsdam, Germany, Innsbruck, Austria, Jungfraujoch, Switzerland, Amsterdam, Holland, Valencia, Ireland, Bandoeng, Java, and Cape Town, South Africa, a so-called Steinke apparatus recorded the ionisation caused by cosmic ultra-radiation at Abisko in Northern Sweden (geogr. lat. 68° 21′ N; geomagn. lat. 66° 5′ N) from the 23rd Sept. 1932 until the 7th July 1933. The ionisation chamber of all these apparatuses is similarly erected and orientated and is surrounded by a lead shield 10 cm thick in every direction. Records with upwards opened and closed shield were taken alternately during regular and simultaneous periods and gave hourly values of the ionisation during day and night. Much care is payed to the constancy of the temperature of the observation room.

In July 1933 the apparatus at Abisko was moved to the iron mine Kiirunavaara at Kiruna in Northern Sweden and mounted on two trolleys in order to record the ionisation of cosmic ultra-radiation below various thicknesses of iron ore. After some preliminary tests the ionisation chamber was surrounded by a lead shield 20 cm thick and, together with this shield, enclosed in an air-tight iron box in order to eliminate the radioactive radiation from the walls and the air of the galleries. The records of the cosmic radiation began in August 1933 and continued until April 1934, and the radiation observed below iron ore was from 0 to 157 meters of thickness, the last-mentioned figure corresponding to 785 meters of water-equivalent. The apparatus was later moved to the Observatory of Lund in Southern Sweden, where it now records the ionisation of cosmic radiation.

The results of the observations at Abisko and Kiirunavaara were published in 1934 as Annals of the Observatory of Lund No 4. They have been compared with simultaneous meteorologic and magnetic records at the geophysical Observatory of Abisko as well as with Aurorae, sunspot-numbers, and flocculifigures. Between ionisation and air pressure a mean correlation of $r = -0.912$ for upwards open shield and $r = -0.862$ for wholly closed shield was found, whereas no correlation was found between ionisation on the one hand and air-temperature and air-humidity on the other hand. Variations of the correlation between ionisation and air-pressure outside the error limits were established, and also secondary forms of this interdependence were found.

Between earth-magnetic disturbances, Aurorae and ionisation no certain (or at least no simple) correlation was found. On the other hand a pronounced correlation was found between ionisation and flocculifigures of the sun, the coefficient of correlation for closed shield being $r = +0.52 \pm 0.07$ for the whole time, irrespective of the weather, and $r = +0.81 \pm 0.05$ for periods of quiet weather.

In Kiirunavaara the ionisation due to cosmic ultra-radiation could be traced down to at least below 132 meters of ore, corresponding to 660 meters of water-equivalent; the ionisation found at the deepest point below 157 meters of ore being considered merely as zero ionisation of the ionisation chamber. At about 100 meters of ore above the apparatus the ionisation suddenly rose and fell again, indicating an anomaly on the absorption curve which is probably a "stop effect" due to increased ionising power of a component of the radiation at the end of its range. Similar stop effects have been found by J. Clay at a depth of 250 meters in the Red Sea and at a depth of 170 meters in a Dutch coal mine. They may be considered as an indication of the corpuscular character of even the hardest components of cosmic ultra-radiation.

OBSERVATIONS AT SVEAGRUVAN DURING THE POLAR-YEAR 1932-1933

By F. LINDHOLM

The Magnetic Observations at Sveagruvan

As previously stated*) the magnetic work at Sveagruvan ($\varphi = 77°\ 54'$ N, $\lambda = 16°\ 45'$ E) during the Swedish Polar-Year Expedition in Spitsbergen 1932-1933 consisted of continuous records of D, H and Z by means of two sets of la Cour magnetographs. With scale values of D = 0.99/mm, of H = 497 γ/mm, of Z = 6.45 γ/mm and with base-line values derived from successive absolute observations of the declination and the horizontal intensity by a reconstructed Lamonts theodolite and of the inclination by a Doves inclinatorium, the following means of all hour-values for the whole period Sept. 1932—July 1933 are obtained:

$D = 4°53.'7$ W, $H = 8329\gamma$ and $Z = 52524\gamma$, from what is derived $I = 80°56'$.

At Cape Thordsen ($\varphi = 78°28'$ N, $\lambda = 15°42'$ E) the following means were determined for the period Aug. 1882-Aug. 1883:

$D = 12°44.'3$ W, $H = 8907\gamma$ and $Z = 52995\gamma$ from what $I = 80°27.'5$. The 18th and 19th August 1933 at the same place and on the same magnetograph pillars as on the Polar-Year 1882-1883 H was determined to 8149γ and $I = 81°15'$.

From the Sveagruva magnetic curves the diurnal variation, the daily maxima and minima and the absolute ranges are calculated for D, H and Z. In the declination a yearly variation is obvious.

The amplitude of the diurnal variation is three or four times greater than that in the middle high latitudes. At the same station it is smaller in 1932-1933 than in 1882-1883, connected as it is with the variation of the solar activity. The relation between magnetic disturbances and auroral phenomena observed at Sveagruvan during the expedition in 1932-1933 has been more closely studied as well as the magnetic activity in its dependence with the solar activity. Concerning particulars reference is made to the publication now in preparation of the results of the expedition.

*) The Polar Record 7, Jan. 1934, Cambridge 1934.

The photogrammetric measurements of aurora

Mr. E. von Zeipel, who was in charge of the parallactic auroral measurements at the base stations in Sveagruvan and in Longyear City and to whom the preparation for publication of the results of these parallactic measurements has been entrusted, communicates concerning the measurements of the photographic auroral plates the following.

The coordinate-nets serving to the orientation and measurements of the plates have been calculated. On each of the 425 pairs of photographs three stars of reference have been selected. The elevations and the azimuths of the stars of reference have been calculated and a suitable lantern slide has been constructed.

The following work remains to be done: The nets ought to be drawn up and photographed. The aurora-images and the nets have to be copied on magnification-copies. On these copies all necessary angles and parallaxis for the calculation of the altitudes and positions of the auroras are to be directly read of.

Cosmic ray measurements in Spitsbergen

Cosmic ray measurements at Sveagruvan with a Hoffmann high pressure ionisation-chamber with compensation*) has given the following results compared with measurements in Stockholm

			ionis.-chamber within 10 cm Pb m A	Barometric pressure mm Hg
Spitzbergen	means	May-July 1933	29.55	763
Stockholm*)	«	1930-1931	30.40	755

			ionis.-chamber open above else 10 cm Pb m A	Barometric pressure mm Hg
Spitsbergen	means	July 1933	33.53	755
Stockholm	«	1930-1931	34.35	755

The variation in the intensity of the cosmic rays between the 78th and 60th latitudes is then smaller than a few per cent. According to these measurements it is also evident that the cosmic rays do not change in intensity to any greater amount with the appearance of aurora. Cosmic ray showers first discovered by Hoffmann**) in 1927 are not more frequent in Spitsbergen than at the sea-level in latitude 60° N. On the other hand they occur in greater numbers at a high level station such as Muottas Muraigl at an altitude of 2500 meters.

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*) See Arkiv för Mat., Astr. och Fysik Bd. 23 A, N:r4, 4, Stockholm 1932.
**) Physik. Z. 31, 348 (1930).

REPORT OF THE MAGNETIC SURVEY WORK OF THE MAINLAND OF SWEDEN CARRIED OUT BY THE GEOLOGICAL SURVEY OF SWEDEN

BY KURT MOLIN

The magnetic survey work of the mainland of Sweden, which was begun in the summer of 1928 has been achieved with regard to the field observations towards the end of 1934.

The measurements comprise a total of 2358 observation locations, which have been distributed during the sequent years as follows:

1928	1929	1930	1931	1932	1933	1934
67	159	419	525	228	462	498

The preponderance point of the observations is 1932.2. As a reduction epoch 1933.5 has been chosen instead of 1932.5 which year-mean most closely coincides with the preponderance point.

This selection of the reduction point was necessitated in order to obtain a joint epoch with the magnetic survey of Finland.

The distribution of the measured elements are as follows:

D	H	I	Z
2044	2297	2266	2146

The surface, which has been surveyed, extends to 440.000 km^2 with a remarkable uniform distribution of the observation localities or points. From this follows an average distribution density of observation points for each element of one point upon 203 km^2. The average distance between the observation points thus extends to 14.3 km.

The magnetic records of Lovö, Rude Skov and Sodankylä have been used during the whole observation period in order to reduce the observations to the means of the corresponding year. During the years of 1928, 1929 and 1930 magnetograms from the temporary magnetic observatory erected by the Geological Survey of Sweden at Näs ($\varphi = 62°$ 58.'4 N, $\lambda = 14°$ 34.'5 E Gr.) have also been used. The magnetograms of Tromsö have also been used for the reductions of the years 1930-1934.

The reduction of the year-means to the epoch 1933.5 have been realized by using formulas based on the yearly variation of the elements from the observatories of Lovö, Rude Skov, Sodankylä, Tromsö and Pavlovsk.

Connection to other measurements has been realized by a comparison of the instruments with Lovö, Rude Skov and Sodankylä.

The extension of observational data necessitates a publication of the results in stages comprising the elements as follows D, I, H. In addition to the ordinary isomagnetic charts anomalie charts for each magnetic element are to be prepared.

Publications

"Vilhelm Carlheim-Gyllensköld som jordmagnetiker" av Kurt Molin, In Kosmos, Physical Papers edited by the Swedish Physical Society, Stockholm, Bd. 13, 1935.

"Observations des variations magnétiques-terrestres à Upsal pendant l'éclipse de soleil de 1914" by Kurt Molin, L'éclipse totale de soleil des 20-21 Août 1914. VI:ième Partie, Stockholm, 1936.

"Magnetic declination for Sweden north of 60° Lat. reduced to the epoch 1936.5" by Kurt Molin. — From observations carried out during the years 1928-34 by the Geological Survey of Sweden. — In "Till Fjälls", Svenska Fjällklubbens årsbok. Årg. 8. Stockholm, Maj 1936.

REPORT OF INVESTIGATIONS OF ATMOSPHERIC ELECTRIC DISCHARGES PERFORMED AT THE INSTITUTE OF HIGH TENSION RESEARCH OF THE UNIVERSITY OF UPSALA SINCE THE LISBON ASSEMBLY

By HARALD NORINDER

The investigations of the rapid variations in the electric field caused by lightnings have been continued. To obtain these measurements horizontal aerials connected to recording cathode ray oscillographs of special construction were used. The instruments allowed time-true correct records of the rapid variations (order of microseconds) in the atmospheric electric field.

New methods have been developed and applied to the records of the rapid variations in the magnetic field as caused by lightning currents. To realize such measurements specially constructed aerial frames have been used. The observed variations in the magnetic field allowed, under special conditions, a calculation of the currents in lightning discharges and their variation characteristic.

The study of the atmospheric electricity at the institute has been extended to comprise ordinary radio atmospherics. The incoming perturbations on aerials of either relatively short lengths (about 100 meters) or longer ones (2.13 kilometers) have been analyzed by using a distortionless amplifier in combination with cathode ray oscillographs.

During an observation period extented over the past two years and during different seasons about 22.000 perturbations have been analyzed by cathode ray oscillograms. The measurements have comprised a study of the atmospherics with regard to amplitudes, polarities, variation forms, durations etc.

A study of the radio atmospherics necessitated an elimination of local disturbances. This was realized by using movable field stations. At the institute two such stations have been in operation for recording atmospherics. Each station contains a full equipment of cathode ray oscillographs with accessary instruments for observations of the variations of the atmospheric electric field.

Publications

"On the Nature of Lightning Discharges" by Harald Norinder, Journ. of the Franklin Inst., Vol. 218, No. 6, Dec. 1934.

"Untersuchungen von Blitzentladungen und atmosphärischen Rundfunkstörungen in Schweden mit dem Kathodenstrahloszillographen" von Harald Norinder, Elektrotechnische Zeitschrift, 56 Jahrgang, Heft 14, 1935.

"Lightning Currents and Their Variations" by Harald Norinder, Journ. of the Franklin Inst., Vol. 220, No. 1, July, 1935.

"Undersökningar över de atmosfäriska radiostörningarnas natur" av Harald Norinder, Tekn. Medd. från Kungl. Telegrafstyrelsen, n:r 7-8, 1935.

"Vergleichende Untersuchungen von Rundfunkstörungen von längerer und kürzerer Dauer" von H. Norinder und R. Nordell, Elektrische Nachrichten-Technik, Band 12, Heft 10, 1935.

"Cathode Ray Oscillographic Investigations on Atmospherics" by Harald Norinder, Proc. of The Inst. of Radio Eng., Vol. 24, No. 2, Febr., 1936.

"Blixtens urladdningsegenskaper" av Harald Norinder, In Kosmos, Physical Papers edited by the Swedish Physical Society, Stockholm, Bd. 13, 1935.

"Die Beziehungen zwischen Rundfunkstörungen und Blitzentladungen" von Harald Norinder, Elektrische Nachrichten-Technik, Band 13, Heft 4, 1936.

"The Relation between Lightning Discharges and Atmospherics in Radio Receiving" by Harald Norinder, Journ. of the Franklin Inst., Vol. 221, No. 5, 1936.

"Atmosfäriska radiostörningar upptagna från en provningsledning för högspänning" av Harald Norinder, Tekn. Medd. från Kungl. Telegrafstyrelsen, n:r 3-4, 1936.

"Radio Atmospherics from a High-tension Test Line" by Harald Norinder, Wireless Engineer, Vol. XIII, July, 1936.

EXTRACTS FROM THE ANNUAL REPORTS OF THE ABISKO OBSERVATORY 1934-1935

By J. ÖSTMAN

Earth magnetism

The magnetic records by the aid of the slow-moving Toepfer instruments have been continued during 1934-1935.

The scalar-values of the magnetograms have been calculated twice for each month by the observer. *The determination* of the absolute values has been realized by using a magnetic theodolite from Jones, London.

A determination of the hour values on all magnetograms has been executed.

The characterisations of the magnetograms for each day have been performed in the scale 0:1:2 and the Tables have been sent quarterly for publication to the Institute of De Bilt.

UNITED STATES

REPORT OF THE AMERICAN SECTION OF TERRESTRIAL MAGNETISM AND ELECTRICITY, 1933 TO 1936

By E. O. HULBURT, Secretary

During the years since the Lisbon meeting in 1933 of the International Association of Terrestrial Magnetism and Electricity the membership of the American Section of the Association has increased steadily, being 112 in 1933 and 178 in 1936. The annual meetings of the Section at Washington, D. C., United States, in April have been well attended. The character of the papers presented at the meetings has evidenced wide and vigorous interest in subjects under the cognizance of the Section.

Institutions in America and outlying territories and the fields of investigation sponsored by them and reported upon in the Section's proceedings published in the annual Transactions of the fifteenth, sixteenth, and seventeenth annual meetings of the American Geophysical Union, may be listed briefly as follows:

Dominion Observatory, Canada — Magnetic survey of Canada and territories for secular variation
National Astronomical Observatory, Mexico — Magnetic survey
Stanford University — Atmospheric electricity

Colorado School of Mines — Magnetic survey; earth-resistivity
University of Colorado — Cosmic rays
University of Chicago — Cosmic rays
California Institute of Technology — Cosmic rays
University of North Carolina — Magnetic survey
Bartol Research Foundation of the Franklin Institute — Cosmic rays
University of California at Los Angeles — Laboratory auroral and night-sky spectra
University of Alaska (formerly Alaska Agricultural College and School of Mines) — Aurora; ionosphere
Mount Wilson Observatory of the Carnegie Institution — Magnetic activity; sunspots; solar ultra-violet light; solar spectroheliograms; solar data for broadcast of cosmic data under the auspices of Science Service
Smithsonian Institution — Solar radiation; atmospheric ozone
Department of Terrestrial Magnetism of the Carnegie Institution — World magnetic survey and secular-variation research; geomagnetic charts of entire Earth; maintenance of magnetic and electric observatories at Huancayo (Peru) and Watheroo (Western Australia); observations for determination of corrections and researches on magnetic standards at observatories; ionospheric investigations in Peru, Australia, and at Washington; electricity of the lower atmosphere; cosmic rays; earth-currents; laboratory research in nuclear physics and applications to magnetic and electric research; reductions of auroral and magnetic data; reductions of Polar-Year data at Point Barrow and College-Fairbanks; instrumental development
Bell Telephone Laboratories — Ionosphere; radio-wave propagation; direction of static; earth-currents
United States National Bureau of Standards — Ionosphere; radio field-intensities; ionospheric data for broadcast of cosmic data under the auspices of Science Service
United States Naval Research Laboratory — Radio-wave propagation; ionosphere; direction of static; electricity of thunder-storms
United States Coast and Geodetic Survey — Maintenance of five magnetic observatories at Cheltenham, Tucson, Sitka, Honolulu, and San Juan, and reductions of results; magnetic surveys for secular variation; magnetic surveys of air ports and water ports; isomagnetic charts of United States and territories; isogonic charts for aviators; instrumental development; reduction of Polar-Year data; magnetic data for broadcast of cosmic data under the auspices of Science Service
United States Hydrographic Office — Isomagnetic charts of the world, latest issue for epoch 1935.

REPORT BY THE DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON, TO THE EDINBURGH ASSEMBLY ON WORK DONE SINCE THE LISBON ASSEMBLY

By J. A. FLEMING

Introductory

Since 1933 the efforts of the Carnegie Institution of Washington through its Department of Terrestrial Magnetism have been directed in general along the following lines: (1) Reduction and study of the extensive accumulated observational data, including results of the Department's survey on land and sea and from its observatories; (2) development of technique and apparatus for recording photographically the electrical conditions and variations in the ionosphere and their investigation and correlation with other geophysical phenomena; (3) development of instruments for measuring the elements of terrestrial magnetism and electricity — especially in the design and improvement of electromagnetic methods for work in the field and at observatories; (4) theoretical and experimental studies of the fundamental aspects of nuclear physics and magnetism; (5) continued extension of, and world-wide cooperation with other organizations in, field-work for the purpose of secular-variation studies and maintenance of observatory-records of the continual changes occurring in the Earth's magnetism and electricity.

Investigational and experimental work

The investigational and experimental programs during 1933 to 1936 may be briefly summarized as follows:

(a) *Terrestrial Magnetism.*

(1) The experimental evidence available in many branches of geophysics and cosmical physics differs from the readings taken in laboratory-research in so far as, in the laboratory, the observations are taken under fixed conditions or involve only a limited number of variable quantities, while the records obtained at geophysical laboratories show variations in time which are not easily expressed as the effect of a few variables. The analysis of such time-functions and of their interrelations is, therefore, an indispensable part of geophysical research. This is particularly true for the more or less pronounced fluctuations variously termed cycles, periodicities, or recurrences found in various geophysical and cosmical phenomena.

In any attempt to find cycles one has to consider the mathematical fact that a time-function f(t) which is given, in a definite interval of time, by a finite number of values — for instance, hourly or daily values — can be represented as the superposition of a finite series of cyclic functions, such as sine-waves, and for one and the same given function f(g) an unlimited number of such series can be found. If, therefore, a representation of f(t) by means of a series of superposed cyclic functions has been effected, this does not at all entitle one to regard the individual cycles as physically significant constituents of f(t). To prove the physical significance of any cycle, it is in most cases sufficient to demonstrate that it recurs frequently enough, and this consideration of frequency leads, in some way or other, to statistical methods and to theory of probability. This fundamental statistical aspect has been considered (*Terr. Mag.*, vol. 10, pp. 1-60, 1935).

(2) The day-by-day record of terrestrial magnetism and solar activity (*Terr. Mag.*, vol. 37, pp. 1-52, 1932) was continued in the form of a diagram demonstrating the 27-day recurrences in the 11-year cycle 1923 to 1933 (*Terr. Mag.*, vol. 39, pp. 201-202, 1934).

(3) The complete change in the character of the solar diurnal-variations in vertical intensity observed at the Huancayo Magnetic Observatory during the past sunspot-cycle was investigated. This change is associated with the secular change of the Earth's general magnetic field which consisted partly of a southern shift of the magnetic equator in the region. Detailed features are qualitatively in agreement with the expected changes resulting from such a movement of the magnetic equator. The large magnitude of the changes indicates, however, that the solar diurnal-variation is a complex function of the Earth's general field, such as is called for by the atmospheric-dynamo theory of Balfour Stewart. (See communication to the Association by A. G. McNish on "Progress of research in magnetic diurnal-variations at the Department of Terrestrial Magnetism, Carnegie Institution of Washington").

(4) An attempt was made to derive a more accurate quantitative conception of the field of magnetic storms from the study of the differences of magnetic intensities observed at various places on the Earth on internationally selected quiet and disturbed days. The treatment was confined to what has been termed the world-wide features of disturbance, that is, those which depend on universal time and latitude rather than on local time and latitude. (See communication to the Association by L. Slaucitajs and A. G. McNish on "The field of magnetic storms as deduced from the mean difference of magnetic intensity on quiet and disturbed days").

(5) In view of the many uses which consideration of the asymmetry of the Earth's magnetic field has, the eccentric dipole approximating that field was computed and communicated in extensive tables and charts (*Terr. Mag.*, vol. 41, pp. 225-250, 1936). The differences between the actually observed magnetic field (for the epoch 1922) and that of the eccentric dipole are of special interest as regional anomalies indicating the effect of the Earth's outer crust.

(6) Charts of geomagnetic coordinates were constructed of the entire Earth and nomographs were prepared for obtaining geomagnetic coordinates for any point on the Globe with an accuracy of about 0.°1 (*Terr. Mag.*, vol. 41, pp. 37-43, 1936).

(7) An investigation of magnetic "bays" based on data from observatories distributed over the whole Earth was begun. Preliminary studies reveal a great intensity for the assumed overhead-current, to which the bays are attributed, as one approaches the zone of maximum auroral frequency. This intense current, directed westward on the dark side of the Earth, is believed to be the primary cause of these magnetic disturbances. A hypothesis has been suggested ascribing this primary current to dynamo-action through heating of the auroral region by incoming particles. (See communication to the Association by A. G. McNish on "Report on investigation of magnetic bays").

(b) *Terrestrial electricity.*

(1) Compilations of the information regarding earth-currents collected at various stations in recent years, particularly during the Second International Polar Year 1932-33, have permitted us to view some of the broader aspects of the system of electric currents which circulate in the Earth. These indicate that, during "quiet" periods, earth-currents circulate in great eddies — eight in the Northern Hemisphere and probably also eight in the Southern Hemisphere. The four middle-latitude eddies in each hemisphere are roughly equally spaced in longitude. The centers of those in the Northern Hemisphere lie on a parallel of latitude not far from the Tropic of Cancer, those in the Southern Hemisphere being similarly placed relative to the Tropic of Capricorn. The centers of the four high-latitude eddies of the Northern Hemisphere lie near the Arctic Circle. The entire system is fixed relative to the Sun so that any point on the Earth passes daily through all the phases of the eddies which correspond to the latitude of that point. (See communication to the Association by O. H. Gish and W. J. Rooney on "New aspects of earth-current circulations revealed by Polar-Year data").

(2) The diurnal variation in the rate of ionization near the ground, computed from small-ion numbers and condensation-nuclei numbers, for several stations shows similarity in the diurnal-variation curve when referred to Greenwich time and has led to the suggestion that the diurnal variation may be universal in character. Results of direct measurements, on the contrary, have indicated that it is a local-time rather than a universal-time phenomenon. Thus it appears that one is not justified in calculating the ionization from small-ion and condensation-nuclei numbers as heretofore has been customary. If one uses large-ion numbers instead of condensation-nuclei numbers, consistent results are obtained. Investigation is now under way of the suggestion that the recombination-coefficient between small ions and condensation-nuclei varies with relative humidity.

(3) Investigations of the relationships among the high-, low-, and intermediate-mobility ions near the ground show, contrary to the findings of Pollock, that the intermediate ions do not diminish in number at any vapor-pressure below saturation owing to the formation of large ions through condensation of water-vapor. Their mobility varies with vapor-pressure of the atmosphere in accordance with Blanc's law. The number of them varies through the day in a manner similar to the large-ion number and more or less opposite to the small-ion number. The intermediate ions are especially numerous during times of thunder-storms. The mobility-spectrum for the intermediate ion appears to be a narrow band. Under normal conditions practically no ions having mobilities between that of the intermediate ion and that of the large ion were found. Errors ranging from 10 to 30 per cent in small-ion counts will result if the intermediate ions collected by the small-ion counter are not taken into account.

(4) The rate of ionization recorded inside a thin-walled chamber showed a large definite diurnal-variation with a minimum shortly after midday. The ionization increased several fold at the time of thunder-storms and usually began abruptly with the beginning of the rain; the total amount of increase was roughly proportional to the total amount of rainfall. From these studies it appears that the increase of ionization during thunder-storms is due to radium B and C brought down by the rain. In the winter, observations of the effect of snow covering the ground on the ionization indicated a marked decrease with snow-blanket present.

(5) Satisfactory records of air-conductivity were obtained by apparatus developed at the Department on the National Geographic Society-Army Air Corps Stratosphere Flight of November 11, 1935, to an altitude of 72,395 feet. It was found

that the conductivity increased in a manner which may be accounted for by known factors up to an altitude of 60,000 feet, but above that point a decrease was observed for which no definite explanation can as yet be offered. The values of conductivity, particularly at the high levels, are considerably less than had been calculated from cosmic-ray measurements. However, a simple modification of the relationship which was used in making the calculations brings the calculated values into good agreement with those observed on the descent from about 19- to 6-km altitude. In view of this and on account of the diverse results obtained from investigations in the laboratory bearing on that relationship, the modified relationship may perhaps be favorably regarded. (See communication to the Association by O. H. Gish and K. L. Sherman on "Information to be obtained from atmospheric-electric measurements in the stratosphere").

(c) *Ionosphere.*

The first ionospheric data from the south temperate zone became available from ionospheric investigations at the Watheroo Magnetic Observatory beginning in January 1935. Results already bear upon the obscure causes of the variation of ion-density in the highest ionospheric region. These are of particular importance because this region is directly exposed to nearly the whole range of solar radiation and therefore should give a sensitive measure of solar changes. These observations, together with the photographic records at the Huancayo Magnetic Observatory, bring out a number of new features of the upper atmosphere. The most important is that the maximum ion-density of the highest region occurs in both the Northern and Southern hemispheres during the same months; therefore, what has been previously believed to be a simple seasonal effect is shown to be much more complex — probably an annual effect. (See communications to the Association by L. V. Berkner and H. W. Wells on "Studies of the E-region of the ionosphere at low latitudes" and "New factors in investigation of the high region of the upper atmosphere").

(d) *Nuclear physics.*

(1) Measurements of the forces between the nuclei of two hydrogen atoms when they are separated by distances of less than two ten-thousand-billionths of an inch were made. By observing the deflections of high-speed hydrogen particles which have collided with hydrogen nuclei in a gas-filled chamber, the attractive forces which hold together the nuclei of atoms heavier than hydrogen were measured for the first time. Without this attractive force — the existence of which has been

previously suspected — the entire universe might consist of nothing but hydrogen. More than five years have been spent in developing the high-voltage technique to a degree of precision and control necessary for this experiment. The experimental extension and theoretical interpretation of the results are in progress at the Department's laboratory in Washington, at the Institute for Advanced Study of Princeton University, and at the University of Wisconsin. The possibility is indicated that the proton and the neutron are identical particles except for small changes arising from the positive electric charge on the proton. However this may turn out, the lack of quantitative knowledge regarding the "proton-proton interaction" up to the present time has been one of the greatest obstacles to the formulation of a satisfactory theory regarding the structure of atomic nuclei. The necessary observations have now been provided.

(2) Studies of a new experimental method for investigation of the upper atmosphere were undertaken. Calculations and tests in the laboratory indicate that by projecting a modulated searchlight-beam and measuring the light scattered from sections of the high-altitude path at an observing station some kilometers distant, using a large mirror with a photo-cell and synchronized amplifier, information can be obtained regarding the molecular density and certain other characteristics of the atmosphere in the almost unexplored region from 30 to 70 km and possibly for even greater heights (*Terr. Mag.*, vol. 40, pp. 452-454, 1935).

(e) *Instrumental design.*

(1) A perminvar vertical-intensity induction-variometer was designed and constructed. It has been recording continuously at the Cheltenham Magnetic Observatory of the United States Coast and Geodetic Survey since August 1935. It has given satisfactory performance over a wide range of scale-value 0.8γ to 4.0γ per mm of ordinate on the photographic record. Simultaneous records with other recording vertical-intensity variometers (Toepfer-Eschenhagen, la Cour, Adie, and Schmidt field-balance adapted to observatory use) at the Observatory prove its satisfactory performance. (See communication to the Association by A. G. McNish on "The new CIW vertical-intensity induction-variometer").

(2) Special attention is being given the development of electromagnetic methods of measuring the Earth's magnetic field. The first step is the design of a universal type of magnetometer capable of making an absolute observation of all the components of the Earth's field rapidly and accurately; in this good progress has been made, and as a result of the experi-

mental and theoretical work the alternating-current method of detection has been applied successfully to the earth indicator and in the design of the universal magnetometer (*Terr. Mag.,* vol. 41, pp. 251-260, 1936). By using an alternating-current amplifier as a detector instead of a commutator and galvanometer, the sensitivity of the CIW type of inductor was greatly increased and is limited only by the dimensions of the circles used for reading angles in measuring both declination and inclination. This application of alternating current is important also in the use of the earth inductor for accurate measurements of declination and inclination at sea, the output of the inductor being recorded by an oscillograph and the time of zero output being compared with the angular coordinates of the base of the inductor which may also be recorded by means of a damped pendulum.

These studies and those of standard cells and current supplies have indicated a design for an absolute instrument to measure the three components H, Z, and F, as well as declination and inclination, and further indicate that a rotating-coil design of instrument may be used successfully as horizontal-intensity and vertical-intensity recording variometers.

Land work

In spite of the unfavorable economic conditions, making curtailment of field-operations necessary, the Department continued to accumulate data through limited expeditions of its own and cooperative work with other organizations and individuals in various countries. Observations have been secured at many of the stations on the proposed list of international repeat-stations recommended by the special Committee of the Association on Secular-Variation Stations. Such stations were reoccupied in Africa, Asia, Australasia, North and South America, and the Islands of the Pacific Ocean.

Cooperative work in China under the direction of F. C. Brown, now connected with the American Church Mission at Hankow, assisted by Dr. C. T. Kwei of the Central China College at Wuchang, was continued.

The Department cooperated with the Second Byrd Antarctic Expedition by training observers and supplying instruments. Magnetograms with the usual absolute observations were obtained from February 12, 1934, to February 4, 1935. In addition, 17 stations were occupied between latitudes 78° and 82° south and longitudes 149° and 164° west, and four stations between latitudes 76.°7 and 78.°6 south and longitudes 145.°6 and 163.°8 west. Observations were also made at Easter Island on the outward journey and at Albemarle Island of the Galapagos Group and at the Canal Zone on the return journey.

In cooperation with the Hydrographic Office of the United States Navy Department, officers of the Navy were instructed in the use of magnetic instruments, and observations were made at stations in Alaska, Panama, and Costa Rica.

The arrangement with A. Walter of the British East African Meteorological Service for cooperative work in British East Africa made possible observations by Dr. E. C. Bullard of the University of Cambridge, England, who went out to the colony to do some gravimetric work.

It is planned, before the next Assembly of the Association, to obtain observations in certain regions — western Africa, Australasia, eastern Asia, and the Pacific Islands — where secular-change rates are either indicated as rapidly varying or where the period since the last data were obtained is longer than desirable. Endeavor will be made to occupy as many as possible of the stations suggested for secular-variation purposes in the first report of the Special Committee on Magnetic Secular-Variation Stations*).

Observatory work

During the past three years the magnetic, atmospheric-electric, earth-current, and meteorological programs at the Watheroo and Huancayo observatories, and the cooperative work in atmospheric electricity with the Apia Observatory and in atmospheric electricity and earth-currents at the Tucson Observatory of the United States Coast and Geodetic Survey were maintained. Measurements of variations of height of the regions of the ionosphere begun through manual observations at Watheroo and at Huancayo are now being continuously recorded at both observatories. At Watheroo the Crichton-Mitchell vertical-intensity electrograph continues in operation. Rapid-run magnetographs of the la Cour type used during the International Polar Year are continuously recording at the Watheroo and Huancayo observatories. Observations of sunspots, flocculi, and prominence are with the Hale spectrohelioscope at both observatories which are taking part in the world network, and reports are communicated regularly to Commission 11 of the International Astronomical Union.

The preliminary values of the magnetic elements as derived from magnetograms of all days for the years 1933 to 1935 are as follows:

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*) Comptes-Rendus de l'Assemblée de Lisbonne, pp. 123-134.

Year	Declination	Inclination	Intensity-components H	Z	X	Y	F
Watheroo Magnetic Observatory, 30° 19.'1 S, 115° 52.'6 E, 800 feet above sea-level							
	° ′	° ′	cgs	cgs	cgs	cgs	cgs
1933	3 53.4 W	64 19.8 S	0.24659	—0.51308	0.24602	—0.01673	0.56926
1934	3 47.8 W	64 20.1 S	0.24669	—0.51340	0.24615	—0.01633	0.56960
1935	3 42.5 W	64 21.0 S	0.24672	—0.51379	0.24621	—0.01596	0.56996
Huancayo Magnetic Observatory, 12° 02.'7 S, 75° 20.'4 W, 11,000 feet above sea-level							
	° ′	° ′	cgs	cgs	cgs	cgs	cgs
1933	7 21.4 E	2 04.7 N	0.29614	0.01075	0.29370	0.03792	0.29633
1934	7 18.1 E	2 08.5 N	0.29622	0.01107	0.29382	0.03765	0.29643
1935	7 15.2 E	2 11.2 N	0.29612	0.01130	0.29375	0.03738	0.29634

The compilation and discussion of the magnetic data at Watheroo and Huancayo observatories are now complete through 1935. The discussions of the magnetic data obtained on the MacMillan Baffin Island Expedition at Bowdoin Harbor during 1921-22 and on the MacMillan North Greenland Expedition at Refuge Harbor during 1923-24 were completed. The compilations of data obtained at the International Polar-Year station College-Fairbanks in Alaska during 1932-33 in cooperation with the United States Coast and Geodetic Survey (terrestrial magnetism, atmospheric electricity, earth-currents, and aurora), at the International Polar-Year station Point Barrow in cooperation with the United States Weather Bureau during 1932-33 (terrestrial magnetism and aurora), and at the International Polar-Year station Little America during 1934-35 in cooperation with the Second Byrd Antarctic Expedition (terrestrial magnetism and aurora) are nearing completion.

The provisional International Magnetic Standards (*Res. Dep. Terr. Mag.*, vol. 4, pp. 395-475, 1921) adopted by the Department were maintained at Washington until it was possible, through the attainment of electric power-supply, additional building and testing equipment, and observing facilities in 1934-35 at the Cheltenham Magnetic Observatory of the United States Coast and Geodetic Survey, to transfer standardizing operations of the Department from Washington to that Observatory. CIW sine-galvanometer 1 (*Res. Dep. Terr. Mag.*, vol. 4, pp. 373-394, 1921) was assigned for absolute observations in horizontal intensity at the Observatory, where it has been so used since August 1935. The standard CIW Schulze earth-inductor 48 was also transferred to the Observatory to control International Magnetic Standards there. Thus, as regards the United States, there has been undertaken the important and long-contemplated step of transferring to Cheltenham the provisional International Magnetic Standards of the Department and complete realization of the Association's resolution 4 at Rome in 1922 and items a and b of resolution 5 at Prague in 1924.

In January 1935 a precision cosmic-ray recording meter, after the design of Professors A. H. Compton and R. D. Bennett and constructed at the University of Chicago, was installed at Cheltenham in accordance with the plans of the Committee of the Carnegie Institution of Washington on Coordination of Cosmic-Ray Investigations (see reports of that Committee in *Year Books* 32, 33, and 34 of the *Carnegie Institution of Washington)*. In May 1936 one of these meters was also installed at the Huancayo Magnetic Observatory.

Arrangements were completed in cooperation with the University of Alaska to install at College, Alaska, equipment to obtain ionospheric data; the strategic location of College in the polar region near the maximum of magnetic vertical-intensity makes this station an important one in a world-wide ionospheric survey. The completion of these plans was delayed by the untimely death of Professor Fuller, but is now being carried forward by his successor, Professor E. H. Bramhall.

International Magnetic Standards and comparisons of standards at observatories

The control of the provisional International Magnetic Standards adopted by the Department (see reference above cited) was maintained. Since the Lisbon meeting, intercomparisons of these standards have been effected directly or indirectly at the following observatories: Abinger, England; Adelaide, South Australia; Agincourt, Canada; Amberley (Christchurch), New Zealand; Apia, Western Samoa; Cape Town, South Africa; Cheltenham, United States; Huancayo, Peru; Niemegk, Germany; Pilar, Argentina; and Watheroo, Western Australia. Besides these intercomparisons, determinations of constants and corrections were made for the absolute instruments used at the Polar-Year station Magallanes.

The standard in horizontal intensity was found to be in substantial agreement with the absolute values given by CIW sine-galvanometer 1 upon comparisons between the two instruments at Cheltenham after the installation of the sine-galvanometer as standard at that Observatory. (See communication to the Association by S. E. Forbush and E. A. Johnson on "Results of international comparisons of magnetic horizontal-intensity with CIW sine-galvanometer 1"). It was found also that through the indirect comparisons obtained with the Schuster-Smith coil-magnetometer at Abinger and with the standard Wanschaff magnetometer at Niemegk there is agreement well within observational error between the several standards. It is also to be noted that after a period of 14 years the results of intercomparisons in June and August 1921 at Washington between

CIW standard magnetometer 3 and sine-galvanometer 1 were in substantial agreement with those obtained in July 1935.

All instruments used by observers of the Department and by observers cooperating with the Department were intercompared at Washington and Cheltenham, both before and after field-use, to determine the corrections of these instruments on International Magnetic Standards.

At the request of Dr. la Cour, intercomparisons in horizontal intensity between his type of quartz-fiber horizontal-intensity magnetometer (QHM) and CIW sine-galvanometer 1 were obtained at the Cheltenham Magnetic Observatory as follows: With QHM 2 in February 1936 and with QHM's 12, 17, and 18 in July 1936.

Ocean work

The reductions of the physical, chemical, and biological oceanographic data accumulated during the last cruise of the *Carnegie* are now nearing completion.

William J. Peters, formerly commander of the Institution's non-magnetic vessel *Carnegie* and largely responsible for the development of the magnetic and electric work at sea during the many years of observations by the *Galilee* and the *Carnegie,* was sent by the Institution to England to act as consultant in the design of the non-magnetic vessel *Research* by the British Admiralty and in the design of the magnetic instruments to be used.

A complete mathematical treatment of all the magnetic data obtained at sea by the Department is under way. This discussion is concerned with the least-square adjustments of the results to obtain secular-variation values and to deduce formulae of the magnetic elements according to geographic position.

Work done following Lisbon resolutions

Work done by the Department following resolutions passed by the Association at its Lisbon meeting in 1933 is indicated below, the numbers in parentheses referring to the numbers of the resolutions (pp. 343-352, Comptes-Rendus de l'Assemblée de Lisbonne, 1934).

(5) The numerical character-numbers and the numerical magnetic character for each day, as deduced from the magnetograms recorded at the Huancayo and Watheroo magnetic observatories, were compiled and forwarded regularly for publication.

(6) The Department secured many intercomparisons of instruments directly and indirectly with the standards of several observatories and with the provisional International Magnetic

Standards adopted by this Department. (See communications to Association by J. A. Fleming on "Intercomparisons of magnetic standards and control of standards" and by S. E. Forbush and E. A. Johnson on "Results of international comparisons of magnetic horizontal-intensity with CIW sine-galvanometer 1").

(7) Because of the other urgent demands on the time of the limited personnel of the Department it has not been possible to prepare, for complete publication, the data left by the late Dr. L. A. Bauer on the Gaussian analysis of the Earth's field for the epoch 1922; it is expected that this will be made ready for publication before the next assembly. Sufficient new data are not yet available to justify new determinations.

(8) Systematic observations of sunspots, flocculi, and prominences have been made daily at the Huancayo and Watheroo magnetic observatories during the periods specified by the program of Commission No. 11 of the International Astronomical Union; a Hale spectrohelioscope, supplied by Mount Wilson Observatory of the Carnegie Institution of Washington, was installed at the Huancayo Observatory late in 1932 and another at the Watheroo Observatory during the latter part of 1933. As elsewhere reported, significant advance was made by the Department in ionospheric research, the results of which have already given interesting conclusions on relationships between solar and geophysical phenomena.

(9) The Department, as agent of the Committee on Coordination of Cosmic-Ray Investigations of the Carnegie Institution of Washington, took part in the world reconnaissance survey of cosmic rays particularly through the work of Drs. R. A. Millikan, A. H. Compton, and T. H. Johnson. It has also installed special precision cosmic-ray meters for continuous registration on behalf of the Committee at the Cheltenham Magnetic Observatory in the United States, at the Huancayo Magnetic Observatory in Peru, and at the Amberley (Christchurch) Observatory in New Zealand. An observatory hut was constructed at Tacubaya, Mexico, by the Astronomical Observatory of Mexico for later installation there of a fourth meter. For details of this cooperation reference may be made to the Committee's reports published in the *Year Books of the Carnegie Institution of Washington* (No. 32, pp. 331-334, 1933; No. 33, pp. 314-315, 1934; and No. 34, pp. 330-335, 1935).

(10) As reported above, the measurements of variations of the ionospheric regions, first by manual multifrequency technique and later by automatic continuously recording apparatus, are being obtained at the Watheroo and Huancayo magnetic observatories. Plans were effected by which a similar station will be established at College, Alaska, under the direction of the Department of Physics of the University of Alaska.

(13) Charts of the geomagnetic coordinates were constructed for the entire Earth as well as nomographs for obtaining the coordinates for any point of the Globe to an accuracy of 0.°1 (*Terr. Mag.,* vol. 41, pp. 161-172, 1936).

(15) The Department cooperated with the International Polar Year Commission 1932-33 in its reductions and compilations of results and reports on the work done.

(16) Rapid-running magnetographs loaned by the International Polar Year Commission 1932-33 were in operation at the Huancayo Magnetic Observatory from January 1933 and at the Watheroo Magnetic Observatory from December 1932.

(17) Several publications bearing on research in terrestrial magnetism and electricity have been published for the Association in the International Journal of Terrestrial Magnetism and Atmospheric Electricity.

(21) The Department, besides maintaining operation of its observatories near Huancayo in Peru and near Watheroo in Western Australia, cooperated to make possible continuation of certain work at the following observatories: Apia, in atmospheric electricity and terrestrial magnetism; Cape Town, in atmospheric electricity and cosmic radiation; College, in ionospheric observations; Cheltenham, in terrestrial magnetism and cosmic radiation; Christchurch, in cosmic radiation; Tucson, in atmospheric electricity and earth-currents; Little America, during 1934-35, in terrestrial magnetism and auroral observations.

(22) Despite unfavorable world economic conditions, considerable progress was made by the Department towards realization of the Association's planned network of magnetic repeat-stations for the investigation of secular variation. The stations occupied since the Lisbon meeting may be summarized as follows, the numbers in parentheses indicating the number of stations reoccupied which are listed in the list of international repeat-stations (pp. 123-133, Comptes-Rendus de l'Assemblée de Lisbonne, 1934): Africa, 44 (15); Antarctica, 22; Asia, 30 (3); Australasia, 44 (10); Europe, 2 (1); North America, 8 (3); South America, 7 (5); Islands Pacific Ocean, 3 (2). The Department expects during 1936-39 to obtain observations in regions where secular-change rates are either varying unusually or where the time since previous data were obtained is longer than desirable; in this, as many of the stations as possible of the list of the Special Committee will be occupied. The regions tentatively planned for these observations include Africa, Australasia, eastern Asia, and the Pacific Islands.

William J. Peters who, on the *Galilee* and the *Carnegie,* contributed so largely to the success of the Department's magnetic survey of the oceans during 1905 to 1929, was upon invitation of the British Admiralty assigned by the Institution as consultant on matters pertaining to the design and construction of the Admiralty's non-magnetic vessel *Research* and of her instrumental equipment. The *Research* is to continue the work so successfully carried out by the *Carnegie*.

Publications

Since the report presented at the Lisbon Assembly the Department has published as usual its annual or progress-reports in the Year Books of the Carnegie Institution of Washington and over 220 articles on investigations and on special subjects contributed to scientific journals by members of its staff. A bibliography of recent publications pertaining to cosmical and terrestrial magnetism and electricity and allied subjects is regularly maintained. Reviews and abstracts of outstanding contributions to geophysics have been published by members of the staff. Some idea of the scope of the publications issued through the Department and its personnel is indicated in the following bibliography containing titles of articles of interest to the Association which have been selected from among the papers published since the Lisbon Assembly.

Bartels, J. Terrestrial-magnetic activity in the years 1931 and 1932. Terr. Mag., vol. 39, 1-4 (Mar. 1934).

— Twenty-seven-day recurrences in terrestrial magnetism and solar activity during 1932-33. Terr. Mag., vol. 39, 201-202 (Sept. 1934).

— Terrestrial-magnetic activity in the year 1933 and at Huancayo. Terr. Mag., vol. 40, 265-266 (Sept. 1935).

— Zur Morphologie geophysikalischer Zeitfunktionen. Berlin, Sitzber. Ak. Wiss., No. 30, 504-522 (1935).

— Random fluctuations, persistence, and quasi-persistence in geophysical and cosmical periodicities. Terr. Mag., vol. 40, 1-60 (Mar. 1935).

— The eccentric dipole approximating the Earth's magnetic field. Terr. Mag., vol. 41, 225-250 (Sept. 1936).

Berkner, L. V. The relation of the Pacific eclipse of June 8, 1937, to investigations of changes of ionization of the atmosphere. Terr. Mag., vol. 39, 317-319 (Dec. 1934).

— and H. W. Wells. Report of ionosphere-investigations at the Huancayo Magnetic Observatory (Peru) during 1933. Proc. Inst. Radio Eng., vol. 22, 1102-1123 (Sept. 1934).

— — F-region ionosphere-investigations at low latitudes. Terr. Mag., vol. 39, 215-230 (Sept. 1934).

Chapman, S. The electric current-systems of magnetic storms. Terr. Mag., vol. 40, 349-370 (Dec. 1935).

— The space gradients of the Earth's magnetic field. Terr. Mag., vol. 41, 127-136 (June 1936).

Dahl, O. Note on disk-type electrostatic generators. Rev. Sci. Instr., vol. 7, 254-256 (June 1936).

Davies, F. T. The diurnal variation in magnetic and auroral activity at three high-latitude stations. Terr. Mag., vol. 40, 173-182 (June 1935).

Ennis, C. C. Relationships between auroral and magnetic activities at Little America, First Byrd Antarctic Expedition, 1928-30. Terr. Mag., vol. 41, 45-55 (1936).
— Magnetic results of the United States Exploring Expedition, 1838-1842, Lieutenant Charles Wilkes, Commander. Terr. Mag., vol. 39, 91-101 (June 1934).
— Graphical aids in the reduction of magnetic observations. Terr. Mag., vol. 38, 331-333 (Dec. 1923).

Fleming, J. A. Terrestrial magnetism (Smithsonian Physical Tables, 8th revised edition). Smithsonian Inst. Misc. Collect., vol. 88, 575-591 (1933).
— Annual report of the Director of the Department of Terrestrial Magnetism for the year 1932-33. Carnegie Inst. Wash., Year Book No. 32, 213-264 (Dec. 15, 1933).
— The relations of magnetic and electric work in the Pacific Ocean to the Polar-Year campaign, 1932-33. Proc. Fifth Pacific Sci. Cong., Victoria and Vancouver, B. C., Canada, 1933, vol. 3, 1685-1690 (1934).
— The distribution and need of additional magnetic observations and secular-variation stations in the Pacific Region. Proc. Fifth Pacific Sci. Cong., Victoria and Vancouver, B. C., Canada, 1933, vol. 3, 1675-1685 (1934).
— Report of ionosphere-investigations conducted at College-Fairbanks during the winter of 1933-1934. Terr. Mag., vol. 39, 305-313 (Dec. 1934).
— and O. H. Gish. Annual report of the Director of the Department of Terrestrial Magnetism for the year 1933-34. Carnegie Inst. Wash., Year Book No. 33, 196-246 (Dec. 14, 1934).
— — Annual report of the Director of the Department of Terrestrial Magnetism for the year 1934-35. Carnegie Inst. Wash., Year Book No. 34, 223-267 (Dec. 13, 1935).

Forbush, S. E. Some practical aspects of the theory of the unifilar horizontal-intensity variometer. Terr. Mag., vol. 39, 135-145 (June 1934).

Gish, O. H. Effects of turbulent air-flow in some apparatus used in atmospheric-electric measurements. Terr. Mag., vol. 38, 257-259 (Sept. 1933).
— Atmospheric electricity (Smithsonian Physical Tables, 8th revised edition). Smithsonian Inst. Misc. Collect., vol. 88, 596-598 (1933).
— The natural electric currents in the Earth. Sci. Mon., vol. 43, 47-57 (July 1936).
— Electrical messages from the Earth; their reception and interpretation. J. Wash. Acad. Sci., vol. 26, 267-289 (July 15, 1936).

Green, J. W. Magnetic secular-variation in the Pacific Region. Proc. Fifth Pacific Sci. Cong., Victoria and Vancouver, B. C., Canada, 1933, vol. 3, 1669-1674 (1934).

Hafstad, L. R. The application of the FP-54 pliotron to atomic disintegration-studies. Phys. Rev., vol. 44, 201-213 (Aug. 1, 1933).
— and M. A. Tuve. Carbon radioactivity and other resonance transmutations by protons. Phys. Rev., vol. 48, 306-315 (Aug. 15, 1935).

Johnson, E. A. Design of tuned resistance-capacity coupled amplifiers. Physics, vol. 7, 130-132 (Mar. 1936).
— and A. G. Johnson. A theoretical analysis of the operation of ionization-chambers and pulse amplifiers. Phys. Rev., vol. 50, 170-176 (July 15, 1936).
— Application of alternating-current methods of detection to earth-inductors for marine and land observations. Terr. Mag., vol. 41, 251-260 (Sept. 1936).

Johnston, H. F. The equipment and work of the Huancayo Magnetic Observatory. Proc. Fifth Pacific Sci. Cong., Victoria and Vancouver, B. C., Canada, 1933, vol. 3, 1835-1840 (1934).
McNish, A. G. Principles of statistical analysis occasionally overlooked. J. Frank. Inst., vol. 218, 255-258 (Aug. 1934).
— A possible test for theories of magnetic diurnal-variations and of magnetic storms. Terr. Mag., vol. 39, 5-6 (Mar. 1934).
— Geomagnetic coordinates for the entire Earth. Terr. Mag., vol. 41, 37-43 (Mar. 1936).
— A new type of vertical-intensity induction-variometer. Terr. Mag., vol. 41, 161-172 (June 1936).
Parkinson, W. C. Problems of terrestrial electricity which further observations in the Pacific Region will help to solve. Proc. Fifth Pacific Sci. Cong., Victoria and Vancouver, B. C., Canada, 1933, vol. 3, 1845-1852 (1934).
Peters, W. J. Present status of the investigation on dynamic and tilting deviations in the Department of Terrestrial Magnetism, Carnegie Institution of Washington. Terr. Mag., vol. 39, 203-207 (Sept. 1934).
Rooney, W. J., and K. L. Sherman. Earth-current measurements at the College-Fairbanks Polar-Year Station. Terr. Mag., vol. 39, 187-199 (Sept. 1934).
Torreson, O. W. On the value of the ratio of the number of uncharged nuclei (N_0) to the number of charged nuclei of one sign (N_+) at Washington, D. C. Terr. Mag., vol. 39, 65-68 (Mar. 1934).
— and G. R. Wait. Measurements of total nuclei, of uncharged nuclei, and of large ions in the free atmosphere at Washington, D. C. Terr. Mag., vol. 39, 47-64 (Mar. 1934).
Tuve, M. A. The energy acquired by a Dirac isolated magnetic pole in a magnetic field. Terr. Mag., vol. 38, 260-261 (Sept. 1933).
— L. R. Hafstad, and O. Dahl. High-voltage technique for nuclear-physics studies. Phys. Rev., vol. 48, 315-337 (Aug. 15, 1935).
— O. Dahl, and L. R. Hafstad. The production and focusing of intense positive ion-beams. Phys. Rev., vol. 48, 241-256 (Aug. 1, 1935).
Wait, G. R. Variations in the small-ion content of the atmosphere and their causes. J. Frank. Inst., vol. 216, 147-155 (Aug. 1933).
— and O. W. Torreson. Large-ion and small-ion content of air in occupied rooms. Heating, Piping, and Air-Conditioning, vol. 7, 105-110 (Feb. 1935).
Wells, H. W. Critical-frequency observations of the E-layer at the Huancayo Magnetic Observatory. Terr. Mag., vol. 39, 209-214 (Sept. 1934).
— and L. V. Berkner. Polarization of radio waves from the ionosphere near the geomagnetic equator. Terr. Mag., vol. 41, 75-82 (Mar. 1936).
Yost, F. L., J. A. Wheeler, and G. Breit. Coulomb wave-functions. Terr. Mag., vol. 40, 443-447 with 11 pages of tables (Dec. 1935).

Dep. Terr. Magn., C. I. W., July 31, 1936.

PROGRESS OF WORK IN TERRESTRIAL MAGNETISM OF THE UNITED STATES COAST AND GEODETIC SURVEY JULY 1, 1933 TO JUNE 30, 1936

By N. H. HECK

The Coast and Geodetic Survey through its magnetic work furnishes data needed on the charts and maps by the navigator and aviator. In the case of the latter it furnishes magnetic information for various airports where magnetic airplane compasses are tested. It enables land surveyors to rerun old land boundaries, aids geophysical prospectors who use magnetic methods and furnishes magnetic information needed in studies of radio transmission. It also cooperates in securing measurements of atmospheric electricity, earth currents, auroras and cosmic rays.

Magnetic Surveys

The magnetic field work during the period was directed chiefly to the occupation of repeat stations and the substitution of triangulation stations for stations in cities and towns for repeat work. As the result of intensive geodetic work by the Coast and Geodetic Survey triangulation stations are available in much larger numbers than formerly, azimuth marks are placed at convenient distances, and though many stations are unsuited for magnetic work, there is sufficient choice from those that are. The advantages are that there is no doubt as to position, no azimuth observations are necessary and, in general, they may be expected to remain available longer. At the close of 1935 sufficient repeat observations had been made to make possible the preparation of the isogonic map of the United States for 1935.

The vessels and parties engaged in hydrographic surveys along the coast of the United States, Alaska, and of the Philippine Islands have made declination observations at many triangulation stations and, especially in Alaska, have investigated areas of local magnetic disturbance. A large area of such disturbance has been examined in the vicinity of Duke Island, southeastern Alaska. Observations of declination have also been made in a number of States in connection with relief work. Special observations of declination have been made to enable vessels to use channel ranges in testing their compasses. Special attention has been given to obtaining a limited number of determinations of magnetic declination at sea using small craft under specially favorable conditions.

Magnetic Observatories and Instruments

The five magnetic observatories at San Juan, Puerto Rico (1926); Cheltenham, Maryland (1901); Tucson, Arizona (1909); Sitka, Alaska (1902); and Honolulu, Hawaii (1902) have been kept in continuous operation. The year after the name is that in which the observations were begun which are still continuing. At all of these observatories magnetic observations and, at all except Cheltenham, seismological observations form the basic program.

At Sitka there is a moderate amount of auroral observation though climatic conditions curtail the output of results.

At Tucson atmospheric electricity observations are made with the cooperation of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, and earth current with the same cooperation and that of the Mountain States Telephone and Telegraph Company. In both cases the Department of Terrestrial Magnetism furnishes the apparatus and interprets the results.

At the instance of the International Association and of the American Geophysical Union, the Cheltenham Magnetic Observatory and the Magnetic Laboratory of the Department of Terrestrial Magnetism have been designated to maintain jointly the magnetic standards of the United States and their interrelation with the provisional magnetic standards first established by the Department of Terrestrial Magnetism as the results of world-wide comparisons of magnetic instruments during the past twenty five years. With the steady encroachment of the city of Washington in the region surrounding the building of the Department of Terrestrial Magnetism, magnetic conditions have become unfavorable for this work. Formerly the facilities at Cheltenham were wholly inadequate; but as a result of the previously reported rebuilding of the absolute building with improved pier facilities, the provision of a test and comparison building, and more recently the rebuilding of the foundation of the large variation building to repair damage by termites, with improvement of the pier facilities, this observatory can now function completely with regard to standardization work.

A joint program with the Department of Terrestrial Magnetism of the Carnegie Institution of Washington has taken advantage of these new conditions to make numerous investigations which have resulted in improvements to instruments and their performance and in new instruments. Practically all of the observations have been made at Cheltenham.

Probably the most important has been the adaptation of the Carnegie Institution of Washington sine galvanometer to observatory use and its installation at Cheltenham for regular observation. Its use immediately emphasized the fact that the magnets of the H variometers were not in the magnetic prime vertical and steps were at once taken to determine the amount, and not only to bring them to the proper position but to make it convenient to test this at regular intervals in the future. Comparison of the Eschenhagen and Adie H variometers showed that with the magnets in the magnetic prime vertical they are in close agreement. A bifilar H variometer of the Eschenhagen type has been developed in accordance with the suggestion of George Hartnell.

Particular attention has been given to the recording of Z and to absolute determinations of its value.. Comparisons have been made simultaneously under similar conditions and in the same immediate vicinity of Adie, Toepfer, La Cour, and Askania (field instrument adapted to observatory use) Z variometers. Tests have been made of the horizontality of the magnetic axis of the recording magnets and necessary corrections have been made. In the case of the La Cour magnets the angles between the plane of the mirror and the magnetic axis ranged from nearly zero to nearly two degrees for different magnets. This is not surprising in view of the remarkable difficulties of construction with magnet, mirror and knife edges in a single unit*).

A new perminvar Z variometer devised by A. G. McNish of the Department of Terrestrial Magnetism has been given an extended test.

More accurate absolute values of H through use of the sine galvanometer make possible better values of Z provided the determination of dip is satisfactory. This depends on earth inductor performance. In recent months three independent determinations of dip have been made, first with the Wild-Edelmann earth inductor, then with the same inductor but with an additional coil furnished by the Department of Terrestrial Magnetism, and also the standard earth inductor of the Schultze type which the Department of Terrestrial Magnetism uses to maintain the provisional international standard of dip. Mr. E. A. Johnson, first with the Coast and Geodetic Survey and later with the Department of Terrestrial Magnetism, has been engaged in the development of electromagnetic instruments for making absolute observations and possibly for observing variations in the magnetic elements. The Department of Terrestrial Magnetism has continued to press this work vigorously.

This cooperative program has already produced results and others are in prospect which prove, beyond a doubt, the superiority of joint attack on problems over independent action in the same fields.

These investigations have emphasized the need for constant vigilance in attention to observatory and field instruments in order that the desired accuracy may be obtained and the need for precautions in cases where a single set of instruments is used.

An attempt to suspend the magnet in the Eschenhagen type of Z variometer by some type of metallic suspension instead of pivots proved unsuccessful though many different materials were tried. In no case was there satisfactory return of the system to zero position after large deflections.

In general, all intensity variometers have been wholly or partly compensated for temperature and further refinements

*) It is not difficult to change the said angle if of any importance. Hitherto no effort at all has been made to obtain an angle of zero.
D. l. C.

have been made in the equipment and methods for determination of sensitivity of variometers by the use of large deflectors. Time marks are placed on all magnetograms by devices operated by pendulum clocks accurate to one or two seconds per day. Apparatus for the direct scaling of magnetograms has been improved.

In addition to the other work described, at Cheltenham there has been in operation, at the request of a committee of the Carnegie Institution of Washington, a cosmic ray meter for which routine operation is provided by the Coast and Geodetic Survey and adjustments and interpretation by the Department of Terrestrial Magnetism.

Magnetic information for the daily ursigram (review of conditions affecting radio transmission) was sent from Tucson to Washington till the close of 1933 and thereafter was furnished from Cheltenham.

The College-Fairbanks Polar-Year station and its activities are fully described in the Proceedings of the Lisbon Meeting. The regular program was completed on August 31, 1933, but magnetic and earth current observations were continued through March, 1934.

Publication

During part of the past three years relief workers were available to assist in the preparation of magnetic results for publication and, as a result, this part of the work was advanced. However, the necessary supervision curtailed the preparation of papers and articles for publication by those engaged in such supervision.

Availability of results is almost as important as obtaining them. Copies of observatory records have been made immediately available to investigators and copies of the College-Fairbanks and Sitka records have been furnished to the Second Polar Year Commission. Computation of results at the five observatories is completed through 1930 and for part of them through 1932. Computation of the College-Fairbanks results is well advanced.

A new departure has been made in the publication of observatory results. It was ascertained through a questionnaire that while those who use these results find them essential, the number of actual users is comparatively small. Accordingly, the results are now reproduced in small numbers and are no longer published in editions of from 800-1200 as formerly.

There were made available during the three year period:

Results at Coast and Geodetic Survey Observatories:

Cheltenham, 1927-8, 1929-30	Sitka, 1925-6, 1927-8
Tucson, 1925-6, 1927-8	Honolulu, 1927-8

Magnetic Tables and Charts, Alaska, 1930

Magnetic Declination in the United States in 1935
(This is latest of series of five yearly publications. It includes tables of change of declination from earliest known values to the present and isogonic map with lines of equal change.)

During the three year period there have been issued, in mimeographed or printed form, in several cases reissues of earlier publications giving Magnetic Declination and Descriptions of Magnetic Stations for the following States:

South Carolina	Mississippi
Georgia	Louisiana
Florida	Nevada
Alabama	Texas
California	

Articles

Auroral Observations and Magnetic Conditions at the Sitka Magnetic Observatory, Franklin P. Ulrich, July 1932 - June, 1933, *Terr. Mag.*, Vol. 39, No. 1.

Celebration of the Completion of One-Third Century of Continuous Observation at the Cheltenham Magnetic Observatory, N. H. Heck, *Terr. Mag.*, Vol. 39, No. 4.

Magnetic Anomalies in Alaska, E. W. Eickelberg, *Transactions of the American Geophysical Union*, Fourteenth Meeting, 1933.

Magnetic Work of the Coast and Geodetic Survey, R. S. Patton, *Ibid.*
Same Number for 1934.
Same Number for 1935.
Some Problems of Magnetic Survey, N. H. Heck, *Ibid.*, 1934.

Need for More Detailed Magnetic Observations Shown by Increasing Application of Results, E. W. Eickelberg, *Ibid.*, 1934.

Outstanding Features of Magnetic Results from the Sitka Magnetic Observatory, Franklin P. Ulrich, *Proceedings, Fifth Pacific Science Congress*, Vol. III.

The Honolulu Magnetic Observatory of the Coast and Geodetic Survey, J. H. Peters, *Ibid.*

AVERAGES OF CRITICAL FREQUENCIES AND VIRTUAL HEIGHTS OF THE IONOSPHERE, OBSERVED BY THE NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C., 1934-1936

Terr. Magn., 1936, vol. 41, pp. 379-381.

PART IV

SPECIAL REPORTS

RAPPORT SUR LA PUBLICATION DU CARACTÈRE MAGNÉTIQUE NUMÉRIQUE DES JOURS

Par G. van DIJK

La publication du «Caractère magnétique numérique des jours» a été continuée régulièrement. Comme on a annoncé dans le rapport précédent (voir: Comptes-Rendus de l'Assemblée de Lisbonne, pp. 158-161; Copenhague 1934) on a publié après les données du quatrième trimestre de chaque année (1933, Tome IX; 1934, Tome XIII; 1935, Tome XVII) les communications retardées. On y a ajouté un aperçu annuel du caractère magnétique numérique des jours, qui a été également inséré dans l'aperçu annuel de la publication «Caractère magnétique de chaque jour».

La plupart des stations ont envoyé des listes avec les valeurs de $H \cdot R_H : 10000$, $Z \cdot R_Z : 10000$ et $(H \cdot R_H + Z \cdot R_Z) : 10000$; San Fernando n'a donné que les valeurs de $H \cdot R_H : 10000$, tandis que de Bilt a présenté en outre pour l'année 1933 des listes aves les valeurs de $X \cdot R_X : 10000$, $Y \cdot R_Y : 10000$, $Z \cdot R_Z : 10000$ et $(X \cdot R_X + Y \cdot R_Y + Z \cdot R_Z) : 10000$.

28 stations ont envoyé des contributions complètes pour les années 1933, 1934 et 1935. Ce sont: Abinger, Agincourt, Antipolo, Bombay, Cheltenham, Copenhague (Rude Skov), De Bilt, Eskdalemuir, Helwan, Honolulu, Huancayo, Kakioka, Kuyper, Lerwick, Lovö (Stockholm), Meanook, Pilar, San Fernando, San Juan, Sitka, Sodankylä, Swider, Tortose (Ebre), Tucson, Val-Joyeux, Vienne (Auhof), Watheroo et Zo-Sè. Le nouvel observatoire de Zo-Sè a remplacé l'observatoire de Lukiapang.

Seddin, qui avait encore contribué en 1932, n'a pas envoyé de listes dans les années suivantes. Abisko et La Quiaca n'ont plus contribué après l'année 1933; Cape Town et Hong Kong (Au Tau) se sont affiliées comme nouvelles stations à partir de 1934.

Saimistsche a envoyé des listes du second trimestre de 1933 et des second, troisième et quatrième trimestres de 1935, Sloutzk et Wyssokaja Dubrawa ont contribué pour les second, troisième et quatrième trimestres de 1935, tandis que Zouy a envoyé des listes des second et quatrième trimestres de 1935.

Pour le premier trimestre de 1936 on a reçu les listes de 33 stations; probablement le nombre d'observatoires contribuants en 1936 se montera à 35.

Il est très désirable que les observatoires collaborants envoient leurs listes le plus tôt possible.

De Bilt, le 14 *août* 1936.

REPORT OF COMMITTEE TO CONSIDER EXISTING AND DESIRABLE DISTRIBUTION OF MAGNETIC AND ELECTRIC OBSERVATORIES AND THE BETTER CO-ORDINATION OF WORK AND PUBLICATIONS OF EXISTING OBSERVATORIES

At the Stockholm Assembly in August 1930 the Association appointed a Committee to consider existing and desirable distribution of magnetic and electric observatories and the better coordination of work and publications of existing observatories. This Committee submitted a report at the Lisbon Assembly of the Association in September 1933 (C.-R. Assemblée de Lisbonne, septembre 1933; Union Géod. Géophys., Internat. Ass. Mag. Electr. Terr., Bull. No. 9, pp. 107-113, 1934), and was reappointed. It consists of S. Chapman, D. la Cour, J. A. Fleming (Chairman), Ch. Maurain, and L. Rodés.

The Association, for reasons given in our Committee report in 1933, authorized at Lisbon the continuance of a Subcommittee to consider the distribution of the work of observatories in Europe. The members of this Subcommittee are S. Chapman, D. la Cour (Chairman), and Ch. Maurain.

The publication of the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization giving the daily magnetic character-numbers shows 52 observatories, in a world total of some 75, regularly reporting upon daily magnetic conditions. This speaks well for the enthusiasm and energy with which magnetic-observatory work throughout the world is being prosecuted. The less readily compiled numerical magnetic character of each day based upon the formula adopted at the Stockholm meeting and published under the auspices of the Association is also kept current for over 30 observatories.

It will be recalled that the Association at Lisbon adopted a long series of resolutions proposed by the Committee on the establishment of additional observatories and regarding some items of work of existing observatories. The difficult economic conditions so world-wide during the past three years have retarded in some measure realization of these resolutions. Despite this, the Committee is happy to report substantial progress. Observatories at several of the locations recommended and established on a temporary basis during the International Polar Year of 1932-33 have been continued. Instruments provided for the Polar-Year program through the generous grant of the Rockefeller Foundation to the International Polar Year Commission of 1932-33 have been loaned by the Commission to establish new observatories and to supplement equipment at existing observatories.

Notes relating to maintenance of magnetic and electric observatories during 1933-36

The following notes relating to magnetic and electric observatories which have been received by the Committee since the Lisbon Assembly offer evidence of progress made during 1933-36. As a matter of convenient reference, they are grouped according to continents and countries.

Africa

In *Belgian Congo* the Polar-Year station near Elizabethville has been placed on a permanent basis by the Belgian Government.

In *Cape Province* the Polar-Year station at Cape Town has been placed on a permanent basis thanks to the indefatigable efforts of Professor A. Ogg of the Cape Town University.

Dr. J. Agostinho, Director of the Meteorological Service of the Azores, has been stressing with his Government the important arguments for the establishment of a new station near Lourenço Marques in *Mozambique,* which is in a region of exceptional magnetic interest, and for a resumption of the João Capello Observatory in Angola in a manner worthy of the distinguished scientist whose name it bears.

Dr. Maurain states that the Observatory at Algers (Bouzaréah) in *Algeria* continued its work. He also reports that the Polar-Year Observatory at Tamanrasset in *French North Africa* has continued its work from 1932 on a permanent basis. He states further that the program at the Tananarive Observatory in *Madagascar* was resumed from 1932.

Asia

In *China*, while definite information requested recently had not been received when this report was prepared, earlier advices from Dr. S. L. Ting of the Academia Sinica indicated that the Chinese Government fully expected to establish another observatory in central or northwestern China following the Association's resolution.

In *India*, the observatories at Alibag and at Dehra Dun were continued. The Director of the Geodetic Branch of the Survey of India reports it had been hoped operation of the Kodaikanal and Toungoo observatories might be resumed in 1931 to 1932, but that unfortunately lack of funds prevented doing this.

Dr. T. Okada, Director of the Central Meteorological Observatory at Tokyo, reporting for *Japan*, states that besides the Government Observatory at Kakioka (36° 13′ 51″ north, 140° 11′ 21″ east, 28.2 meters above sea-level) operated in charge of S. Imamiti, a second observatory belonging to his Service has been maintained, in accordance with the Association's Lisbon resolution, since the International Polar Year at Toyohara (46° 58′ north, 142° 45′ east, 61.5 meters above sea-level) in charge of M. Hirayama. These stations are fully equipped as regards instruments and professional staffs. At Shimoda, the southern extremity of the Izu Peninsula near Tokyo, a magnetic station is being maintained by Dr. S. Ono of the Bun-Rika University for his own researches at the Marine Biological Station of the University with an assistant to look after the recording instruments for which, however, no control-observations are taken. At the request of the Hydrographic Office of the Imperial Japanese Navy, the Meteorological Observatory at Taihoku in Formosa, Otomari in Saghalien, Jinsen (Chemulpo) in Korea, and Palau are making readings of declination once a week.

Australasia

In *Australia* the Observatory of the Carnegie Institution of Washington at Watheroo and the Observatory at Toolangi under the auspices of the Melbourne Observatory continue active operation. Apparently only occasional observations are made at the Adelaide and Red Hill (Sydney) locations.

New Zealand has continued the Amberley (Christchurch) Magnetic Observatory. There was added at this station early in 1936 a precise cosmic-ray recording meter. With some support from the Rockefeller Foundation, the Carnegie Corporation, and the Carnegie Institution of Washington, New Zealand has maintained without interruption the long series of records at the Apia Observatory in Western Samoa.

Europe

Reporting for *Finland,* Dr. J. Keränen advises that, in addition to the permanent station at Sodankylä (67° 22′ north, 26° 39′ east), there have been or are in operation temporary stations provided only with rapid-running magnetographs as follows: Vuotso (68° 04′ north, 27° 06′ east), from 1935 to May 1936; Kajaani (64° 13′ north, 27° 46′ east), from November 1932 to June 1936; Helsinki (60° 16′ north, 24° 58′ east), since January 1934.

Dr. Maurain states the chief magnetic observatory of *France* at Val Joyeux, established in 1901, and the Nantes Observatory, established in 1923, were continued. However, the magnetic observations at Val Joyeux being disturbed by industrial electric lines established in the region, this Observatory will be replaced soon by a new one (Observatory of Chambon) situated in the midst of a large forest, where measurements were begun January 1, 1936.

Reporting for *Germany,* Dr. A. Nippoldt states that the following German observatories were in operation in addition to the principal Adolf Schmidt Observatory at Niemegk (52° 04.′3 north, 15° 56′ east) which, because of interference with electric-car lines, replaced the Seddin Observatory in 1931: Maisach near Munich (48° 12′ north, 11° 15′ east); Wilhelmshaven (53° 32′ north, 8° 09′ east); Gros Raum in east Prussia (54° 49.′6 north, 20° 30.′0 east). He reports a magnetic observatory is under construction at Ratibov.

Leiv Harang reports that in *Norway,* in addition to the chief Observatory at Tromsø (69° 40′ north, 18° 57′ east, 112 meters above sea-level), there are two stations, one at Bjørnøya or Bear Island (74° 28′ north, 19° 17′ east, 29 meters above sea-level) recording D, H, and Z from July 1935 and one at Jan Mayen (70° 59′ north, 8° 18′ east, 23 meters above sea-level) where D, H, and Z were recorded from July 1934 to July 1935 and D and H only from July 1935. Dr. Harang reports also that at Tromsø, where the elements D, H, and Z have been recorded since 1929, there have been continued since the International Polar Year of 1932-33 rapid registrations and insensitive magnetograms by two sets of la Cour magnetographs. Besides these, Trumpy reports for the Magnetic Bureau the continued activity of the Observatory at Dombås in southern Norway.

In *Poland* the observatories are at Swider (52° 06.′9 north, 21° 15.′2 east), Janów (49° 54.′5 north, 23° 44′ east), and Hel (54° 36′ north, 18° 49′ east). Janów, not far from Lwów, was selected to replace the station Daszawa because of flooding of basement at that place.

Dr. Gustaf S. Ljungdahl (Kungl. Sjökarteverket) states the Government observatories in *Sweden* are: Lovö near Stockholm (59° 20.′7 north, 17° 49.′6 east), where in 1935 a set of la Cour variometers for registering D, H, and Z was installed to run parallel with the older "normal" magnetographs (the equipment includes also a set of rapid-registering la Cour variometers installed during the International Polar Year to record D, H, and Z); Abisko (68° 21.′5 north, 18° 49.′3 east), where only normal registrations of D, H, and Z are obtained.

In the French Mandate of *Syria* the Ksara Observatory has been operating since 1931.

The Government of the *Union of Socialist Soviet Republics* has been unusually active in maintaining magnetic observatories as reported by N. Rose (*Terr. Mag.*, vol. 40, pp. 401-406, 1935). In 1935 a new observatory was established at Seimtchany (63° 51′ north, 118° 30′ east), and there was put under way a new observatory at Stepanowka (46° 47′ north, 30° 53′ east) to replace Odessa where the previous series ended in 1910. Other magnetic observatories functioning or beginning operations during 1933-36 were: Buchta Tichaja in Franz Josef Land (80° 20′ north, 52° 48′ east), from 1931; Myss Tscheliuskin (77° 17′ north, 104° 17′ east), from 1934; Insel Dickson (73° 30′ north, 80° 25′ east), from 1932; Wellen (66° 10′ north, 190° 09′ east), from 1933; Jakutsk (62° 01′ north, 129° 43′ east), from 1932; Slutzk, the central observatory of U.S.S.R. (59° 41′ north, 30° 29′ east), for which the series is continuous from 1878; Wyssokaja Doubrawa (56° 44′ north, 61° 04′ east), from 1930; Saimischtsche (55° 50′ north, 48° 51′ east), previously Kazan, where the series has been continuous from 1887; Sui (52° 28′ north, 104° 02′ east), which replaced in 1914 the Irkutsk Observatory in operation since 1887; Nishnedewitsk (51° 33′ north, 38° 21′ east), from 1934; Maitun, Wladiwostok (43° 15′ north, 132° 20′ east), from 1933; Karsani or Tiflis (41° 50′ north, 44° 42′ east), where there has been a continuous series from 1905. In connection with this intense program of observatory-work, certain of the observatories in U.S.S.R. were discontinued during the period since the Committee's last report. These were: Matotschkin Schar (73° 16′ north, 56° 24′ east), closed in 1935, ending work begun in 1923; Kandalakscha (67° 08′ north, 32° 26′ east), closed in 1935, having operated since 1928; Swerdlowsk (56° 30′ north, 60° 38′ east), previously called Ekaterinburg, discontinued in 1930, having been in operation since 1837; Kutschino (55° 46′ north, 37° 58′ east), closed in 1934, ending recording begun in 1919; Taschkent (41° 20′ north, 69° 18′ east), closed in 1934, having begun in 1926.

Spain: The fast-running magnetographs of the la Cour type have been loaned to the Ebro Observatory by the International Polar Year Commission for another term of five years, and they are being used regularly, together with the other set of variometers of Mascart type.

Practically all the records obtained during the Polar Year were sent to the Central Bureau, Copenhagen, for photographic reproduction.

The new geophysical Observatory, at Toledo, far away from any disturbing high voltage line, is completing, under the efficient direction of A. Rey Pastor, the installation of first quality variometers and complementary instruments which will make of it a magnetic station of high scientific value.

North America

The Meteorological Service of *Canada* continued its Agincourt and Meanook observatories, and is understood to have made arrangements to make permanent the International Polar Year Observatory at Chesterfield. At Agincourt a new variation-room was added in which were installed open-scale and ordinary-scale la Cour magnetographs in addition to the magnetograph so long used.

In *Mexico* the Magnetic Section of the Observatorio Astronomico de Mexico continued the Magnetic Observatory at Tacubaya. Arrangements have been made and an observing hut has been built for the installation of a precise cosmic-ray meter.

The Coast and Geodetic Survey of the *United States* has continued its five observatories at Cheltenham (Maryland), Tucson (Arizona), Sitka (Alaska), Honolulu (Hawaii), and San Juan (Puerto Rico). Particularly to be noted is the development of experimental, instrumental, and superior facilities for control of standards at the Cheltenham Observatory. At Tucson, besides the magnetic work, programs in atmospheric electricity and earth-currents are followed in cooperation with the Carnegie Institution of Washington and the American Telephone and Telegraph Company.

South America

In *Argentina,* Dr. O. Lützow-Holm, Chief of the Section of Terrestrial Magnetism, Atmospheric Electricity, and Solar Radiation at Pilar, advises that the three observatories were continued as follows: Pilar, Córdoba (31° 40′ south, 63° 53′ west, 338 meters above sea-level), where the magnetic elements D, H, and Z are registered by both Eschenhagen and Edelmann magnetographs; La Quiaca, Jujuy (22° 06′ south, 65° 36′ west, 3462 meters above sea-level), where the magnetic elements D, H, and Z are recorded with an Eschenhagen magnetograph; Orcadas del Sud (60° 44′ south, 44° 47′ west), where the magnetic elements D and H were registered without interruption during 1933 but where the Z-variometer broke down at the beginning of that year, and where D, H, and Z were registered without interruption during 1934 and 1935.

In December 1935 a new cosmophysical observatory at San Miguel about 30 km from Buenos Aires, Argentina, was inaugurated. The National Committee on Observatories of Argentina extended its patronage and invested the observatory with an official governmental character although it is the property of the Society of Jesus. The eventual program will be similar to that of the Ebro Observatory in Spain. The organization includes three sections, namely, Geophysical, Electro-meteorological, and Astrophysical. Thus far only recording of meteorology, atmospheric electricity, and earth-currents have been initiated.

For *Brazil,* Dr. Sodré da Gama, Director of the National Observatory of Rio de Janeiro (Public Ministry of Education and Health), advises that the permanent magnetic observatory at Vassouras was in operation and that during the International Polar Year a magnetic station was established in Para in the north of Brazil. It has not yet been possible to establish a permanent station at Para, but Dr. da Gama states the Brazilian Government is interested in a permanent observatory at that location.

In *Peru* the Huancayo Magnetic Observatory of the Carnegie Institution of Washington was continued. Equipments for recording electrical conditions of the ionosphere and cosmic-ray intensity were installed there.

Islands Atlantic Ocean

In the *West Indies* the observatory at Fort de France, Martinique, was continued.

In the *Azores* the San Miguel Observatory was continued. Dr. Agostinho hopes there may be established soon an observatory in the *Cape Verde Islands.*

Islands Pacific-Ocean

See notes for *United States, New Zealand,* and *Japan.*

The Committee regrets that it cannot report realization of a greater number of the resolutions adopted at the Lisbon Assembly suggesting the establishment of new observatories which would materially improve present distribution. As regards the observatory suggested for Cape Comorin, the Government of Travancore advises in February 1935 that it "does not find it possible at this time to establish a magnetic observatory because of the cost, although deeply sensible of the advantages of such an observatory." The Secretary of State for the Colonies of Great Britain writes in February 1934 that it was most unlikely that St. Helena will be in a position in the near future to provide any funds for the magnetic and geophysical observatory recommended in our resolution. Again in September 1934 the Secretary of State for the Colonies of Great Britain advised that word had been received from the Conference of British East African Governors intimating that, while the Governors of the East African Dependencies agree that valuable results might be secured from the establishment of a magnetic and geophysical observatory in British East Africa, they are at present unable to provide the necessary funds for the purpose. While it was possible to continue for a few months the work at the Polar-Year College-Fairbanks Observatory, funds could not be made available to make that a permanent station.

In view of the unique character and frequency of giant micro-pulsations recorded at Reykjavik, it is unfortunate that the Government of Iceland early in 1934 advised no funds could be made available for the continuation of the Polar-Year Observatory there. It is to be hoped that any suggestion which may permit the installation and operation of open-scale magnetographs of the la Cour type, even if for relatively short periods only, may receive the support of the Association. Doubtless records from this place, on a great-circle path much used for radio communication, would be most useful for investigations of relations between magnetic-storm occurrences and radio-circuit performance.

Comments on adjustments of magnetic instruments at observatories

The Committee invites attention to a subject which is as important — in some respects more so — as the establishment of additional observatories. It is that of the maintenance of proper adjustments of instruments and, in particular, of variometers, especially those having to do with the registration of the intensity-components. It is quite understandable that once equipment is operating the need for more or less frequent checks on adjustments of axes of magnet-systems and of their proper orientations may be overlooked in an apparently satisfactory observatory-routine. Thus, for example, the orientation of the magnet-system of a horizontal-intensity variometer in the prime vertical, of a vertical-intensity variometer in the horizontal plane, etc., may change considerably even with secular variation in a few years, and then we have records of variations not of the supposed components but of ex-meridian components. Displacements of a few degrees may at times be quite serious for certain magnetic latitudes. The Committee feels, therefore, that arrangements for accurate tests of adjustments of orientation of recording magnet-systems should certainly be made at least once each year or even more frequently at all observatories and that notes regarding such tests should be indicated in publications. Lack of proper adjustments may indeed involve serious errors or even invalidate conclusions drawn from laborious mathematical reductions and discussions concerned in the analysis of a world net of observatories for a selected few or many geographically well-distributed stations, for example, in the study of the Earth's magnetic activity, in compilations of correlations with solar, lunar, and other cosmical phenomena, etc.

With growing application of electromagnetic methods for absolute measurements to control variometers and standards, calibrations of all standard cells used should be regularly made because changes in their electromotive forces may often be significant, especially if the non-saturated type is used, and like control should be exercised of standard resistances, potentiometers, insulation, etc. For standard magnetometers care must be used especially to redetermine, say every year or two, moments of inertia of magnet-systems, induction- and temperature-coefficients, as well as possible changes in distribution-coefficients. Changes of inertia of magnet-systems alone, if not so controlled, may be such as to vitally affect secular-variation values resulting from observatory records. Periodic checking of true directions of azimuth-marks by reference to secondary marks through measurements of included angles should be made. Tests should be made from time to time of possible station-differences and particularly to determine disturbing effects, if any, introduced by auxiliary magnets and interaction between magnet-systems when new equipment is added.

In atmospheric-electric records, similar precautions are essential, for example, periodic and frequent determination of reduction-factors for atmospheric potential-gradient records and of scale-values for conductivity records, tests of batteries used for quadrant-electrometer potentials, tests of collectors, etc. For earth-current installations, tests of possible electrode variations, for example, those caused by chemical reactions, by seasonal changes, etc., are needed.

Publication of data

In general, the form in which data compiled at observatories are published is satisfactory as far as it goes. There is a growing impression that, while this form meets the requirements of past experience and methods of treatment, the records contain much more material useful in answering the more complex questions raised by advances in theoretical and experimental physics. May there not be more effective methods of publication insuring availability of the whole of the recorded material to investigators? Photographic reproduction of all records on motion-picture film, as introduced by the International Polar Year Commission, seems a promising and economical method of doing this. Besides making available the whole record, it permits ready intensive study of any unique features and conditions at many stations.

There may also be mentioned the use of photographic methods for reproduction of daily records to adopted equivalent scales in time and ordinate, which is a promising one from several viewpoints, notably that of the immediate comparison thus made possible for the records from several or many stations. The development of such a technique seems to offer no problem unusually difficult of attainment.

It may be that improvements as suggested in the form of publication will increase the funds required for publication. However, the expense may be materially decreased by the preparation of tabular matter at once in form for reproduction by photographic or offset methods such as already adopted by some of the leading magnetic bureaus. More sharply defined limitation of distribution and number of edition consonant with the limited number of investigators may also reduce the present expense of publication and thus provide for the compilations and photographic reproductions suggested.

List of observatories

While our Committee's report at Lisbon recommended there be prepared and distributed a revised edition of the list of observatories with detailed information regarding each, originally published in 1910, and while the Association then considered the proposal favorably, no resolution was adopted to provide for it. Such a list is much needed in connection with matters relating to international services, unification of publications, and centralization of magnetic data. An up-to-date summary of the status of observatory reductions and publications would be invaluable to investigators of magnetic phenomena. Such diversification of published material in the past, both for various observatories and for the same observatories in different years, exists that difficulty is encountered in the selection of homogeneous material for investigation. Special need for information concerning operation during the International Polar Year of 1932-33 doubtless will be met by a publication of the Polar Year Commission; a list of such stations both for the First Polar Year and for the Second Polar Year and their details might appropriately be included in the publication proposed by the resolution offered below. The suggestion of Dr. Nippoldt that a thesaurus of all magnetic values at observatories for full series be prepared may be appropriately carried out in such a list. The Committee therefore submits the following resolution for action by the Association:

Resolution — The Association regards as desirable the publication of a revised edition of the "Liste des Observatoires magnétiques et des Observatoires séismologiques" by Merlin and Somville published in 1910 giving a complete list of all fixed magnetic and electric observatories, both operating and non-operating, with brief statements of geographical coordinates, elevations, instrumental equipment, data published regularly, data available upon special request, and special remarks covering operation and investigations, and authorizes its Executive Committee to allot such funds as may be necessary to compile and publish such list.

Washington, D. C.,
August 15, 1936.

J. A. FLEMING, *Chairman*
For the Committee

REPORT ON SUDDEN COMMENCEMENTS OF MAGNETIC STORMS IN JAPAN

By A. TANAKADATE

A comparison of Sudden Commencements of magnetic storms obtained from quick running magnetographs during the Second Polar Year is given in the Comptes-Rendus of the Lisbon Assembly; it is seen therefrom that the differences of time of occurrences are of the order of a few seconds in general, and a suggestion is made to take into account instrumental particulars in responding to such changes. Mr. Imamiti, Director of the Kakioka Observatory, has worked out such corrections and finds that it may amount to the order of one second among the instruments now in use.

Not a small part, however, of the discrepancies in that report arises from the difference in locating the instant of commencement in the curve by different observers, as the Reporter found out later.

A still important factor to be taken into account is the change of the *type* of disturbance from place to place, as revealed in the Roneographed curves (not published) in that Report. If the velocity of propagation, as it was called by previous authors, of the disturbance is to be looked after, comparisons of time observed at stations at moderate distances, where the *types* of disturbance remain essentially similar, may be expected to bring out concordant results. Mr. Imamiti, with such a view, compares the records of Toyohara and Kakioka and obtains the results as given in the following table. The last one marked with an asterisk has decidedly a different type from the rest. The first three were presented in the preliminary report to the Lisbon Assembly, and is now reduced by applying proper corrections. The double signs ± indicate probable errors of the mean values of determinations made by several observers. The instants selected are the minimum points of the dip or kick in the curves from which the rapid rises begin. This is later by a few seconds than the instant adopted by Dr. la Cour, as mentioned in the Lisbon Report.

It may be added here that Imamiti finds the velocity of propagation of disturbance to be 100 to 200 km in S-N direction, and by comparing the time with that at Tsingtau, which lies towards the magnetic West of Kakioka, the velocity W-E is 700 to 800 km, if there is propagation at all.

Time difference of sudden-commencement between Toyohara and Kakioka

				Toyohara	Kakioka	T - K
1932	Oct.	14	17h 47m	10s.1 ± 0.4	0s.3 ± 0.2	+ 9s.8
1933	April	30	16 28	21 .9 ± 0.3	10 .4 ± 0.3	+ 11 .5
»	May	29	6 25	34 .1 ± 0.2	24 .3 ± 0.3	+ 9 .8
»	June	25	10 01	36 .2 ± 0.2	29 .5 ± 0.2	+ 6 .7
»	July	8	20 37	13 .1 ± 0.2	07 .3 ± 0.2	+ 5 .8
»	»	23*	9 41	42 .8 ± 0.1	40 .0 ± 0.0	+ 2 .8

Time difference by identification of waves

The indefiniteness of the instant of commencement in attenuated records may be evaded to a certain extent by taking the crest of a wave of definite character when such a train of waves are present. Mr. Imamiti has selected the waves of a period of about one minute which are often very clearly registered with the result given in the following table:

Time difference of magnetic pulsatory waves in Toyohara and Kakioka

				Toyohara	Kakioka	T - K
1932	Oct.	3	13h06m	04s.8	04s.5	+0s.3
		4	16 37	57 .9	58 .2	−0 .3
			38	20 .2	19 .8	+0 .4
		13	13 36	51 .8	49 .6	+2 .2
			37	21 .2	20 .9	+0 .3
		15	13 27	42 .8	43 .5	−0 .7

				Toyohara	Kakioka	T - K
1932	Oct.	15	13h28m	21s.0	21s.8	—0s.8
			44	02 .4	02 .6	—0 .2
			44	26 .7	26 .3	+0 .4
		17	13 24	27 .2	27 .2	0 .0
			24	46 .5	46 .6	—0 .1
			25	0 .9	0 .9	0 .0
1933	Feb.	21	12 40	0 .6	1 .1	—0 .5
			40	24 .0	23 .6	+0 .4
		22	3 02	14 .7	16 .0	—1 .3
			14 28	16 .6	16 .3	+0 .3
	March	27	17 02	36 .5	35 .9	+0 .6
			02	46 .6	46 .2	+0 .4
			02	58 .1	57 .0	+1 .1
			44	59 .6	45m 0 .1	—0 .5
			45	15 .2	15 .1	+0 .1
	April	16	13 54	44 .4	44 .0	+0 .4
			55	16 .0	15 .5	+0 .5
		19	12 43	19 .8	18 .7	+1 .1
		22	12 43	08 .4	08 .0	+0 .4
			43	28 .0	28 .3	—0 .3
		24	14 57	30 .0	30 .2	—0 .2
			57	51 .7	53 .3	—1 .6
	May	1	15 09	19 .0	18 .4	+0 .6
			09	21 .7	21 .0	+0 .7
			09	56 .9	56 .4	+0 .5
		7	9 48	29 .8	29 .5	+0 .3
		15	10 51	13 .7	14 .4	—0 .7
	July	11	14 34	55 .6	55 .6	0 .0
	Nov.	2	10 24	20 .6	20 .9	—0 .3
		23	15 05	36 .7	35 .9	+0 .8
	Dec.	7	12 41	01 .7	01 .9	—0 .2
1934	Feb.	15	16 17	60 .5	59 .4	+1 .1
			21	09 .9	08 .2	+1 .7
			22	09 .5	08 .3	+1 .2
			23	12 .0	11 .6	+0 .4
		17	13 03	21 .1	21 .7	—0 .6
			03	42 .7	43 .2	—0 .5

Toyohara — Kakioka

frequency		mean
+........	24	0s.68
0........	3	
—........	16	0 .55
total.....	43	0 .17 ± 0 .11

The result shows that this kind of disturbance takes place practically simultaneously. It may be worth while to carry out the same investigation in other regions.

The writer of the present report regrets very much, as a member of the Committee on Sudden Commencements, to be obliged to miss the opportunity of hearing valuable reports and communications from his affectionate colleagues at the Edinburgh Meeting. No doubt, Mr. Peters will bring or send his expected stereogrammes after Dr. Bartels' idea which will give great illumination on the subject. The question of *types* of disturbance is attracting attention here by Hasegawa and Ono among others, but they are not yet ripe for communication. I hope they may bring forth something by the next meeting.

REPORT TO THE PRESIDENT OF THE COMMITTEE ON SUDDEN COMMENCEMENTS

By Luis RODÉS, S. J.

At the present state of our investigations on the simultaneity or non-simultaneity of sudden commencements it seems that the time of propagation, if there is any, around the earth, is of the order of a few seconds; consequently it was thought of interest to the writer to determine the accuracy with which the exact time of a sudden commencement can be recorded.

We take for granted that the clock keeps the exact time and that the motion of the fast revolving drum, at 3 mm per minute, is uniform; what is then the mean error one may expect in the time given for a sudden commencement of a magnetic storm?

In order to answer this question experimentally, a large solenoide, with only three or four spires, was mounted on the middle of the recording room in such a way as to have all the variometers perturbated when the electric circuit was established.

As a test for the error which might arise from the inertia of the instrument in answering to the perturbation of the electromagnetic field, the circuit was closed by the writer, from above, while the assistant was below looking directly at any change of the reflected ray coming from the mirror attached to the variometer; he had to say *top* as soon as he noted the displacement of the image; practically the *tops* were coincident with my contacts within less than a second interval; consequently there is no appreciable error to be feared from this side.

Of far greater value may be the errors arising in global form from the readings and measuring of the curves; to determine them experimentally, artificial storms were produced by the writer using the same method described above, and noting to himself the exact time on which the contact was established; then the time of sudden commencement was measured on the record, without any previous knowledge of the true time, to prevent subjective unsconscious influence; the measures were made by Sr. Benítez, assistant in the Electromagnetic Section.

Discarding values which, for one cause or another, were doubtful or quite lost, we still have 18 sudden commencements for the horizontal component H; 13 for the vertical component Z; and 6 for the declination D; the results are given in Table 1.

Table 1

True time					Recorded time + after, — before		
					H	Z	D
1934	August 4	16^h	22^m	8^s	—	—	$+1^s$
		19	53	8	$+0.3^s$	—	0
	August 5	11	38	4	$+3.2^s$	$+5.8^s$	$+3.2^s$
		17	23	14	$+3.6^s$	$+1.6^s$	$+6.5^s$
		19	13	58	$+1.1^s$	$+1.1^s$	$+5.0^s$
	August 7	11	49	19	-4.0^s	-3.3^s	$+0.3^s$
		16	8	29	-3.7^s	1.3^s	
		18	39	34	6.0^s	-6.0^s	
1935	December 4	16	7	53	-2.8^s		
		16	14	43	$+3.3^s$		
		17	39	38	-10.0^s		
	December 5	8	15	48	-1.4^s		
		11	29	30	$+2.1^s$	$+3.4^s$	
		12	14	2	2.2^s	-3.2^s	
		13	34	32	$+0.6^s$		
	December 6	8	28	37	-3.0^s	2.0^s	
		11	33	50	$+0.5^s$	-3.6^s	
		12	13	5	—	-7.0^s	
		13	42	29	$+2.2^s$	$+1.8^s$	
	December 7	9	50	43	$+0.9^s$	-0.8^s	

The mean deviation of measured time from the true time is, regardless of sign, 2.77^s for H; 3.14^s for Z; and 2.66^s for D; if we take account of the sign, the mean *positive* deviations are respectively, 1.8^s, 2.7^s and 2.6^s; and the negative, -4.1^s; -3.4^s; and 0.0^s; with a prevailing negative value of -2.3^s for H and -0.7^s for Z.

From these data it appears that the errors arising from the reading of the records, even when fast-running magnetographs are used of the La Cour type, are of the same order as the time interval we try to measure; any lack of accuracy in keeping the exact astronomical time, either by the meridian circle or by the radio receiver, as well as any error in transmitting the same to the revolving photographic paper, will render valueless the records for the object of solving the problem of how the magnetic storms of cosmic character are propagated around the earth.

Every precaution will have to be taken by the different Observatories, and as many cases as possible will have to be discussed, if we wish to reach a definite conclusion on this important matter, by the coming next maximum of solar activity around 1938-1939.

REPORT FOR THE AURORAL COMMITTEE

Kindly submitted, at short notice, by J. M. STAGG,
as the Chairman of the Committee was prevented from assisting
at the Assembly

I.

Report on replies to questionnaire regarding auroral observations made during 1932-34

With a view to forming a catalogue of available information about auroral observations carried out during the years 1932-33 and 1933-34 a questionnaire over the signature of the President of the Auroral Commission was sent to 20 countries in April 1936. Replies have been coming in up to the end of August. 14 countries have replied but of these two (Canada and Finland*) said that full replies will be forwarded later and Australia has only acknowledged receipt. Argentine, Chili, Esthonia, Iceland, Switzerland and U.S.S.R. have not yet replied. Of the eleven countries which have so far sent positive replies, two (France and Poland) do so by reference to their published reports on auroral observations during the Polar Year and Austria has only few observations to report; the remaining eight countries which have replied in more or less detail in the format of the questionnaire are Denmark, Germany, Great Britain, Holland, New Zealand, Norway, Sweden and U. S. A.. The reports from these countries along with the two publications from France and Poland contain much valuable information.

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*) Detailed reply from Finland relating to visual observations arrived 14th Sept. 1936, after this report had been prepared.

Auroral Eye Observations

In the few days available since seeing the reports I have tried to make use of the material for the most obvious purpose of seeing how the frequency of distribution of auroral occurrences fits in with the Fritz's lines but I have found it inexpedient to take the matter farther till replies from such countries as U. S. S. R., Finland, Iceland and Canada are forthcoming. Without them we are confined to small sections of the auroral zone.

Arising out of this trial and restricting my attention to the eye observations I would like to make two comments:

(1) It is over 50 years since the Fritz's lines of auroral frequency were drawn; we ought now to be able to say whether and to what extent modifications are necessary. But before we can do this with certainty I think we shall require even more information than the questionnaire supplies. In particular we shall require to know which of the nights when aurora was not seen at any one place, were nights such that aurora could not have been seen even if it had been present, because of thick and continuous cloud.

(2) There are fairly clear indications both from the auroral observations at some stations and from the associated magnetic phenomena that the zone of maximum frequency may not be stationary from year to year or even from month to month. I think that before we could modify the Fritz's lines with a precision and certainty appropriate to this stage of our knowledge, we should therefore have data similar to that now available for 1932-33 for a year near the maximum of a solar cycle, say 1937-38, and that for one or two sectors of the zone in which the permanent observing stations are most closely arranged, a month to month examination of the frequency distribution should be made.

Among the other uses of the complete set of replies to the questionnaire would be the study of selected auroral forms and their peculiarities. For this the records of one or two stations would be examined and occasions listed of certain conspicuous or unusual features of displays. The questionnaire would then say which stations observed aurora on these evenings and a supplementary questionnaire would supply further information about the details required. In this way particular displays could be studied synoptically over large areas. In this connection it is worth noting that only a small minority of the countries in which auroral observations are made indicate that any use has been made of the eye observations; on the other hand, most of the countries would be willing to supply details for such purposes as outlined above.

Auroral Spectrum

In collaboration with Messrs. Leiv Harang and E. Tönsberg, Professor Vegard has continued his valuable work on the study of the auroral spectrum. New spectrographs and an interferometer have been added to the equipment at Tromsö Observatory and these have enabled the regions of the spectrum under exploration to be extended well into the red. Some important papers and articles outlining the results so far obtained have been published.

Spectroscopic observations of the intensity of the principle auroral lines were also carried out during the years under review in various countries in the Northern Hemisphere, and at Little America, Antarctica, by the Second Byrd Expedition.

Résumé of available details
concerning auroral photographs 1932-34

Country	Name of Stations used	No. of Photographs from: Single Station	No. of Photographs from: Double Station	Notes
Norway Southern	Oslo, Oscarsborg, Kongsberg, Tömte, Lillehammer, Lökken Verk, Trondheim, Darbu, Dröbak. 1932-34 (9 stations in operation)	489	436	In addition 131 photographs simultaneously at 3 stations and 22 at 4 stations. Some results already published: other reports in preparation
Northern	Tromsö and Tenness 1932-34		2964	Film cameras used for some photographs; only those photographs which seemed unusual have so far been measured and reports published
Denmark (Greenland)	Thule	277	11	Owing to difficulties of situation and limited staff relatively small number of double photographs. The double photographs from Thule are measured and are to be published
	Thule, secondary station 1932–33	119		
	Godhavn 1932–33	261		
	Julianehaab 1932–34	1316		

Country	Name of Stations used	No. of Photographs from Single Station	No. of Photographs from Double Station	Notes
U. S. A. (Alaska)	Point Barrow 1932-33	4203		Prints of negatives and photographs to be published; some double photographs taken in conjunction with Fairbanks
	College-Fairbanks 1932-34 (2 stations)	1465	526	Calculations partially completed for 198 pairs 1932-33; publication planned
France	Scoresby Sound 1932-33	300		Details to be published in Vol. II of French Polar Year results
Great Britain	Lerwick & secondary station 1932-34	127	25	No measurements made
	Fort Rae, N. W. Canada 1932-33		4629	700 pairs measured; results to be published
Holland	Angmagssalik 1932-34	917		No measurements made; no specific project for publication
Poland	Bear Island 1932-33			Few photographs; no details for measurement
Sweden	Sveagruvan 1932-33	617	436	Preparations for measurement made

II.

Proposal for future auroral photography at Observatories

All who have been actively engaged in auroral photography, in the reduction of the photographs and the application of the results to problems involving relationships with other phenomena will agree that such work makes heavy demands on the time of the workers. In some countries it is also difficult and expensive to arrange for the maintenance of two stations suitably orientated and in communication for useful double station photography.

Many will question whether enough such work has not already been done, and may consider that what is required now is not more photography but more intensive use of the material already available. However that may be, the revival of auroral activity during the next few years will probably renew demands for photography in some countries. For this reason it is worth while considering whether some scheme corresponding to the programme proposed for such work during the second Polar Year, but with appropriate modifications, might not be effectively introduced.

Let us suppose that an isolated observatory such as Lerwick or Sodankylä is equipped with an auroral camera and plates but has not the staff to maintain a continuous watch throughout every auroral season and also that there is little possibility of setting up local auxiliary stations for parallactic work. The problem is to encourage effective and useful photography at such isolated observatories with limited staff and financial resources.

The proposal is that the photography should be concentrated into one pre-arranged season or into specified individual months of two or three successive seasons when auroral activity will be near its maximum, and that within those months photography should be done only at exact instants related to G. M. T.; the times will be at the exact hour, half hour or quarter hour if the aurora is quiet; at the exact five minutes or minute or submultiples of a minute if active. The year or months will be decided by an authority (or committee) in the subject; this committee also, having regard to the times of rising and setting of the sun and moon and the phase of the moon, might determine the sequence of hours on each night when the cooperating stations could most usefully maintain continuous watch and be ready to take auroral photographs.

III.

Report on circulation of a pamphlet "General Characteristics of Aurora at Fort Rae, Canada"

Partly to incite other observers into critical comparison of auroral events in N. W. Canada during the Polar Year with those in other localities a summarised account was prepared of the main features of auroral behaviour as observed by the British Polar Year Expedition. Copies of the pamphlet containing the account were distributed to institutions (or observers particularly interested) in 13 countries by Dr. la Cour as President of the Polar Year Commission and 14 replies have been received. Copies of most of these were distributed under cover of the Circular Letter No. 3134 of 11th July 1936.

Though intended only as an experiment some valuable comments and criticisms have been made in a fair proportion of the replies. It is generally agreed for example, that there are certain features — general diffuseness and lack of robustness — of auroral behaviour peculiar to displays during periods of low solar activity, and that there are features of aurora which are absent in localities in the immediate vicinity of the maximum frequency zone though fairly common at a distance from it. Other characteristic modes of behaviour (for example the various evolutionary stages of a quiet arc along the horizon to a corona in violent movement near the zenith) seem to be common to all localities. When all the points brought out in the replies have been examined so that differences and similarities can be summarised, a useful basis should be provided for future elaboration.

The experiment also served the purpose of showing that many observers who have contributed to the fund of auroral observations which too often remain undigested in many observatories and offices, are eager to see their work used even if only to confirm or refute the generalisations of others. It is to be remembered that auroral eye observations in bulk are notoriously difficult to handle so that any scheme for stimulating further use of the material now available would be welcome.

IV.

Project for 2nd Supplement to Auroral Atlas)*

This matter was raised at Lisbon: The purpose of the 2nd Supplement was to supply detailed instructions for the measurement of auroral photographs by the Norwegian Technique. It has been felt that all who were anxious and could see their way to utilise photographs taken during the Polar Year or subsequently had already available adequately detailed information in the numerous publications of Størmer, Vegard, Harang, and their colleagues. No one was being prevented from measuring photographs for lack of the Supplement and on the other hand the time of those to whom would fall the making of such a supplement could better be used in positive investi-

*) *Note by J. M. Stagg:*
It was intended to submit such a note at Edinburgh: it was indeed ready for presentation on the afternoon when the General report of the Auroral Commission was submitted. But the time for submitting this general report together with the other papers on aurorae (items XII. t, u & v of the Agenda) was limited to 10 minutes (actually extended to 30) that there was no opportunity for bringing it to the notice of the Association.

gations. Moreover it was uncertain whether an alternative technique might not soon be available. The matter was deferred till the views of the members of the Association could be ascertained again at Edinburgh.

REPORT ON NUMERICAL CHARACTER FIGURES

By A. CRICHTON MITCHELL

Since the meeting of the Association at Lisbon in 1933, the publication of the numerical character-figures of magnetic activity $[F = (HR_H + ZR_Z) : 10000 = (XR_X + YR_Y + ZR_Z) : 10000]$ has been continued in accordance with the arrangement made at the Stockholm meeting of 1930. The lists now published include returns from 28 observatories. For the care taken in assembling these figures and attending to their publication, the Association is deeply indebted to Dr. van Dijk of De Bilt Observatory.

The distribution of the contributing observatories is of importance. In the northern hemisphere there are 23, in the southern 5. In the eastern hemisphere, we have 16; in the western 12. In Europe, there are 10; in N. and S. America and Canada 8; in Africa 2; in Asia and the Pacific 7; and in Australia 1. A closer consideration of the distribution shows some very large gaps. We have no data for the auroral zone, although one observatory (Sodankylä) is close to it. There are none for India or New Zealand, or for the immense area which lies eastward from the eastern frontier of Germany to the Behring Sea.

The material collected up to date is only sufficient to warrant conclusions of a preliminary kind. There are however plain indications with regard to some points, one or two of which are dealt with in papers recently published, and referred to below. One of these is the high value of F as measured at Huancayo and (though to a lesser extent) at Watheroo. The data from Meanook appear to be anomalous in some respects. There is also evidence of a longitude-effect (if it may be so termed) due to the tabulation of the data for 24 hours beginning at midnight at a particular meridian. Lastly, it is clear that the quantity F, for a given observatory, shows a marked seasonal variation.

Since the publication of the values of F began, several papers have appeared which deal with the general question as to the nature and utility of the quantity so tabulated. Duvall (*Terr. Magn.*, 37, pp. 253-258) showed that F has a seasonal variation. As was pointed out in the Lisbon report, this was to be expected. Egedal (*Terr. Magn.*, 40, pp. 205-207) advocated separation of the activity due to diurnal variation from that due to disturbance. This might be done provided the diurnal part had a constant value or varied with time in some known manner. But it has neither of these characteristics. It has to be remembered that on a certain scale, magnetic activity may range in value from 1 on very quiet days up to 200 on highly disturbed days; and that on the same scale may vary from 1 to 4. Stagg (*Terr. Magn.*, 40, pp. 255-262) opened up new ground by studying the variation of mean values of F with geomagnetic latitude. It was shown that F has a very pronounced maximum about 72° north geomagnetic latitude; from this it falls quickly to a minimum about 30°; after which arises to a zone, about 20° breadth, centred over the magnetic equator. Anomalies in this distribution were pointed out and reference made to peculiarities in the value of F which are doubtless due to the longitude-effect. It is suggested that this is an important contribution to the subject, and is capable of further treatment when full details of the Polar Year work become available. Some of the relations between F and C (the international character-figure) are referred to in papers by van Dijk (*Terr. Magn.*, 40, pp. 371-380) and Bartels (*Terr. Magn.*, 40, pp. 381-382).

The following proposals are submitted for the consideration of the Assembly:

(a) That the Executive Bureau appoint a Reporter to follow the progress made in the study of this subject and of others associated with it, and to report at the next Assembly;

(b) That the Executive Bureau call the attention of the directors of observatories to the desirability of supplying values of the quantity F for those areas from which data are at present lacking.

Edinburgh, 19th September 1936.

REPORT OF THE COMMITTEE FOR STUDY OF RELATION BETWEEN SOLAR ACTIVITY AND TERRESTRIAL MAGNETISM

At the Lisbon Assembly in September 1933 the Association appointed a Committee for Study of Relation between Solar Activity and Terrestrial Magnetism. The members designated were Bartels, Chapman, Fleming (Chairman), and Maurain.

The field of our Committee is much the same as that of the Commission for the Study of Relations between Solar and Terrestrial Phenomena of the International Research Council of which two of our men (Chapman and Fleming) are members. The Commission's fourth report to the International Council of Scientific Unions, together with appended papers, was published in April 1936 (Conseil Internat. Unions Scientifiques, Quatrième Rapport, Comm. Relations Solaires et Terrestres, 159 pages, Firenze, Tipografia Barbèra, April 8, 1936). Chairman G. Abetti has contributed an excellent review of the results of more recent research and papers by some 20 authorities relate to the following subjects: Solar radiation; conditions of terrestrial magnetism and electricity; aurora; ionospheric research; absorption in the high atmosphere; cosmic radiation; light of the night-sky; meteorological and climatological variations. Of these the majority — indeed all indirectly — are of immediate interest to our fields. The report includes references to many researches published as recently as 1935; it thus includes practically most of the three years since our Lisbon meeting. It therefore would appear appropriate that, if possible, steps be taken by which our Committee may be merged with the Commission or by which it might otherwise act jointly with it.

From our viewpoint, one of the most important approaches to the relations between solar activity and terrestrial magnetism is through the study of periodicities evidenced by observation. An outstanding communication bearing on this is that by Bartels entitled "Random fluctuations, persistence and quasi-persistence, in geophysical and cosmical periodicities" (*Terr. Mag.*, vol. 40, pp. 1-60, 1935). He calls attention to new aspects and improvements on the basis of the theory of probability of the statistical viewpoint introduced by A. Schuster, the so-called periodogram-analysis or investigation of hidden periodicities. The application of the generalized harmonic dial for the transition from sine-waves to periodicities of other forms is shown. This and several other contributions recently published emphasize the great need of better understanding on the part of investigators of the requirements of statistical methods in drawing conclusions; many discussions in the past have drawn unwarranted conclusions which are quite questionable because of lack of correct appreciation of statistics.

New material on the relation of solar phenomena to the electrical conditions in the ionosphere have been reported by Appleton, Berkner, Dellinger, and their colleagues. (See communications to the Association by L. V. Berkner and H. W. Wells on "Studies of the E-region of the ionosphere at low latitudes" and on "New factors in investigation of the high region of the upper atmosphere"). Attention has been focused recently upon what appear to be variations of the ionospheric regions more or less simultaneously with recorded magnetic, atmospheric-electric, and earth-current perturbations through communications by Dellinger, Richardson, Torreson and others.

A matter deserving special attention is the question of the homogeneity of observed data of solar phenomena by various organizations. Each series is homogeneous in itself and of course Brunner's annual reviews refer all such data to a homogeneous basis. However, the broadcasting of such activity-numbers compiled at individual stations is likely to occasion some confusion when comparing the results of discussions by various investigators who may use them without consideration of necessary reduction to a uniform scale.

The expanding investigation of the effects of solar and magnetic conditions upon radio transmission and reception promises to help the solution of problems bearing on solar and terrestrial-magnetic relationships. The importance of such effects in the commercial application of radiotelegraphy has enlisted wider attention in the results of investigations of possible correlations. The daily broadcasts of cosmic data through the American, Japanese, French, and other governments and the published summaries of these data are rapidly building up an accumulation of material which must be of great service.

The cosmic-ray researches of Millikan, Compton, Johnson, and others in the field and in the laboratory bear in some degree on relations of solar and magnetic conditions to cosmic radiation. A program, sponsored by Professor A. H. Compton with the support of the Carnegie Institution of Washington, to install four or five precise cosmic-ray meters in a net of widespread stations is expected to yield data within the next few years which may solve some of the debated questions of cosmic-ray variations. Three of these installations (Cheltenham, United States; Christchurch, New Zealand; and Huancayo, Peru) are already recording. The cosmic-ray reconnaissance world-surveys completed during the past three years chiefly by Millikan and Compton have shown marked parallelism of cosmic-ray intensity with the Earth's magnetic intensity (see Carnegie Inst. Washington, *Year Book* 34, pp. 330-345, 1935, in which there is a map of the lines of equal relative cosmic-ray intensity at sea-level).

Attention is called to the recent publication of a brief but comprehensive monograph by Dr. Chapman of our Committee on "The Earth's magnetism" (xi + 116 pages with 35 figs., London, Methuen and Co., Ltd., 1936). This small volume reviews briefly the present state of investigations on the relations between solar and magnetic conditions.

Washington, D. C.,
August 15, 1936.

J. A. FLEMING, *Chairman*
For the Committee

REPORT OF SPECIAL COMMITTEE ON MAGNETIC SECULAR VARIATION

A special committee on Magnetic Secular Variation was appointed at the Stockholm meeting of the Association and its membership was modified later. It consisted of Messrs. Carlheim-Gyllensköld (since deceased), Chapman, la Cour, Fleming, Heck (Chairman), Jolly, Kalinowski, Mathias, and Maurain. The Committee based its work on a report on the distribution of permanent repeat-stations by H. W. Fisk and J. A. Fleming at the Stockholm meeting. The Committee made a report at Lisbon which was published in the Proceedings in the form of a suggested list of stations which would meet the minimum needs for secular-variation studies. It seemed to the Committee that a logical extension of its work would be to ascertain what has been accomplished during the three-year period, July 1, 1933, to June 30, 1936, and plans for the immediate future. It has no desire to invade the field of the national reports but merely to bring together in convenient form the situation in this particular subject. Letters were sent to every country adhering to the Union and many that are not, in the effort to make the information complete.

In view of the lack of a non-magnetic vessel for ocean surveys during the period no work has been done in this very large part of the Earth's surface. The prospect that this situation will be remedied during the next three years through the operation of the British non-magnetic vessel *Research* when completed, is warmly welcomed by the Committee and those whom it represents. The report of the Committee takes the form of an abstract of the information received, arranged by continents, and some of the more comprehensive reports and some maps are attached as appendices. Some of the appendices go beyond the immediate scope of the Committee but are included because of their value and lack of availability elsewhere.

References to the Department of Terrestrial Magnetism, Carnegie Institution of Washington are so frequent that the abbreviation, DTMCIW is adopted.

Europe

For most of Europe there are sufficient magnetic observatories (the best possible repeat-stations) to meet most of the needs in recording the magnetic secular variation. Accordingly, many countries have not replied. A summary of the information received follows:

Austria — Report through Nippoldt of Germany. A new magnetic observatory is being erected.

Cyprus — Direction of Land Registration and Surveys reports that there are no magnetic repeat-stations in Cyprus.

France — Appendix 1 gives a complete list given by Ch. Maurain on behalf of l'Institut de Physique du Globe of repeat-stations in France with years of occupation. Since the very complete survey of 1924 no observations have been made but the observatory at Val Joyeux has continued in operation.

Germany — A comprehensive statement by A. Nippoldt, Magnetic Observatory of the University of Berlin in Potsdam-Niemegk follows:

We have completed in 1934 and 1935 a new magnetic survey of the country. In all 552 stations have been occupied, of which 95 are repeat-stations. Of these 95 some are suitable as repeat-stations through observation in the past and probable availability in the future (see Appendix 2).

These are: Gros Raum in East Prussia (observatory with recording and some absolute measurements), 54° 49.'6 north, 20° 00′ east; in north, Zizow near Rügenwaldermünde in Pommern; in the northwest, Marine Observatory at Wilhelmshaven, 53° 32′ north, 8° 09′ east; near the Danish border, Niebüll; near the Netherlands border, Sellen; in the west, Wehrshausen in Hessen-Nassau and Grafenhausen in Hesse; in the southwest, Tullinger Höhe not far from Basel; in the south, Maisach Observatory near Munich, 48° 12′ north, 11° 15′ east; in the southeast Königssee, Upper Bavaria, Ebersdorf in Schlesien and Rabitor Observatory now being established; Zweibrücken near Pfalz.

With regard to the Lisbon list it should be noted that the Seddin Observatory was discontinued in 1931. Complete observations are now made in Niemegk, 52° 04.'3 north, 12° 41′ east. Potsdam is now only used for other purposes (see report of Committee on Observatories*). Missing from the list are Maisach, Gros Raum, Wilhelmshaven, and Ratibor now in the process of erection.

*) Page 167.

Great-Britain — H. L. P. Jolly, Ordnance Survey Office, reports that no magnetic repeat-stations were occupied in the British Isles during the period. However, the observatories at Abinger, Stonyhurst, Eskdalemuir, and Lerwick continued in operation to meet all needs. Mr. Jolly has rendered great assistance in obtaining reports from British Colonial authorities.

Netherlands — E. van Everdingen, Royal Netherlands Meteorological Institute. Only repeat-station in Netherlands is De Bilt Magnetic Observatory.

Norway — B. Trumpy, Geophysical Institute. No repeat-stations occupied outside of three observatories in Tromsø, Dombås, and Bergen. A plan for survey is being developed which will include one hundred stations over the area of Norway.

Poland — St. Kalinowski. There are six repeat-stations in Poland, two of which are the observatories at Swider and Hel. It is planned to mark all stations with special pillars during the present year (see Appendix 3).

U. S. S. R. — N. W. Puschkow. Résumé of all activities in the entire U. S. S. R. in the December 1935 number of the *Journal of Terrestrial Magnetism and Atmospheric Electricity.* In addition to 18 observatories, about 300 secular-variation stations are regularly occupied through all parts of the U. S. S.R. Observations were made at most of these during 1931-35 and at the same time a comprehensive magnetic survey was made with 13,000 complete determinations of all the elements. In addition a large number of determinations by Z-variometer were made. Special secular-change observations were made in the vicinity of the Kursk anomaly.

Asia

Arabia — DTMCIW reports observations at Aden.

China — Magnetic surveys in China were started by the DTMCIW. They are now being maintained by that Institution, the Academia Sinica, Central China College, and the Zikawei Observatory with all their activities coordinated. Reports have been received from John A. Fleming, DTMCIW (see Appendix 4), R. P. Burgaud, S. J., of the Zikawei Observatory (see Appendix 5), and C. T. Kwei of Central China College and of DTMCIW.

During 1932-36 and especially from 1934 on, 50 repeat-stations have been occupied in different parts of China in the following provinces:

Hupeh	5	Shensi	2	Szechwan	14	Shansi	1	Honan	1
Kwangsi	3	Hunan	1	Sikang	4	Fukien	2	Yunnan	2
Ahnwei	1	Kansu	1	Kiangsu	2	Kwangtung	5	Hopeh	4

M. Burgaud states that it is proposed by Zikawei and Academia Sinica to occupy repeat-stations in some parts of China every year but there are often serious difficulties. He suggests in regard to Lisbon list of International repeat-stations that Liangchow be replaced by Lanchow (36° 03.′4 north, 103° 46′ east). He also suggests that instead of including Mengtsz, Laokay, near the border of French Indo-China be selected.

Dr. Fleming states that planned field-operation of the DTMCIW during the next three years includes eastern Asia.

Federated Malay States and Straits Settlements — Report from the office af Surveyor General states that there has been no opportunity to make the necessary observations but that they will start as soon as the necessary equipment has been obtained.

French Indo-China — See Appendix 1 for repeat-work up to 1924. See also Appendix 5 for work reported by Father Burgaud; four stations were occupied by him in 1935.

India — Report from the Director, Geodetic Branch. India has an excellent magnetic survey and through 1930, 31 repeat-observations had been made west of meridian 83° east and north of parallel 16° north. During the three-year period since the Lisbon Assembly the observatories at Dehra Dun and Alibag were kept in operation but lack of funds prevented all other observations.

French Mandate in Syria — See Appendix 1 for repeat-observations through 1924. The observatory at Ksara is in continuous operation.

U. S. S. R. in Asia — Report for U. S. S. R. given under "Europe" includes the part which lies in Asia.

Africa

DTMCIW, with the aid of cooperators has occupied repeat-stations in various parts of Africa, as follows:

Union of South Africa	8	Anglo-Egyptian Sudan	2
Portuguese East Africa	4	Egypt	1
Southern Rhodesia	3	Libya	1
Northern Rhodesia	1	Tunisia	1
Tanganyika Territory	2[a]	Algeria	1
Uganda	8[a]	Belgian Congo	2
Kenya	8[a]	Gold Coast	3[b]

[a]) S. Chapman reports that Dr. Bullard in connection with gravity-survey occupied three stations in British East Africa as part of above cooperative activity. He states that Mr. Walter of the East African Meteorological Service has also occupied some stations in cooperation with DTMCIV, but that no details have been received.

[b]) The Survey Department of the Gold Coast has occupied three repeat-stations, Accra, Kumasi, and Sekondi for declination only.

North Africa — See Appendix 1 for list of stations in North Africa (French). This includes Morocco, Algeria, and Tunisia. Note especially observations in 1932 at Ouled-Djellah, 1933 at El-Golea, Ghardaia, and Ouargla, and that since 1933 the observatory at Tamanrasset has been in operation.

East Africa and Equatorial Africa (French) — See Appendix 1 for repeat-stations. Note that Timbuctoo was occupied in 1934.

Madagascar — See Appendix 1 for earlier repeat-observations. Note that the observatory of Tananarive has been in operation since 1932.

French Somaliland — See Appendix 1 for repeat-station.

Australasia

Observations have been made by DTMCIW and cooperating agencies, as follows (see Appendix 4):

Australia — Western Australia, 7 (incl. Watheroo Obsy. of CIW); South Australia, 10; Victoria, 3; New South Wales, 9; Queensland, 13.

The Government Astronomer at Melbourne Observatory reports that in Victoria the Toolangi Observatory has been active. He also states that observations have been made by the Commonwealth Geological Exploratory Survey in North Australia, using the instruments furnished by DTMCIW but no information as to results is as yet available.

New Zealand — Amberley (Christchurch Observatory) has continued in operation.

Islands, Pacific Ocean

Hawaiian Islands — Coast and Geodetic Survey Observatory continued in operation.

Galapagos (Albemarle Island), Easter Island, and Observatory at Apia, Samoa, have been occupied during the period by DTMCIW (see Appendix 4). Further observations in Pacific Islands during the next three years are planned by DTMCIW.

See Appendix 1 for list of repeat-stations in *New Caledonia* and the *Society* and *Fiji Islands.*

Antarctica

Byrd Expedition with cooperation of DTMCIW reoccupied the station at *Little America* and observed at other repeat-stations as stated in Appendix 4.

North America

Alaska — The magnetic observatory of the Coast and Geodetic Survey at Sitka continued in operation and the Polar Year Observatory at College, Alaska, continued through March, 1934. Observations were made at Attu and Point Barrow by the DTMCIW and cooperative agencies, an observatory being operated at Point Barrow during the Polar Year. According to present plans the occupation of repeat-stations in accordance with a ten-year program of the United States Coast and Geodetic Survey which should be made in 1938, will be postponed till 1941 to fit in better with the observation program for the continental United States.

Canada — Report through the Dominion Observatory. Two seasons, 1934 and 1935, were devoted to the field-work of the magnetic survey of Canada. Eighty stations were occupied of which 59 are repeat and 29 are new. On account of possible future lack of availability, nine of these new stations were established near former stations. Table 1 relates to repeat-stations listed in the report of the Committee at the Lisbon meeting.

Table 1

Station	Latitude north	Longitude east	Reoccupation and remarks
	° ′	° ′	
Dawson	64 04	220 34	Add 1924, 1934; available for future repeat-work
Chesterfield Inlet	63 18	269 08	Observatory
Fort Burwell	60 25	295 08	Add 1928, 1934; available for future repeat-work
Fort Churchill	58 48	265 48	Add 1930, 1934; new station in 1934 but no comparison with old
Chippewyan	58 43	248 51	Available for future repeat-work
York Factory	57 00	267 34	Good repeat-station, but not convenient of access
Kettle Rapids	56 24	265 27	Suggested substitute occupied 1924, 1934
Meanook	54 37	246 39	Observatory
Prince Rupert	54 15	229 30	Add 1934; available for future repeat-work
The Pas	53 49	258 37	Add 1935; new station, comparison with old
Battle Harbor	52 16	304 25	Add 1925; available for future repeat-work
Fort Albany	52 22	277 22	Available for future repeat-work
Banff	51 11	244 27	Add 1935; new station, comparison with old
Winnipeg	49 53	262 51	Station exists but artificial disturbance is bad
Vancouver	49 18	236 53	Station gone; suitable stations for repeat-observations may be selected from repeat-stations given below

Station	Latitude north	Longitude east	Reoccupation and remarks
	° ′	° ′	
Victoria	48 24	236 38	
Victoria (Mt. Douglas)	48 29	236 41	
Nanaimo	49 13	236 04	
Squamish	49 43	236 50	
Fort William	48 24	270 46	Gone; suggest substituting new station
Twin City Junction	48 22	270 35	
Rivière du Loup	47 50	290 27	Good station; future uncertain
Sydney	46 09	299 48	Bad artificial disturbance
Agincourt	43 47	280 44	Observatory

Plans for the future are somewhat uncertain but it is hoped that at least adequate repeat-observations can be made.

United States — During the year 167 repeat-stations were occupied, some of which were at triangulation-stations in the attempt to substitute such stations in the open country for stations in towns with the greater possibility of future disturbance. The work was part of that over a five-year period in order to prepare the five-yearly maps. This was done in 1935 for declination. Of the 26 repeat-stations listed in the Lisbon report, 11 were occupied during the three-year period and 8 others during the five-year period, leaving only 5 unoccupied during the period, exclusive of the observatories. In some cases other stations were occupied in their vicinity and at a later time it may become desirable to make some changes in the list.

There are difficulties in sight which may prevent the occupation of as many stations during a five-year period as in the past but it is planned to make every effort to carry out an adequate repeat-plan.

Mexico — Dr. Joaquin Gallo, Director of the Observatorio Astronomico Nacional, states that it is expected to observe at Oaxaca and Merida very soon — last observed in 1930. Other stations in the Lisbon list were observed in 1932 except Mazatlan.

Central America — The following work is reported by the DTMCIW which carried on work during the past three years either directly or with cooperation:

Costa Rica:
  San José and Puntarenas
Panama:
  Puerto Armuellos
Panama Canal Zone:
  Telvers Island

West Indies — No repeat-stations have been occupied but the magnetic observatories at San Juan, Puerto Rico (United States Coast and Geodetic Survey) and Fort de France (see Appendix 1), have continued in operation. There is a possibility that magnetic repeat-observations will be taken in connection with a gravity-expedition of the United States Navy and associated organizations within a year.

The Land and Surveys Office at Trinidad reported that no repeat-work has been done.

South America

The only reports are from the DTMCIW (see Appendix 4).

Argentina — Pilar
Brazil — Vassouras; Goyaz (2); Annapolis; Catalão (3)
Peru — Huancayo (observatory)
Guiana — See Appendix 1 for repeat-stations at Cayenne, French Guiana.

Résumé

Europe — Since observatories are numerous there is little need for repeat-stations except in the eastern portion.

Asia — Repeat-observations were made over a very large area, though other large areas have not been reached. It is hoped that India can find it possible to resume repeat-work in the well-arranged group of repeat-stations. No replies have been received from Japan or Dutch East Indies. Prospect of continued observation on a similar scale to that in recent years in Asia is good.

Africa — Repeat-program during three-year period has been quite adequate except in certain portions. It is hoped that the work can be extended to more of the stations in the excellent network in the French areas. However, the establishment of the observatory at Tamanrasset is in itself an important contribution to repeat-work in central Africa. No reply has been received regarding Italian regions. In general, prospect of continuation of observations along recent lines is good.

Australasia — The present situation is quite satisfactory and prospect of continued observations along the same lines is good.

Pacific Islands — Number of repeat-observations limited, though there has been no report for Japanese regions. Many more observations needed but probably these cannot be made until ocean-surveys are resumed.

North America — Adequate work in Canada, United States, and Mexico. More observations needed in Central America and West Indies. Prospects for continuation of the present program is good.

South America — A moderate amount of repeat-work, but three previous years were very active. Little work planned for immediate future.

Ocean-basins — No work has been at sea during the period. Future work is assured through the construction of the British non-magnetic vessel *Research*.

Appendices

1 — List of repeat-stations in France and France d'Outre-Mer. Ch. Maurain.
2 — Map of German repeat-stations.
3 — Map of Polish repeat-stations.
4 — Memorandum regarding secular-variation data of Department of Terrestrial Magnetism of the Carnegie Institution of Washington. J. A. Fleming.
5 — Report of secular-variation stations of China and Indo-China. R. P. Burgaud, S. J.

APPENDIX 1

Stations de Répétition en France

(au moins trois observations)

[On a négligé les observations antérieures à 1850 (voir Hansteen et Fox); les dates sont celles des réductions des réseaux; pour les positions se reporter aux réseaux de 1896 et de 1924]

Agde (Hérault)	1896, 1913, 1924
Agen (Lot-et-Garonne)	1858, 1875, 1885, 1896, 1924
Ajaccio (Corse)	1887, 1896, 1924
Alais (Gard)	1896, 1913, 1924
Amiens (Somme)	1858, 1869, 1885, 1896, 1924
Angers (Maine-et-Loire)	1858, 1869, 1896, 1924
Angoulême (Charente)	1858, 1896, 1924
Arras (Pas-de-Calais)	1858, 1885, 1896, 1924
Auneau (Eure-et-Loir)	1896, 1905, 1924
Auxerre (Yonne)	1875, 1896, 1924
Avesnes (Nord)	1885, 1896, 1924
Avignon (Vaucluse)	1869, 1885, 1896, 1924
Bagnères-de-Bigorre (Hautes-Pyrénées)	1885, 1896, 1924
Baisieux (Nord)	1885, 1896, 1924
Bastia (Corse)	1887, 1896, 1924
Bayonne (Basses-Pyrénées)	1858, 1869, 1896, 1913, 1924
Beauvais (Oise)	1885, 1896, 1905, 1924
Belfort (Haut-Rhin)	1858, 1885, 1896, 1924
Berck-sur-Mer (Pas-de-Calais)	1885, 1896, 1924
Besançon (Doubs)	1875, 1885, 1896, 1924
Blesmes (Marne)	1885, 1896, 1924
Bonifacio (Corse)	1887, 1896, 1924
Bordeaux (Gironde)	1858, 1869, 1875, 1885, 1896, 1913
Boulogne-sur-Mer (Pas-de-Calais)	1869, 1896, 1924
Bourges (Cher)	1869, 1896, 1924
Brest (Finistère)	1869, 1875, 1879, 1896, 1924

Caen (Calvados)	1885, 1896, 1924
Cahors (Lot)	1896, 1924
Capdenac (Aveyron)	1885, 1896, 1924
Carcassonne (Aude)	1858, 1875, 1896, 1924
Carpentras (Vaucluse)	1885, 1896, 1924
Castelnaudary (Aude)	1896, 1913, 1924
Cette (Hérault)	1858, 1875, 1885, 1896, 1924
Chambéry (Savoie)	1875, 1896, 1924
Le Chapus (Charente-Inférieure)	1896, 1913, 1924
Chartres (Eure-et-Loir)	1885, 1896, 1924
Châteauroux (Indre)	1858, 1875, 1896, 1924
Chaumont (Haute-Marne)	1885, 1896, 1924
Chelles (Seine-et-Marne)	1885, 1896, 1924
Cherbourg (Manche)	1875, 1885, 1896, 1924
Clermont-Ferrand (Puy-de-Dôme)	1858, 1869, 1875, 1885, 1896
Commersy (Meuse)	1858, 1896, 1924
Le Conquet (Finistère)	1885, 1896, 1924
Corte (Corse)	1887, 1896, 1924
Cosne (Nièvre)	1885, 1896, 1924
Dax (Landes)	1896, 1913, 1924
Dijon (Côte-d'Or)	1858, 1869, 1875, 1885, 1896, 1924
Dôle (Jura)	1869, 1896, 1924
Douai (Nord)	1869, 1896, 1924
Dunkerque (Nord)	1858, 1879, 1885, 1896, 1924
Epernay (Marne)	1858, 1896, 1924
Etampes (Seine-et-Oise)	1858, 1896, 1924
Evreux (Eure)	1896, 1905, 1924
Figeac (Lot)	1875, 1896, 1924
Foix (Ariège)	1896, 1913, 1924
Gourdon (Lot)	1896, 1924
Grenoble (Isère)	1869, 1875, 1885, 1896, 1924
Hendaye (Basses-Pyrénées)	1856, 1869, 1885, 1896, 1913, 1924
Langeac (Haute-Loire)	1885, 1896, 1924
Laon (Aisne)	1885, 1896, 1924
Laval (Mayenne)	1869, 1896, 1924
Lille (Nord)	1885, 1896, 1924
Limoges (Haute-Vienne)	1858, 1896, 1924
Lisieux (Calvados)	1885, 1896, 1924
Lorient (Morbihan)	1879, 1896, 1924
Lyon (Rhône)	1869, 1875, 1885, 1896
Mâcon (Sâone-et-Loire)	1885, 1896, 1924
Le Mans (Sarthe)	1858, 1875, 1885, 1896, 1924
Marseille (Bouches-du-Rhône)	1858, 1869, 1875, 1885, 1896, 1924
Meaux (Seine-et-Marne)	1858, 1896, 1924
Metz (Moselle)	1869, 1911, 1924
Moissac (Tarn-et-Garonne)	1896, 1924
Mont de Marsan (Landes)	1858, 1896, 1924
Montauban (Tarn-et-Garonne)	1896, 1924
Montbrison (Loire)	1885, 1896, 1924
Montelimar (Drôme)	1858, 1875, 1896, 1924
Montpellier (Hérault)	1858, 1869, 1875, 1896, 1924
Morceux (Landes)	1896, 1913, 1924
Moulins (Allier)	1858, 1869, 1885, 1896, 1924
Nancy (Meurthe-et-Moselle)	1858, 1875, 1885, 1896, 1924
Nantes (Loire-Inférieure)	1858, 1875, 1885, 1896, 1913, 1924, magnétographe à partir de 1923
Narbonne (Aude)	1858, 1896, 1924
Nice (Alpes-Maritimes)	1875, 1885, 1896, 1924; série de 1885 à 1901
Orange (Vaucluse)	1858, 1896, 1924

Orléans (Loiret)	1858, 1875, 1896
Le Palais (Morbihan)	1885, 1896, 1924
Pamiers (Ariège)	1896, 1913, 1924
Parc Saint Maur	Magnétographe de 1883 à 1900
Pau (Basses-Pyrénées)	1869, 1875, 1896, 1924
Périgueux (Dordogne)	1858, 1869, 1875, 1885, 1896, 1924
Perpignan (Pyrénées-Orientales)	1858, 1875, 1885, 1887, magnétographe de 1886 à 1900
Pic-du-Midi (Hautes-Pyrénées)	1885, 1896, 1924
Poissy (Seine-et-Oise)	1896, 1905, 1924
Poitiers (Vienne)	1858, 1869, 1885, 1896, 1924
Le Puy (Haute-Loire)	1858, 1896, 1924
Quiberon (Morbihan)	1879, 1896, 1924
Reims (Marne)	1869, 1896, 1924
Rennes (Ille-et-Vilaine)	1885, 1896, 1924
La Roche-sur-Yon (Vendée)	1896, 1913, 1924
Saint Etienne (Loire)	1869, 1896, 1924
Saint Martin-de-Hinx (Landes)	1886, 1888, 1896, 1924
Saintes (Charente-Inférieure)	1896, 1913, 1924
Sarrebourg (Moselle)	1858, 1911, 1924
Saverdun (Ariège)	1896, 1913, 1924
Segré (Maine-et-Loire)	1885, 1896, 1924
Strasbourg (Bas-Rhin)	1869, 1911, 1924
Tonnerre (Yonne)	1885, 1896, 1924
Toulon (Var)	1879, 1896; série de 1866 à 1871
Toulouse (Haute-Garonne)	1858, 1869, 1875, 1885, 1896; série de 1846 à 1862
Tours (Indre-et-Loire)	1858, 1885, 1896, 1924
Trappes (Seine-et-Oise)	1896, 1905, 1924
Uzès (Gard)	1896, 1913, 1924
Val Joyeux (Seine-et-Oise)	Magnétographe depuis 1901
Vannes (Morbihan)	1869, 1896, 1924
Vernon (Eure)	1896, 1905, 1924
Vierzon (Cher)	1858, 1896, 1924
Villefort (Lozère)	1885, 1896, 1924
Villefranche-sur-Mer (Alpes-Maritimes)	1875, 1879, 1885, 1896

Stations de Répétition dans la France d'outre-mer

Afrique du Nord (Maroc, Algérie, Tunisie, Territoire du Sud)

Mogador	1906, 1912, 1925, 1926
Mazagan	1906, 1912, 1920
Casablanca	1906, 1912, 1920, 1925, 1926
Rabat	1906, 1912, 1925, 1926
Larache	1906, 1912, 1926
Tanger	1888, 1906, 1912, 1925, 1926
Colomb-Bichor	1906, 1912, 1927
Nemours	1891, 1912, 1923
Tlemcen	1891, 1923, 1927
Sidi-Bel-Abbes	1888, 1923
Oran	1888, 1906, 1912, 1922, 1927
Ain-Sefra	1891, 1906, 1912, 1927
Méchéria	1888, 1891, 1927
Mascara	1888, 1923, 1927
Saida	1888, 1912, 1929, 1934
Orléansville	1888, 1906, 1912, 1927
Tiaret	1891, 1912, 1927
El Goléa	1891, 1912, 1930, 1933

Laghouat	1891, 1927, 1930
Ghardaia	1891, 1927, 1933
Médéa	1891, 1906, 1926
Alger (Bouzaréah)	1860, 1872, 1888, 1906, 1912, 1918, 1922, 1926, et tous les ans ensuite
Dellys	1923, 1925, 1926
Ouled-Djellal	1891, 1930, 1932
Bougie	1906, 1912, 1926
Sétif	1888, 1912, 1926
Biskra	1888, 1891, 1904, 1906, 1909, 1912, 1927
Touggourt	1891, 1904, 1912, 1922, 1928
Constantine	1888, 1891, 1906, 1927
Ouargla	1904, 1909, 1912, 1933
Batna	1888, 1906, 1930
Philippeville	1888, 1906, 1912
Souk Ahras	1888, 1912, 1928
Tunis	1888, 1891, 1912, 1922, 1924
Sfax	1888, 1906, 1912, 1922
In Salah	1904, 1909, 1912, 1930
Tamanrasset	1909, 1912, 1913, 1930, 1932, 1933 puis magnétomètre

Afriques occidentale et équatoriale françaises

Dakar	1886, 1887, 1889, 1896, 1910, 1913, 1920, 1925
St. Louis	1889, 1896, 1904, 1906, 1913, 1925
Podor	1896, 1913, 1925
Conakry	1910, 1913, 1914, 1925
Matam	1896, 1913, 1926
Koulikoro	1913, 1922, 1926
Kotonou	1897, 1908, 1913, 1926
Paraku	1908, 1913, 1925
Tin Zaouten	1904, 1909, 1913
Tomboucto	1913, 1926, 1934
Hassi Meniet	1904, 1909, 1913
Tit	1904, 1909, 1913
Niamey	1908, 1913, 1926
Gaya	1908, 1913, 1926
Fort Gentil	1911, 1915, 1917, 1920
Libreville	1887, 1896, 1917, 1920
N. Djole	1888, 1908, 1917
Booué	1888, 1911, 1917
Lastourville	1888, 1911, 1917
Garoua	1891, 1916, 1919
Franceville	1887, 1888, 1911, 1917
Fort Lamy	1902, 1908, 1917, 1919
Brazaville	1888, 1906, 1911, 1913, 1915, 1917
Ouesso	1906, 1911, 1919
Port Archambault	1900, 1903, 1917
Bangui	1891, 1900, 1901, 1902, 1912, 1917
Fort Crampel	1900, 1901, 1917
Tountouma	1917, 1920, 1925

Madagascar

Diego Suarez	1889, 1895, 1900, 1902, 1905, 1907, 1914, 1921, 1924
Antsirane	1889, 1905, 1907

Vohemar	1885, 1888, 1921
Nosi Bé (Helville)	1888, 1889, 1900, 1902, 1905, 1921
Majunza	1888, 1889, 1892, 1895, 1898, 1900, 1902, 1906, 1921, 1924
Ste. Marie de Madagascar	1885, 1888, 1902
Tamatave	1892, 1902, 1924
Tananarive	Magnétomètre depuis 1902 à 21, 1929, 1930, 1931, 1932, puis magnétomètre
Andevorante	1888, 1892, 1921
Maharidaza	1904, 1905, 1921
Saovina	1904, 1905, 1921, 1931
Maroudavo	1889, 1898, 1921
Tulear	1889, 1902, 1907, 1921, 1924

Côte française des Somalis

Djibouti	1915, 1918, 1921, 1928

Indo-Chine

Tourane	1891, 1909, 1912, 1922
Saigon	1896, 1904, 1906, 1912, 1922, 1924
Baie d'Along	1907, 1908, 1909, 1911
Haiphong	1907, 1911, 1923

Iles françaises du Pacifique

Nouvelle Calédonie	
Ile Lifu	1915, 1922, 1927
Ile Maré	1915, 1922, 1927
Nouméa	1890, 1897, 1915, 1922, 1927
Iles de la Société	
Papéete	1890, 1897, 1906, 1907, 1912, 1916, 1922
Pte. Fareute	1906, 1916, 1920, 1922, 1928
Iles Fidji	
Suva	1906, 1912, 1927, 1928

Guyane et Antilles

Cayenne	1908, 1918, 1921, 1923, 1927
Martinique	
Fort de France	Magnétomètre

Mandat français

Ksara	1909, 1910, 1931, puis magnétomètre
Beyrouth	1885, 1890, 1896, 1911, 1924
Damas	1885, 1910, 1922
Alep	1910, 1922, 1923
Alexandrette	1885, 1910, 1920, 1922

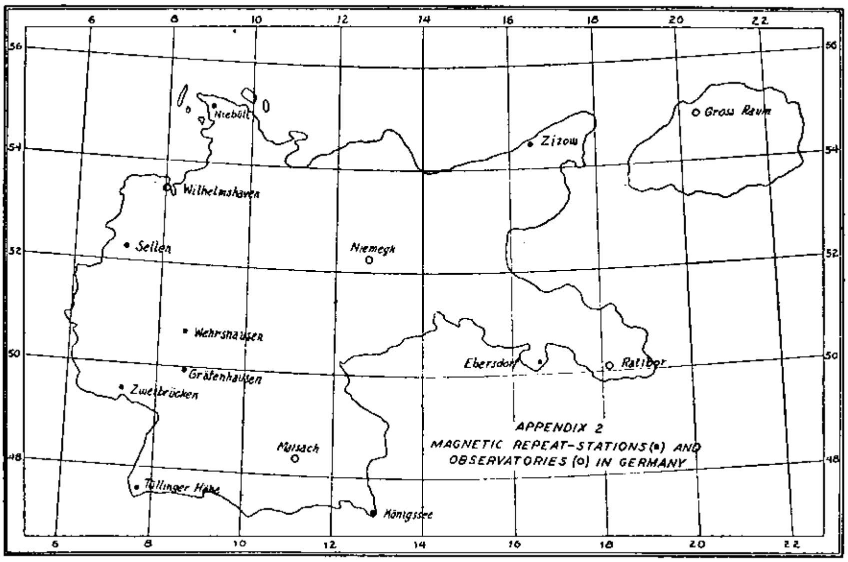
Institut de Physique du Globe de l'Université de Paris,

Paris, France, 1er *avril* 1936.

APPENDIX 2

Magnetic repeat-stations and observatories in Germany

By A. NIPPOLDT



APPENDIX 3

Magnetic repeat-stations and observatories in Poland

By St. KALINOWSKI

Map: See page 130.

APPENDIX 4

Memorandum regarding secular-variation data obtained by the Carnegie Institution of Washington through its Department of Terrestrial Magnetism during July, 1933 to June, 1936

By J. A. FLEMING

The completion of a first magnetic survey of the Earth begun in 1904 by the Carnegie Institution of Washington through its Department of Terrestrial Magnetism has laid a firm foundation upon which our knowledge of the magnetic secular-variation may be built. The large number of stations established afforded a good basis for selecting localities where reoccupations, at suitable intervals, would yield information most needed regarding the secular changes for theoretical studies of the Earth's magnetism and for possible investigation of changes in the Earth's crust and interior.

While secular change for a given locality is most effectively determined from continuous registrations obtained by a magnetic observatory there, and while the evaluation of the effect produced by the solar cycle can be fairly well determined for much of the Earth's surface from the present distribution of magnetic observatories, this distribution is far from adequate for furnishing the information necessary to outline the areas of regional activity. Only after there had been an accumulation of observations at widely scattered stations — an accumulation to which the Institution has contributed substantially — was it possible to gain even an approximate picture of what has been taking place over the Earth as a whole or to obtain a comprehensive idea of this extremely important aspect of the problem. While the apparent variation in the annual rates of secular change clearly indicates that the regional activity is far from constant, the time over which sufficiently accurate data have been gathered is much too short to state what the period may be through which the phenomenon runs its course. The nature of the problem is such that substantial progress toward its solution demands that periodical observations be made at stations scattered over the whole surface of the Earth, and since in addition to the oceans there is much of the land-surface under governments unable, or at present indisposed, to undertake work of this character, there is still an urgent demand for continuing the survey-operations which the Institution has carried on since its organization in 1904.

The work done by the Institution on this enterprise since that reported at the Lisbon Assembly in 1933 is shown by the following list of stations in which those belonging to the tentative list of international repeat-stations suggested by the Special Committee on Magnetic Secular-Variation Stations (C. R. Assemblée de Lisbonne, 1933; Union Géod. Géophys. Internat., Ass. Mag. Electr. Terr., Bull. No. 9, 119-136, 1934) are indicated by italics (the number in parentheses following any station indicates the number of points, if more than one, in the locality at which observations were made).

Africa

Union of South Africa		
Capetown	Johannesburg	*East London*
Orange River	Uitenhage	Durban
Pretoria	*Mafeking*	
Portuguese East Africa		
Lourenço Marques	*Beira*	*Mozambique*
Pessene		
Southern Rhodesia		
Bulawayo	Salisbury	*Victoria Falls*
Northern Rhodesia		
Livingstone		
Tanganyika Territory		
Dar es Salaam	*Tabora*	
Uganda		
Kampala	Fort Hall	Equator
Entebbe	Jinja	Kichwamba
Fort Portal	Hoima	
Kenya		
Nairobi	Kijabe	Naivasha
Mombasa	Nanyuki	Gilgil
Kampi ya Moto	Kisumu (2)	
Anglo-Egyptian Sudan		
Port Sudan	Gondokora	
Egypt		
Suez		
Libya		
Tripoli		
Tunisia		
Tunis		

Algeria
- *Algiers*

Belgian Congo
- Bogoro
- Kissenyi

Arabia
- Aden

Zanzibar
- Zanzibar

Antarctica

Little America, Observatory (reoccupation observatory of 1928-30)
Seventeen stations between latitudes 78° and 82° south and longitudes 149° and 164° west
Four stations between latitudes 76.°7 and 78.°6 south and longitudes 145.°6 and 163.°8 west

Asia

China

Hupeh Province		
Ichang (3)	Shasi (2)	Yochow
Hankow	Wuchang	
Szechwan Province		
Chungking (2)	Chengtu	Luting
Fowchow	Yaan	Loshan (Kiatingfu)
Wanhsien	Hwangnipu	Tawei
Kweichowfu (2)	Nitow	Ipin (Suifu)
Omei	Fulin	
Hunan Province		
Hengchow		
Kwangtung Province		
Shiuchow	Canton	
Kwangsi Province		
Wuchow	Nanning	Kweilin
Sikang Province		
Mosimien	Kangting	Yinkwanchai
Tzetati		
Chekiang Province		
Zosè (Zikawei)		

Australasia

Australia

Western Australia		
Bunbury	*Coolgardie*	Eucla
Albany	Balladonia	*Watheroo*
Merredin		
South Australia		
Ceduna	Yalata	Flinders
Strathalbyn	Goolwa	Port Victor
Kuitpo Forest	Nairne	Port Augusta
Adelaide		
Victoria		
Portland	Melbourne	Swan Hill
New South Wales		
Broken Hill	Ivanhoe	Wagga Wagga
Burrewarra Pt.	*Red Hill*	Dubbo
Bourke	Werris Creek	Moree
Woolgoolga		

Queensland		
Brisbane	Chinchilla	*Charleville*
Maryborough	*Rockhampton*	Longreach
Hughenden	*Townsville*	MacKay
Tambo	Roma	Toowoomba
Clermont		
New Zealand		
Amberley (Christchurch Observatory)		

Europe

England		
Abinger		
Germany		
Niemegk		

North America

Alaska		
Point Barrow	Attu	
Costa Rica		
San José (2)	Puntarenas	
Panama		
Puerto Armuellos		
United States		
Cheltenham	Mt. Pleasant	
Canal Zone		
Telvers Island		

South America

Argentina		
Pilar		
Brazil		
Vassouras	Goyaz	Catalão (3)
Araguari	Annapolis	
Peru		
Huancayo		

Islands, Pacific Ocean

Galapagos		
Albemarle Island		
Easter Island		
Western Samoa		
Apia		

It is the hope of the Department that during the period between the sixth and seventh triennial assemblies of the International Association of Terrestrial Magnetism and Electricity it may obtain observations in certain regions where secular-change rates are either indicated as rapidly varying or where the period since the last data were obtained is longer than desirable. In this, as in the past, the endeavor will be to occupy as many as possible of the stations suggested for secular-variation purposes in the first report of the Special Committee on Magnetic Secular-Variation Stations submitted at the Lisbon Assembly.

The regions tentatively planned for operations during the next three years include western Africa, Australasia, eastern Asia, and the Pacific Islands.

It is to be hoped that, with the completion of the British Admiralty's non-magnetic vessel *Research* now being constructed, attention may be given at an early date by that organization to determining the magnetic elements in the Indian, South Pacific, and South Atlantic oceans as had been planned for the last cruise of the *Carnegie* which was interrupted by the loss of that vessel in November, 1929. It appears that in these regions the rates of secular change are much needed.

Washington, D. C., U. S. A., June 30, 1936.

APPENDIX 5

Magnetic repeat-stations in China and Indo-China

By M. BURGAUD, S. J.

I am glad to send herewith observations made at some repeat-stations in China and Indo-China during 1933 to 1936.

It is contemplated by the organization of the Academia Sinica or the Zikawei Observatory to reoccupy regularly every year some repeat-stations according the local possibilities in the different provinces of China. Of course difficulty is sometimes very great.

Relating to the list of International repeat-stations proposed in the list adopted at Lisbon I suggest two stations, namely, Liangchow in 37° 57′ north and 102° 45′ east (too difficult of access) and Mengtsz (not on the Yunnan Railway and where the hospital is closed) be replaced by Lanchow in 36° 03.′4 north and 103° 48′ east and by the reoccupation of Laakay on the China-Tongking border, respectively. These substitutions are strongly recommended because of the difficulty of relocating the original station.

Magnetic repeat-stations in China and Indo-China

Station	Latitude north	Longitude east	Reoccupied	
			Date	Observer
China				
	° ′	° ′		
Fort Bayard	21 08	110 24	Dec. 1934	RPB
Pakhoi	21 30	109 06	Dec. 1934	RPB
Nanning	22 43.4	108 22.4	July 1935	CTK
Canton	23 07.2	113 20	July 1935	CTK
			Apr. 1936	AC
Mengtsz	23 22.7	103 26	Jan. 1935	RPB
Wuchow	23 28.7	111 17	July 1935	CTK
Shiuchow	24 48.6	113 23.8	July 1935	CTK
Yunnanfu	25 04.2	102 42	Jan. 1935	RPB
Kweilin	25 17.7	110 16.1	Aug. 1936	CTK
Hengchowfu	26 57.7	112 39.2	July 1935	CTK
Suifu	28 46	104 38	Nov. 1934	FCB
Yochow	29 27.1	113 12	Aug. 1933	FCB
Chungking	29 33	106 33	Nov. 1934	FCB
Kiatingfu	29 33.3	103 41	Nov. 1934	FCB
Fowchow	29 58.8	102 56	Oct. 1934	FCB
Yaan	29 43.7	107 23	July 1933	CTK
Shasi	30 18.1	112 15	Aug. 1933	FCB
Hengchow	30 19.3	120 08	Nov. 1935	RPB
Hankow	30 36.4	114 17	Sep. 1933	FCB, CTK and reg. obs'ns

Station	Latitude north	Longitude east	Reoccupied	
			Date	Observer
	° ′	° ′		
Chengtu	30 38	104 03	Sep. 1934	FCB
Ichang	30 43.3	111 18	Aug. 1933	FCB
Wannsien	30 49	108 17.4	July 1933	CTK
Wuhu	31 21	118 20	Dec. 1935	RPB
Nanking (rep)	32 02.5	118 46.2	Dec. 1935	RPB
Tchenkiang	32 12	119 24.9	Dec. 1935	RPB
Chengchow	34 45.2	113 42.6	July 1932	FCB
Shenchow	34 48.3	110 11.2	July 1932	FCB
Sian	34 16.3	108 56.2	July 1932	FCB, CTK
Changteh	36 05.9	114 22.5	July 1932	FCB, CTK
Taiyuang	37 52.1	112 37.7	July 1932	FCB, CTK
Shihchihuang	38 04.6	114 31	Sep. 1932	FCB, CTK
Peiping	39 56.8	116 23	Aug. 1932	FCB, CTK
Kalgan	40 51.6	114 51	Aug. 1932	FCB, CTK
Foochow, Amoy, Swatow were reoccupied during April 1936 by AC				
Indo-China				
	° ′	° ′		
Hanoi	21 03.2	105 50	Jan. 1935	RPB
Yenbai	21 38.5	104 54	Jan. 1935	RPB
Langson	21 51.6	106 42	Jan. 1935	RPB
Laokay	22 28	104 00	Jan. 1935	RPB

Note: The observers in the above list are indicated as follows:

CTK = C. T. Kwei of the Central China College in Wuchang
FCB = F. C. Brown of the American Church Mission
RPB = R. P. Burgaud, Director of the Magnetic Department of Zikawei Observatory
AC = Party of two observers of the Department of Physics of the Academia Sinica and of the Zikawei Observatory.

Dr. Filchner, en route to Tibet, reoccupied the following stations: Lanchow (36° 03.′4 north, 103° 48′ east), Sian (34° 16.′3 north, 108° 57′ east), and Sining (36° 37′ north, 101° 55′ east).

Zikawei Observatory, Shanghai, China, April 16, 1936.

Communication from C. L. Ting, National Research Institute of Physics, Academia Sinica

The following addition is made which affects statement regarding China, on page 191 and appendix 5. It covers the months of March and April, 1936, and was received after preparation of reprints:

Woosung	31° 23.′2 N.	121° 30.′3 E.	
Wenchow	28 01.6	120 39.1	(1 additional station)
Ning Po	29 53.8	121 34.2	(1 " ")
Putu Id.	29 59.8	122 22.7	

Detail of occupation of Foochow, Amoy, Swataw mentioned in appendix 5, has been received. 2 additional stations have been occupied at Canton.

There is expected to be a permanent field party engaged in the occupation of repeat-stations for secular variation studies.

The magnetic standard and recording house at the Purple Mountain, Shanghai, will soon be in operation. Three more permanent stations including one in northwest China, are planned.

Washington, D. C.

N. H. HECK, *Chairman*
For the Committee

REPORT OF THE COMMITTEE FOR THE STUDY OF ELECTRICAL CHARACTERIZATION OF DAYS

By O. H. GISH, *Chairman*

The Committee for the Study of the Electrical Characterization of Days appointed by the Association at the Lisbon Assembly consists of O. H. Gish (Chairman), Luis Rodés, Ed. Salles, O. W. Torreson, and F. J. W. Whipple. Such progress as has been made in the study of electrical characterization of days by this Committee is reported here.

In a circular letter sent May 16, 1936, by the Chairman to the members of the Committee some specific topics, which seemed to require consideration, were outlined as follows:

(1) Is a uniform practice as regards the electrical characterization of days likely to be of sufficient value to justify efforts toward the inauguration of such a practice?

(2) What should be the objective of such practice? For example, should the character-number, or symbol, (a) be designed chiefly to express certain outstanding characteristics of the electrogram which are not indicated by such data as hourly means, daily means, and diurnal range, or (b) should it be designed to serve primarily as a basis for forming such group-means as are to be published, or as a basis of selection where hourly values are published for selected days only?

(3) Should a meteorological classification be employed instead of, or in conjunction with, electrical characterization? Although this Committee was appointed to *study the electrical*

characterization of days, yet there are matters associated with this question which cannot be entirely neglected in that study. Thus, if there is a negative response to (1) above, that is, if the majority of the Committee deems it unprofitable to devise and employ electrical characterization, then perhaps the Committee would favor instead some *meteorological classification,* for example, like that suggested by O. W. Torreson (C. R. de l'Assemblée de Lisbonne, septembre 1933, Union Géod. Géophys. Internat., Ass. Mag. Electr. Terr., Bull. No. 9, p. 255, 1934). Or perhaps both electrical characterization and meteorological classification are to be desired. The latter may be especially desirable if meteorological data are not published in full. If the objective of electrical characterization is that suggested under (2b), then in a study of this some consideration of what electric and meteorological data are to be published would seem required.

(4) Should the Committee recommend at this time any specific scheme for electrical characterization? If a uniform practice in the electrical characterization is worth while, then it is desirable that an international agreement regarding the character of that practice should be reached as soon as possible. However, it is the writer's opinion that the study of this matter has not yet been carried to the point where specific recommendations should be made. If possible, a quantitative study, designed to ascertain the comparative value of some possible systems of electrical characterization, should first be made before selecting a scheme for international use.

(5) What quantitative studies of the comparative value of schemes of electrical characterization are feasible at the present time? It is suggested that each member describe the scheme or schemes of electrical characterization which he deems most promising and that he indicate quantitative tests which he thinks may be made with data now available.

(6) If there are reasons for thinking that a uniform practice of assigning an electrical character is not desirable, then it should be helpful if those reasons are expressed either in the report of this Committee or as a separate comment. If a member of this Committee has made any quantitative studies which bear on any aspect of this subject, they should be briefly reported.

(7) So far as is known to the writer, no reports of quantitative studies which pertain to the value of electrical characterization have been published. However, it seems desirable that such studies should be made before any specific proposal for electrical characterization is recommended to the Association for international adoption.

(8) Therefore, unless some members of the Committee have made quantitative studies, it seems that the report should

consist in expressing either approval or disapproval of the *principle* of uniform electrical characterization, and in the case of approval it should be accompanied by a statement of the objectives. Some promising schemes for characterization should then be indicated with the suggestion that a committee be appointed to make a quantitative comparison of these and report its findings and recommendations at the next General Assembly.

(9) *Electrical characterization* has repeatedly appeared as an item of the agenda for the meetings of the Association, but these have called forth very little comment. An expression of opinion from all concerned with measurements of the electric field of the Earth is also to be desired before offering any definite proposal.

The comments on these topics, together with other suggestions received from members of the Committee, follow.

Reverend Luis Rodés, Director, Observatorio del Ebro, writes (June 6, 1936):

"I have discussed your interesting communication with Dr. Romaña, Chief of the Electromagnetic Section, and I am glad to enclose here his point of view with which I quite agree.

I would venture to add that the main objective of such characterization should be the study of the correlation of the atmospheric potential-gradient with other phenomena, either cosmic or local.

First of all, I should distinguish between curves influenced by known meteorological factors, such as rain, fog, storm, etc., and curves free from these disturbances; the first ones could be denoted by m and the second ones by n, and both could be classified from 0 to 2, taking, as a basis for it, the *intensity* and the *duration* of the perturbations. As Dr. Romaña offers, we shall present at Edinburgh a definite scheme on this line."

The communication from Dr. A. Romaña, Chief of the Electromagnetic Section, Observatorio del Ebro, is as follows:

"Le Rev. P. Rodés m'ayant prié de lui exposer mon opinion sur la réponse à donner à la lettre de M. Gish, je pense qu'on pourrait lui écrire ce qui suit:

(a) Il ne faut pas interrompre les efforts pour arriver à une méthode uniforme de caractérisation électrique des jours dans les enregistrements du potentiel atmosphérique; car tout en reconnaissant que les causes de caractère local, surtout météorologiques, de nature à troubler l'allure normale du phénomène, sont ici beaucoup plus nombreuses que dans l'étude du magnétisme et des courants telluriques, on ne peut pas oublier cependant qu'il reste encore un nombre considérable de jours où de pareilles causes sont absentes, et ceux-ci semblent suffire largement à trouver des rapports de caractère général et très intéressants avec l'activité solaire, par exemple, et les phénomènes magnétiques et électro-telluriques.

(b) A mon avis le système de classification doit être double. Tout d'abord il doit servir à séparer les jours aptes pour les études de caractère général, que l'on pourrait appeler *jours "normales" ou "ordinaires"*, de ceux qui ne le seraient pas, que l'on pourrait désigner avec la qualification de *jours "météorologiques"* ou *"singuliers"*. Pour ce choix il faudrait ne tenir compte que de l'absence ou présence des phénomènes météorologiques que l'on admet généralement comme perturbateurs. *Cette première classification serait donc météorologique.*

Pour ne pas trop restreindre le nombre des jours "ordinaires", je crois très opportune l'idée de M. Torreson, de classer parmi eux les jours où une cause perturbatrice s'étant présentée, elle aurait été pourtant d'une si courte durée, qu'il serait facile de suppléer par interpolation les valeurs que la courbe aurait prises, si la cause perturbatrice ne s'était pas présentée.

Après cela il faudrait classer les jours ordinaires en trois groupes et les désigner avec les numéros 0, 1, 2. L'avantage d'un tel groupement serait de rendre plus facile le travail de comparaison, etc., avec les données du magnétisme terrestre et des courants telluriques. *Cette classification doit être faite purement du point de vue électrique,* c.-à-d. d'après la nature des courbes. Bien que celles-ci présentent deux sortes de mouvements nettement séparés, ceux qui influent sur l'allure générale de la courbe et en outre les mouvements d'oscillation presque continue autour d'une position moyenne, je pense pourtant que pour cette classification il faut les employer tous deux indifféremment, de même qu'on les emploie sans les distinguer pour la publication des valeurs horaires moyennes. Naturellement il faudrait faire attention non seulement à l'amplitude des mouvements, mais encore à leur durée.

Quant aux jours singuliers il serait peut-être aussi intéressant de les classer également du point de vue électrique, dans le but de pouvoir mieux fixer les rapports des changements du champ électrique de l'atmosphère avec les phenomènes météorologiques. En tout cas il faudrait tout au moins faire mention de la nature du phénomène météorologique ayant servi à les classer comme jours "singuliers".

Comme il est impossible de proposer immédiatement une méthode de classification plus ou moins digne d'être soumise à la considération de l'Assemblée et moins encore de la contrôler par des études comparatives avec d'autres systèmes, je pense que l'on peut s'offrir à M. Gish à faire le suivant:

(1) A élaborer avant l'Assemblée d'Edimbourg une méthode de classification à proposer comme sujet d'expérimentation que nous baserons sur les courbes de cinq années au moins, et dont nous contrôlerons les résultats en les comparant à ceux

obtenus moyennant l'application aux mêmes courbes de notre système actuel de classification ou de celui proposé par M. Gish dans son rapport à l'Assemblée de Lisbonne (C. R. de l'Assemblée de Lisbonne, septembre 1933, Union Géod. Géophys. Internat., Ass. Mag. Electr. Terr., Bull. No. 9, pp. 221-229, 1934).

(2) A faire une étude comparative après la célébration de l'Assemblée d'Edimbourg des résultats de l'application aux courbes de nos enregistrements (1905-1936) de toutes les méthodes qui auront été proposées à l'Assemblée et celle-ci jugera dignes d'être essayées dans le but d'un choix définitif à soumettre à l'Assemblée de 1939."

Dr. Ed. Salles, Institut de Physique du Globe at Paris, makes the following comments and suggestions (June 19, 1936):

"J'ai cru comprendre (voir article 4, ligne 5, de votre lettre), que vous ne pensiez pas qu'actuellement, on puisse faire des propositions bien nettes, je suis entièrement de cet avis. Ne serait-il pas sage de proposer le mode de caractérisation en usage à Kew et à Eskdalemuir, en abaissant peut-être le maximum de 1000 volts, qui me semble bien élevé.

On pourrait, si cette proposition était adoptée, établir un palier intermédiaire à 500 volts.

D'autre part il serait à envisager des échanges de vue fréquents entre les membres de notre Commission.

Je suis d'avis qu'une caractérisation des jours est à souhaiter, mais ne faudrait-il pas au préalable unifier les modes de mesures et de dépouillement. Il me semble difficile d'appliquer les mêmes règles à des stations ayant des situations climatologiques entièrement différentes; par exemple, dans certaines régions du globe, les pluies sont continuelles pendant une partie de l'année, tandis qu'une sécheresse relative règne pendant les autres mois. Ou contraire, en d'autres endroits, le régime des pluies est loin d'être ainsi tranché.

Je crois impossible de ne pas tenir compte des éléments météorologiques et je verrais avec plaisir une classification de ce genre. Mais l'allure de l'électrogramme a son importance, et il est indispensable de la noter, ainsi que les accidents. Par accidents j'entends les passages au négatif, leurs durées, l'influence de la pluie. Il serait bon aussi de consigner l'agitation, nulle, faible ou forte de la courbe, l'importance du maximum du matin ou de celui du soir, l'amplitude moyenne de la journée, dépassant ou non une certaine valeur. Mais ne serait-on pas amené à trop de complications.

La caractérisation de Kew est simple, il serait à désirer qu'on la prenne pour base en tenant compte des éléments météorologiques."

Dr. F. J. W. Whipple, of the Meteorological Office at London, offers the following comments and suggestions (July 30, 1936):

"I have found it difficult to make any recommendations, but on the whole I think it would be sufficient advance if all stations adopted the practice of giving for each day the duration of negative potential gradient and published the number of days each month with no durations, durations up to three hours, and durations more than three hours. These classes correspond with the character-figures of the Meteorological Office.

I am interested in the possibility of correlating simultaneous potential-gradient readings and I should like to propose:

(a) That the mean potential gradient should be published for each of the hours ending at 1, 7, 13, and 19, GMT.

(b) That the relevant weather-conditions should be indicated by a simple code.

(c) That it should also be indicated if the potential gradient was negative for any part of the hour.

You will see that these indications would be a helpful guide in selecting the potential-gradient readings which might fairly be correlated with those at other stations."

It appears from these comments to be a common opinion of those members of the Committee who have found it possible to give attention to this question that, although some scheme of electrical characterization of days is desirable, yet it cannot be decided at this stage of the study whether any specific scheme of electrical characterization can be applied to advantage at all places on the Earth.

Some quantitative studies which are being made (see reports of O. H. Gish and A. Romaña) are designed to determine the comparative merits of several schemes. Such studies should be helpful whether or not a uniform practice of characterization is found to be feasible.

It therefore seems desirable that the study of this matter be continued.

Washington, D. C., August 15, 1936.

REPORT ON INTERNATIONAL COLLABORATION TO ADVANCE THE STUDY OF THE MOON'S EFFECT UPON GEOPHYSICAL PHENOMENA

By S. CHAPMAN

At Lisbon in 1933 I presented to the Association a report*) with the same title as the present one, in accordance with a request made by the Association (then the "Section") at Stockholm in 1930**).

In part the report discussed the desirability of establishing an international centre for the extensive and specialized computations required in studies of lunar effects on geophysical phenomena.

At Lisbon the report was referred to the Executive Committee of the Association, and I was continued as reporter on this subject.

Subsequently the Executive Committee made a grant of £ 100 per annum for three years towards the expenses of "Systematic researches of the effect of the moon on terrestrial magnetism" directed by myself. Such researches are, and for many years have been, made at the Computing Bureau in the Department of Mathematics at the Imperial College of Science, together with similar researches relating to the barometric pressure and air temperature.

The annual costs of this Bureau include a sum of about £ 550 for salaries, and about £ 50 for materials (mainly computing cards); Hollerith computing machines, whose rent and maintenance normally costs about £ 480 per year, are provided free of charge through the generosity of the British Tabulating Machine Company; Imperial College provides ordinary calculating machines, together with accommodation, light, heating, cleaning, etc. On a commercial basis the expenses of the bureau, exclusive of the direction of the work, would amount to about £ 1200 per year, or rather about £ 1000 per year allowing for the fact that the Hollerith equipment is by no means used to its full capacity.

The Bureau gives only part of its time, perhaps one-third, to studies of lunar effects on terrestrial magnetism, though the other studies which it undertakes, on the lunar atmospheric tide and on lunar effects upon the air temperature and (more recently) on winds, also bear on magnetic problems, and were started because of their relation to such problems.

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*) See pp. 136-143 of the Comptes-Rendus of the Lisbon Meeting of the Association.

**) See p. 466 and pp. 330-333 of the Comptes-Rendus for the Stockholm Meeting of the Section.

The £ 100 per year granted by the Association has been applied towards the salary of the chief assistant in the Bureau; the remaining cost of the salaries is provided out of a research grant made to the Imperial College by one of the ancient City Companies or Guilds of London, namely the Clothworkers Company. The grant from the Association is valuable not only in itself but also as indicating to the College and the Clothworkers Company the importance attached by an international scientific Association to the work of the Bureau.

The first two annual grants were expended in the two (College) financial years October 1, 1934 - September 30, 1936, and the third of the authorized annual grants will be expended in the year following the forthcoming Edinburgh Assembly of the Association. This plan gives a year in which to make any necessary re-arrangements in the expenses of the Bureau, should it be decided not to continue the grant. It has the effect also that at the time of writing this report (May, 1936) the actual expenditure from the grants amounts to about £ 165 out of the £ 300 paid. This has been applied towards the concluding stages of determinations of the lunar daily magnetic variation in the horizontal force at Greenwich, and in all three elements at Cheltenham, U. S. A.; and to the first part of a "lunar" investigation of the long series of declination data (to 1930) at Batavia. These investigations are extensive and usually overlap at least two, sometimes several years.

In addition, with the aid of an assistant paid for by the Egyptian Government, the lunar daily magnetic variation in all three magnetic elements at Helwan is being determined.

No account of this work assisted by the Association has yet been prepared for publication. Hitherto accounts of my work on this subject have been published in the Philosophical Transactions of the Royal Society, and if agreeable to the Association my further papers can likewise be communicated to the same Society, with, in addition, a very brief statement of the main results obtained, in my report to the Association.

May 1, 1936.

REPORT ON ERRORS ARISING IN ION-COUNT WORK

By G. R. WAIT, *Reporter*

A report was prepared (C. R. Assemblée de Lisbonne, septembre 1933 ; Union Géod. Géophys., Internat. Ass. Mag. Electr. Terr., Bull. No. 9, pp. 143-147, 1934) for the Lisbon meeting of the Association on certain systematic errors common to most ion-counters. The various points discussed in that report were errors arising from the following sources: (1) The repulsion of ions coming into the counter caused by an electric field arising from a potential applied to the tubes of the counter; ((2) ionization inside the air-flow tube due to the accumulation of radioactive matter on parts exposed to the electric field; (3) charge on the top of the counter induced by the Earth's electric field; (4) the inclusion of less mobile ions in ion-number determinations. The attention of those engaged upon ion-count work has been called to this report, with the request that suggestions be furnished for improvement of ion-counting technique, in order to improve the accuracy with which ion-numbers may be determined. The fourth point above was discussed in somewhat more detail, and an appeal was made for the cooperation of all investigators in preparing a general report on the magnitude of any such effect at each station where ion-counts have been made in the past or are now being made. There has not been, as yet, a sufficient number of stations sending in a report to justify a general report to the Union on this matter at the present time.

Intermediate ions of high mobility are quite numerous in the atmosphere of Washington, D. C. Consequently, it appears likely that at the station of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, which is in a suburb of Washington, conditions are especially favorable for the introduction of a large error due to the factor listed under (4) above. For this reason, it appears justifiable to reproduce records that illustrate the relatively large current coming to the central electrode of the ion-counter, owing to the collection of intermediate ions, during the process of counting the small ions of the atmosphere.

In order to take account of the current to the central electrode contributed by ions less mobile than the small ions, the air-stream was made to pass through an electric filter across which any desired potential could be applied for the purpose of removing all small ions from the air-stream. In so doing, a certain fraction of the less mobile ions were also removed, but, knowing the mobility of the less mobile ions, the ions thus removed could be taken into account in determining the number of less mobile ions in the atmosphere. Every alternate hour (beginning at even hours) a potential sufficient to remove all small ions was applied to the filter. Consequently the current to the central electrode was entirely due to the intermediate ions in the air (neglecting the small effect due to the catching of a small number of large ions). During the remaining hours (beginning at odd hours) the current was due to intermediate ions plus small ions caught by the counter. The difference in the two currents is that attributed to the small ions, except for a small factor that needs to be subtracted owing to the few intermediate ions which are removed from the air-stream by the filter coincident with the removal of the small ions.

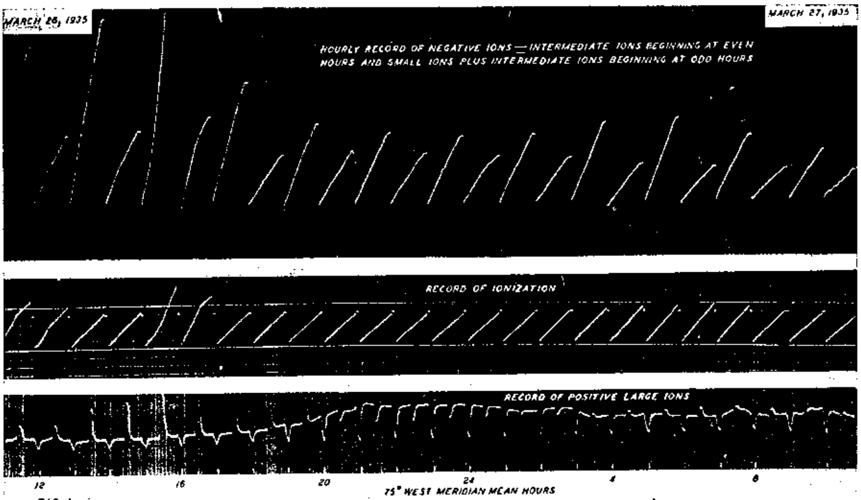

FIG. 1—SIMULTANEOUS RECORDS OF IONS AND IONIZATION OF THE ATMOSPHERE, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON, MARCH 26-27, 1935

The uppermost curve of Figure 1 shows the resulting record obtained from 11^h March 26, 1935, to 11^h the following day. During the night-hours fully 75 per cent of the current to the small-ion counter was due to intermediate ions. In general, the number of intermediate ions increases while the number of small ions diminishes during the night-hours, and on an average about 50 per cent of the current coming to the central electrode at this time of the day is due to less mobile ions than to the small ions. Obviously under such circumstances it is absolutely imperative that the current arising from the collection of the less mobile ions be recognized and be allowed for in the determination of the number of small ions. To fully allow for such collection, it is necessary to determine the critical potential (saturation-value) of small ions as well as that for the intermediate ions (providing the large-ion mobility is already known) in both ion-counter and electric filter. It does not seem necessary to give a detailed explanation of the general scheme usually employed for determining the mobility of ions from the saturation-curve. The general method employed is well known among the workers in this field, as the general principles have been widely used since they were first discussed by Thomson (*Phil. Mag.*, v. 47, p. 253, 1899), Rutherford (*Phil.

Mag., v. 47, p. 109, 1899), and Zeleny (*Trans. R. Soc.*, A, v. 195, pp. 193-234, 1900) many years ago.

By emphasizing the above source of error, it was not meant to imply that other errors are necessarily small. It seems equally important to examine conditions for the other possible errors as well as to keep in mind errors not discussed. For example, it has been suggested to the writer by V. F. Hess that an error is frequently made in determining the volume of air drawn through the counter. The source of this error lies in incorrect calibrations of the anemometers used. Dr. Hess points out that each anemometer should be frequently compared with a correct standard — as often at least as once per year. In the ion-count work at the Department of Terrestrial Magnetism, a synchronous motor is employed to rotate the fan. The volume of air under such circumstances is found to be very constant with time. It is suggested, therefore, that such a motor be used whenever conditions permit.

Dep. Terr. Magn., C. I. W., July 29, 1936.

RAPPORT SUR LA PUBLICATION DES CARACTÈRES MAGNÉTIQUES PENDANT L'ANNÉE POLAIRE 1932-1933

Par G. van DIJK

L'Organisation Météorologique Internationale à sa Réunion à Varsovie Septembre 1935 a adopté la résolution suivante:

> La Conférence (des Directeurs) trouve désirable que le caractère magnétique de chaque jour soit publié pour toutes les stations de l'Année Polaire comme un supplément aux publications actuelles et recommande que les données de toutes les stations magnétiques qui ont fait des enregistrements pendant l'Année Polaire et qui n'ont pas encore envoyé ces informations à De Bilt, soient envoyées le plus tôt possible et au plus tard le premier mars 1936.
>
> La Conférence est d'avis qu'il serait désirable d'en faire autant pour ce qui concerne la publication du caractère magnétique numérique des jours.

La question de l'édition d'un tel supplément aux publications actuelles avait été soumise à la discussion à Varsovie par le Docteur Fleming et Commander Heck, Washington, et la Commission de Magnétisme terrestre et d'Electricité atmosphérique avait adopté la résolution.

Le Docteur la Cour, Président de la Commission Internationale de l'Année Polaire 1932-1933, en demandant dans une lettre circulaire de bien vouloir contribuer aux efforts de publier le dit supplement aussi complet que possible, a prié de vouloir envoyer les caractères magnétiques de chaque jour (échelle 0, 1 et 2) et les caractères magnétiques numériques des jours pour l'Année Polaire au Docteur van Dijk, De Bilt, qui s'était chargé de prendre soin de la rédaction et de l'impression des suppléments.

En ce qui concerne les caractères magnétiques numériques des jours obtenus par les stations de l'Année Polaire, le Président de l'Association de Magnétisme et Electricité Terrestres a aprouvé que le Bureau Central de l'Association se chargera des frais de l'impression de ces valeurs.

En réponse à la circulaire susmentionnée un grand nombre de stations magnétiques m'ont envoyé des listes. Quelques-unes de ces stations n'ont pas envoyé de données complètes, plusieurs autres stations n'avaient pas encore répondu à la circulaire au commencement de juin 1936. C'est à ces stations que j'ai, d'accord avec le Président de la Commission Internationale de l'Année Polaire, adressé une lettre circulaire, datée Juin 1936, où j'ai prié de bien vouloir bientôt envoyer les données manquantes, si possible.

Le tableau suivant donne un aperçu de la collaboration des stations magnétiques, temporaires et permanentes. Les données reçues jusqu'au 15 août 1936 ont été indiquée par —; on n'a pas inséré dans le tableau les données des stations permanentes qui ont été déjà publiées dans les publications actuelles du caractère magnétique.

Le symbole (H) signifie: $\frac{HR_H}{10000}$, (Z): $\frac{ZR_Z}{10000}$, (H, Z): $\frac{HR_H+ZR_Z}{10000}$.

Stations	Période	Car. 0,1,2	Car. num. (H)	(Z)	(H,Z)
Terre François Joseph	Août 1932 - Août 1933	—			
Sveagruvan	Sept. « - Août «	—	—	—	
Thule	Août « - Juill. «	—	—	—	—
Björnöya	Oct. « - Août «	—	—	—	—
Matotschkin Char	Août « - Août «	—			

Stations	Période	Car. 0,1,2	Car. num. (H)	(Z)	(H,Z)
Dickson	Déc. 1932 - Août 1933	—			
Point Barrow	Oct. « - Août «	—	—		—
Jan Mayen	Nov. « - Juill. «	—	—	—	—
Scoresby Sund	Nov. « - Août «	—	—	—	—
Tromsö	Juill. « - Sept. «	—			
Petsamo	Août « - Août. «	—	—	—	
Godhavn	Août « - Août «	—	—	—	—
Kandalakscha	Août « - Août «	—			
Angmagssalik	Sept. « - Août «	—	—	—	—
Fairbanks	Oct. « - Mars 1934	—			—
Chesterfield	Sept. « - Sept. 1933	—			
Fort Rae	Août « - Août «	—	—	—	—
Yakoutsk	Févr. 1933 - Août «	—			
Julianehaab	Sept. 1932 - Août «	—	—	—	—
Niemegk	Août « - Août «		—		
Manhay	Sept. « - Août «	—			
Nantes	Août « - Août «		—	—	—
Toyohara	Août « - Août «	—			
Castellaccio	Août « - Août «	—	—		
Tsingtao	Août « - Août «		—	—	
Hongkong (Au Tau)	Août « - Déc. 1932		—		
« « «	Jan. 1933 - Août 1933		—	—	—
Teoloyucan	Juill. 1932 - Sept. «	—			
Moka, Fernando Póo	Sept. « - Août «	—	—	—	—
Mogadiscio	Août « - Juill. «	—	—		
Tatuoca	Sept. 1933 - Janv. 1934	—			
Elisabethville	Oct. 1932 - Août 1933	—			
Tananarive	Nov. « - Déc. «		—	—	—
Cape Town	Août « - Déc. «	—	—	—	—
Magallanes	Janv. 1933 - Août. «	—			

De Bilt, le 15 *août* 1936.

INTERNATIONAL COMMISSION OF TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY

NOTE BY THE SECRETARY ON THE APPOINTMENT OF A BOARD CHARGED WITH AN INTERNATIONAL SERVICE OF COMPARISONS OF MAGNETIC INSTRUMENTS, MADE WITH INSTRUMENTS CIRCULATED BY MAIL

(1) At the meeting in Warsaw of the International Commission of Terrestrial Magnetism and Atmospheric Electricity it was decided to authorize their Bureau to appoint in agree-

ment with Dr. Fleming a Sub-Commission charged with the organization of such international comparisons which are dealt with in the Resolution VI of that meeting. The reason for prefering this procedure and not to appoint straight away the Sub-Commission was, that while it was the wish of the Commission to support the work in question as much as possible, the Commission recognized that the Association had a certain priority in the matter due to the initiative already taken by its Central Bureau in procuring 3 QHM for international work. As indicated in the minutes of the said meeting the Commission is in favour of the members of the Sub-Commission in question to be members both of the Commission and of the Association. If nominated in this spirit, the Sub-Commission is not an ordinary Sub-Commission depending on a single Commission nor is it a joint Sub-Commission consisting of some representatives of the Commission and other representatives of the Association. It seems to the Secretary that the most appropriate name of the new body should be "Committee on Comparisons of magnetic measurements" (CoC).

(2) As the CoC should take over the whole responsibility of the service of comparisons organized by international agreement and as the success of the undertaking is contingent upon close and cordial collaboration all over the world between magnetic observatories the Secretary proposes that the presidency of the CoC should be taken over by the Presidents of the Association and of the Commission and that a representative of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and a representative of each of the continents except America should be the members. Further the Secretary proposes that once appointed the Committee should have the power to fill any vacancy as long as the Association and the Commission give their assent, or do not withdraw this.

(3) The supervision of the international service of comparisons and the use of this service claim constant activity of the CoC. The task of the Committee would be considerably facilitated if the current work was concentrated in a suitable manner for being carried out along the lines drawn up by the CoC. The Secretary proposes that this work should be concentrated in an Executive Bureau appointed by the CoC. He considers it advantageous if a close connection between the Executive Bureau and the Central Bureau of the Association be established and proposes the Executive Bureau to consist of the Director of the Central Bureau and of one or two experts living not too far from the actual seat of this Bureau. The Executive Bureau should report to the CoC by sending them copies of their transactions.

(4) The experiences obtained up to now with the QHM clearly show the outstanding need for the organization of an

international service of comparisons. However, there are various ways which could be followed and other instruments than the QHM which could be used for the purpose.

Under the actual circumstances the Central Bureau of the Association in collaboration with the Danish Meteorological Institute has made some preparations towards the organization of an international service of comparisons (see f. inst. *Communications Magnétiques, etc.*, No. 15 and No. 16, published by the Danish Meteorological Institute).

(5) In order to elucidate the constitution of the CoC according to the policy given in item 2 and 3 the following *example* should be given. The *Committee on Comparisons* appointed by the Bureau of the International Commission on Terrestrial Magnetism and Atmospheric Electricity and the President of the International Association on Terrestrial Magnetism and Electricity

Presidency:	Messrs. Fleming and Maurain	
Members:	"	Okada, Lejay or Ono, Kidson or Parkinson, Ogg or Sutton, (Gish and Bartels)
Executive Bureau:	"	(van Dijk, Goldie, la Cour).

Putting the names of Gish and Bartels within parentheses means that the Secretary for his own part is in doubt whether or not the CoC should be added to by other representatives for America and Europe than Messrs. Fleming and Maurain.

The appointment of the members of the Executive Bureau is not an actual matter but should be left to the CoC, if they wish to have such a Bureau established. The three names have been indicated here only to indicate the actual ideas of the Secretary about such a Bureau.

PROGRESS-REPORT OF THE JOINT COMMITTEE
of the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organisation and the Association
ON METHODS AND CODES TO ADEQUATELY DESCRIBE MAGNETIC DISTURBANCES AND PERTURBATIONS

At its Warsaw meeting in September 1935 the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization adopted the following resolution (Proces-Verbaux Réunion de Varsovie, Comm. Mag.

Terr. Electr. Atmos., Organisation Mét. Internat., No. 30, pp. 17, 29, and 41, 1936):

Resolution

The Commission recommends the appointment of a joint Committee of the Commission and of the International Association of Terrestrial Magnetism and Electricity to consider and to propose suggestions at the Edinburgh Assembly of the International Association for uniform methods and codes to adequately describe magnetic disturbances and perturbations.

J. A. Fleming, as a member of both bodies, was designated as Chairman of this joint Committee with A. Nippoldt and E. Sucksdorff, of the Commission, and S. Chapman and N. H. Heck, of the Association, as the other members.

It is a source of gratification to all investigators of terrestrial magnetism and electricity that there is developing so rapidly increasing activity in theoretical discussion of the vast amount of accumulated and accumulating observatory-data. This finds its urge, in considerable measure, also in the promising applications of such material now being given to its possibilities in subsurface geological interpretations, in geophysical prospecting, and in wireless communication. Both theoretical discussion and practical application will be forwarded greatly through prompt distribution of preliminary particulars regarding details of varying magnetic conditions recorded at the observatories before the lapse of time, after these conditions are recorded, necessary to compilation and extended publication. Investigators interested in possible correlations now frequently can be guided in their selections of needed material only by records of one or two observatories immediately available to them. Selected records supplied from other observatories upon request for a particular period may not exhibit a suitable manifestation of the phenomenon; thus advance knowledge of the character of the records at various observatories as regards disturbances and perturbations would guide the selection of those particular records most suitable for study.

There is thus ample justification for concerted action, such as contemplated by the resolution of the Commission, looking towards the realization of some usable code-method which will serve this urgent need. But it calls for most careful deliberation to insure successful application without adding to the burden already imposed upon the usually limited personnel charged with maintenance of, and research at, observatories. A prime consideration is therefore the possibility, in devising such a code-method, of making it helpful also, perhaps, in decreasing that burden.

In the scant time available since the designation of the Committee, communications have been received from all its members as also from several other persons. These are attached to this report as appendices 1 to 6. It is to be remarked, that in preparing this progress-report the Chairman has added some remarks not in the original communications; these remarks are indicated by enclosure in brackets [ ]. Because of the thought given and codes adopted through the activity of the International Union of Scientific Radiotelegraphy, there is also attached as Appendix 7 a report*) made to the American Geophysical Union in 1935 by Watson Davis, under whose direction Science Service broadcasts a daily Ursigram. If consideration is to be given definition of a code to broadcast daily or weekly information decided upon, this report will be useful. It is the result of experience gained in the development of the Ursigram service in Japan, France, and America; in particular, it reflects certain aspects of minimizing the demands upon the limited time available for broadcasts — an important matter when governmental broadcasting facilities are already so taxed.

Dr. Nippoldt's excellent and constructive comments (Appendix 1) have stimulated the helpful comments given in appendices 2 to 6. They furthermore are so developed as to reduce rather than increase demands on personnel of observatories since they would simplify, in considerable degree, descriptive statements of daily magnetic conditions now generally published in data compiled for each observatory. His statement — in which there is unanimous agreement — that no code-method of description can do more than give in general terms the features of the original magnetograms is beyond question. In this it is apparent that the method of reproduction for distribution of the record on motion-picture film introduced by the International Polar Year Commission is a real and an economical solution.

Mr. McNish's comments (Appendix 4) call attention to, and give an example of, one of the outstanding needs. That is a more systematic presentation for preliminary publication of descriptions of magnetic storms and perturbations in scientific press, for example, the *Journal of Terrestrial Magnetism and Atmospheric Electricity* or other organ. As editor of the *Journal*, the Chairman has found the diversity of description offered by observatories submitting reports a perplexing task when attempting to put them in concise yet sufficient form for prospective users. The adoption of some definitive and approved code-method of description would aid greatly in clarity essential to those investigators who wish to make selection of special phenomena for discussion.

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*) Not printed in this publication. See: Transactions of the American Geophysical Union, 16th Annual Meeting, 1935, pp. 41-49. Reprints will be sent on request by: Science Service, 2101, Constitution Avenue, Washington, D. C. (U. S. A.). *D.l.C.*

The complexity of the task set the Committee is such that it feels no immediately acceptable recommendation of a code-method sufficiently adequate may be made. It therefore submits for consideration and discussion the following tentative suggestions based upon the communications and comments received. It is believed, in view of the variety offered by standard printer's fonts for printed publications and of the several efficient devices available for rapidly making special letters or symbols on tabulations published by the offset method of direct reproduction now so much used by many observatories, that letters to indicate various features are preferable to symbols. This is especially so since letters may be readily recognized as abbreviations. On the other hand, the use of symbols can be recommended for the various possible instrumental sources of failure to record. Such symbols used by the United States Coast and Geodetic Survey and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington are noted in suggested code-method of description.

Tentative suggestions for a method to adequately describe magnetic disturbances and perturbations

Explanatory remarks:

(1) Indications for increasing or decreasing trends are based upon the north-seeking end of the magnetic needle reckoning east declination positive, north inclination positive, intensity-components as positive for H, nadir Z, east X, north Y.

(2) Magnetic character-numbers are suggested as 0, 0.5, 1, 1.5, and 2, as it is felt a somewhat wider latitude in this regard is desirable; the scale proposed would, however, not disturb the system of three character-numbers 0, 1, and 2 so long used.

(3) The suggested order of the several features seems a logical one.

(4) Experience seems to indicate a code-system of 5-number groups satisfactory for broadcasting or telegraphing, although some prefer 5-letter groups. In code-groups provision is indicated to cover repeated features.

(5) Extent to which code may be used must depend upon whether facilities may be had upon a free basis. The suggestions regarding broadcasting or telegraphing code contemplated that only a certain limited number of observatories representative of world conditions will be selected by the Commission and Association; it may perhaps be desirable later to add others should it develop that some station shows records of unique disturbance such as giant micro-pulsations or of unique frequency of certain features such as pulsations or bays. In any case designation by letter or number to indicate the observatory reporting will be required.

(6) Naturally the date and time in any broadcast or telegraph code-message should be Greenwich date and Greenwich mean time. For published tabulations Greenwich date and Greenwich mean time or local date and local standard time as adopted by the particular observatory should be used. In tabular entries the designation of features is to be used against hour or hours of occurrence.

(7) The condition of days, whether quiet or disturbed, when the average is under or above normal seems a feature which may be significant.

Suggested magnetic designations

Item or feature	Suggested designation	Definition	Designation to be used for day-entries				
			Published tabulations		Broadcast code and requirements		
			For hours	For days	Daily entry (1 for each trace)	Time-elements GMT	Digits in code-group
Observatory	....		...	...	Yes	.....	One
Day of week			...	...	Yes	.....	One (1 to 7, 1 for Sunday)
Daily character-number	0	Quiet record					
	0.5	Record between 0 and 1					
	1	Moderately disturbed record	?	Yes	Yes	.....	One (1 to 5, 1 for "0" character)
	1.5	Record between 1 and 2					
	2	Greatly disturbed record					
Daily mean	U or ∓	Under normal	No	No	Yes	.....	One
	A or ∸	Above normal					
Pulsations	P or ≷	As defined by van Bemmelen	Yes	No	Yes	Hour and tenth	Three
	P̄ or ‖	Giant micro-pulsations	Yes	No			
Oscillations	O or ϕ	Maximal activity	Yes	?	Yes	Hour	Two
Bays	B̂ or ∧	Increasing	Yes	No	Yes	Hour and tenth for maximum departure	Three
	B̌ or ∨	Decreasing	Yes	No			
Gradual commencement	Ĝ or ∠	Increasing	Yes	No	Yes	From H-record, hour and tenth for G and hour and minute for S	Four
	Ǧ or ⋖	Decreasing	Yes	No			
Sudden commencement	Ŝ or ⊥	Increasing	Yes	No			
	Š or ⊤	Decreasing	Yes	No			
Daily maximum	M or ↑	Absolute	Yes	No	No	.....	....
Daily minimum	N or ↓	Absolute	Yes	No	No	.....	....

General designations for special or instrumental matters

(Symbols listed are those used by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the United States Coast and Geodetic Survey)

* = one of selected 10 least-disturbed days	[ ] = estimated hourly value
† = one of internationally selected quiet days	Δ = lamp out
‡ = one of internationally selected disturbed days	∇ = record off sheet
[ ] = approximate hourly value lost on magnetogram	□ = clock stopped
( ) = interpolated hourly value	Δ̲ = no record

Washington, D. C., August 15, 1936.

J. A. FLEMING, *Chairman*
For the Committee

APPENDIX 1

Suggestions on methods of adequately describing magnetic disturbances

By A. NIPPOLDT

Scope. — It is desirable that monthly tabulations of hourly magnetic values be so arranged and annotated that investigators may determine readily those hours suited for any special consideration and those which are not.

Independent judgment. — It is necessary that each observatory describe disturbances independently of information for other places, basing descriptions solely on its own records. Therefore, it is impossible to differentiate for a single station between polar and equatorial disturbances since that would require comparison between several observatories.

Superfluous data. — It would be superfluous to give symbols designating features which may be readily noted from examination of the tabulations, for example, whether an element is increasing or decreasing in value.

Minimal requirement. — It is required that at least the character of each hourly value during disturbance be indicated in a special way. This can be done without any added cost of printing and without increasing the size of the printed page through the use of bold-face type. Thus, numbers in bold-face type would be used from the beginning of the disturbance until the end even in cases where single hours may not show great activity.

Symbols. — The following list of new symbols is suggested for characterization of disturbance with the idea that each hourly interval may be described without comparing it with the values for adjacent hourly intervals:

P = pulsations, as defined by van Bemmelen.

B = bays, the term being defined as single disturbance occurring during an otherwise quiet condition. It is true bay-like variations are to be found during most magnetic disturbances but, in such cases, they are merely a part of the whole disturbance and have no individual importance.

GC = gradual commencement, this symbol to be given only once for the first hour of the disturbance.

SC = sudden commencement, this symbol to be given only once for the first hour of the disturbance.

O = oscillations. The real measure of the character of disturbances is the activity of each hour for which it is not readily possible to suggest distinctive symbols; therefore, the symbol O may be used only for all hours of greatest oscillation — the real time of maximal activity.

Mx and Mn = maximum and minimum, respectively. These symbols to be indicated in the hour containing the absolute maximal or minimal value and to indicate the hours in which the extremes were recorded for the Greenwich date [or local date should the particular observatory not use Greenwich dates in its tabulations]; in many cases Mx and Mn may be different for the hour of greatest hourly value.

These seven new symbols seem adequate for a short description of disturbances; to give more would complicate not only the work to be done by the scientist in characterizing the hourly intervals but also that of the compositor [or tabulator in case the direct offset publication of original tabulations is followed in publication]. The use of symbols as suggested will add somewhat in the labor of preparing tabulations for official year-books, but there seems to be no way to avoid this. In making the suggestions above it seemed to me best to restrict each sign to not more than two letters. On the other hand, one might choose as symbols, instead of letters, signs such as arrows, asterisks, or especially made letters, but it would be difficult to make selection which could be easily read and understood [except perhaps in publication by direct reproduction of original tabulations by the offset method]. It seems quite impossible to develop any scheme of symbols sufficient to cover all features of disturbed hours; in this regard there is nothing which can satisfactorily replace the original records.

Potsdam, February 27, 1936.

Supplementary suggestions after receiving comments by Messrs. Chapman and Sucksdorff

By A. NIPPOLDT

Die gedruckten Monatstabellen der Observatorien sind untereinander recht verschieden. Einige haben so viel Platz, dass man leicht neue Lettern einschalten kann. Andere drucken so eng, dass dies kaum geht. Einige vervielfältigen mit Schreibmaschinen; diese können keine Unterschiede in den Lettern machen, höchstens unterstreichen.

Mithin gelingt es nicht, eine Vorschrift zu erlassen, die für *alle* Observatorien verpflichtend ist. Es kann sich bei den adäquaten Signifikationen nur um einen *Wunsch* der Internationalen Versammlung handeln, dass jene, welche solche Bezeichnungen einbauen können, es nach einer Vorschrift tun.

Eine Minimum-Vorschrift ist das Kennzeichnen der gestörten Stunden, entweder durch eine andere Letterart (fett) oder bei Typewriters durch unterstreichen. Das kann jeder tun, ohne die Kosten wesentlich zu erhöhen. Nur muss es *einheitlich* geschehen, und das wäre von der Stunde des Störungsausbruches an bis zur Erlöschung der Störung für jede zwischenliegende Stunde.

Alles Weitere kann nur ein Vorschlag sein, für die, welche in ihrem Schema dazu Platz haben. Wir können niemanden hier zwingen, weil eine Verbreiterung der Tabellen mehr kostet.

Wenn ein Observatorium solche Bezeichnungen einführen will, dann allerdings sollen es überall dieselben sein, also: P für Pulsationen; B für

Bays; G für gradual commencement; S für sudden commencement; X für Maximum; N für Minimum.

Der Vorschlag von Sucksdorff, jeder einzelnen Stunde noch eine Charakterzahl zu geben, ist zwar schön, aber mit einer so grossen Mehrarbeit verbunden, dass man das nicht allgemein empfehlen kann. Das gilt auch, wenn man die Charakterzahl durch drei Formen von Lettern kennzeichnet, nur dass zu der Mehrarbeit des Fachmanns, welcher den Charakter bestimmt, noch die des Setzers kommt und schliesslich die Mehrarbeit beim Lesen der Korrekturen.

Internationale Vorschläge müssen immer einfach sein, sonst werden sie nicht von allen befolgt.

Potsdam, den 9. *Mai* 1936.

APPENDIX 2

Comments on Dr. Nippoldt's suggestions of February 27, 1936

By S. CHAPMAN

I am fully in agreement with Dr. Nippoldt's first three propositions, namely, scope, independent judgment, and superfluous data. I think also that the number of new signs should be a very limited one. I think the seven he proposes are valuable though the signs showing the hours of maximum and minimum might perhaps be omitted in the case of those observatories which publish the actual times and values of maxima and minima, as is done, for example, for Greenwich and in the Observatories Year-Book. As regards the seven signs, I think, if it is intended to print them on the tables of hourly values, each sign should consist of one rather than of two letters. I think the letters P, B, G, S, O, X, N, might serve for the seven mentioned in his letter, though I think any proposals to replace the letters by pictorial signs should be carefully considered. I fear that in some tables of hourly values the addition of the new signs might rather crowd the page, but this would be a matter for each individual Director to consider. There might of course be certain hours for which more than one sign might be required, but doubtless these would be exceptional and might perhaps be dealt with by foot-notes. As regards his proposition on the minimum claim — to use a special type for disturbed hours — I think this would have value, though there might be practical difficulties either of expense or of typing in the case of those observatories whose tables of hourly values are reproduced from type-script.

London, March 3, 1936.

APPENDIX 3

Comments on Dr. Nippoldt's suggestions of February 27, 1936

By E. SUCKSDORFF

I understand Dr. Nippoldt's proposal to be a contribution to the discussion as to how, in year-books of magnetic observatories, information is to be given on magnetic disturbances recorded.

There would appear to be no doubt that suitable remarks in monthly tabulations regarding those hours which are considered disturbed and those which are considered calm would, in many instances, facilitate orientation of year-book material for research. The observatory at Sodankylä has striven, from the very beginning of its work, to bring this about.

The most important of the proposals Dr. Nippoldt makes seems to me to be the minimum claim of using special type for the disturbed hourly values, and it would most certainly be a great advantage if an international recommendation could be had on this question. Without for the moment making any definite proposal, I nevertheless express my opinion that it would be quite reasonable if one — in analogy with international magnetic characterization of the Greenwich days in groups 0, 1, and 2 — were to apply a three-part scale for the character of the individual hourly intervals as well. The hourly values thus characterized as undisturbed, moderately disturbed, and strongly disturbed, should be indicated in the tables by ordinary, italicized, and bold-face type, respectively [or suitably otherwise when original tabulations are reproduced by the offset method of publication]. According to my experience, the technical part of the matter is fairly easy to solve, and it does not imply any extra costs. It is considerably more difficult, however, to find the best means of fixing the characterization for the hours, because a number of different considerations may here come into question, such as the deviation of the mean hourly value from the normal value for the hour, the range, the greatest deviation from the normal value within the hourly interval, etc. A necessary qualification for an international recommendation to use special type [or special symbols] must be in any case an agreement on what these are to mean.

Even if it should be possible to find in the monthly tabulations space for individual letters or other marks for emphasizing special kinds of the recorded disturbances, it nevertheless appears to me impossible to give a satisfactory description of a disturbance in this way. Only by good reproductions of the curves themselves can one be sure to get everything in that is of interest to the question one is examining. For instance, the designation by a letter of the hourly interval during which a sudden commencement has occurred is hardly worth while since it would seem to give quite insufficient information of such a feature. But for preparation of text following the tabulations it would doubtless be of great advantage to develop a collection of definitions — such as Dr. Nippoldt proposes — for describing the most characteristic kinds of magnetic disturbances. I suggest that for a bay there be used, instead of the letter B, either the sign $\vee$ or $\wedge$, depending on whether the bay is directed down or up.

Sodankylä, April 30, 1936.

APPENDIX 4

Comments regarding uniform methods and codes to adequately describe magnetic records

By A. G. McNISH

The purpose of verbal or codal description of a magnetic record is to convey, as far as possible, such intelligence as would be derived from actual examination of the record. At best, such description must be inadequate. By the selection of salient features a uniform system of description can be developed which will in general be adequate for preliminary studies. Naturally certain magnetic phenomena are of greater interest than others and warrant more thorough description. Thus a great magnetic storm should be described in detail while a few remarks usually suffice for a lesser disturbance. Quiet conditions should not pass without reference. The mention of each manifestation of bays or pulsations on otherwise undisturbed days would involve much labor sometimes, so that only outstanding examples of those phenomena should be described. When complete description of a phenomenon is unwarranted, certain details of greater significance than others should be recognized. In a magnetic storm the range in horizontal intensity (H) is usually of primary concern, the range in vertical intensity (Z) being secondary and the range in declination (D) being tertiary. These facts should be borne in mind in considering the following list which represents a desirable maximum of description:

Storms

- Ranges in gammas for H, Z, and D, or for X, Z, and Y, that is, the northward, vertical, and eastward components.
- Time of beginning, days, hours, and minutes.
- Time of end, days and hours. (The time of end to be taken as the time when agitated movements have ceased in all elements).
- Intensity of storm. (A subjective intensity-scale to be used with classes similar to those used by Maunder — great, very active, active, moderate — a great storm occurring on the average of about once a year; Maunder's classification was based on ranges, but for this purpose a subjective classification seems more desirable as a classification by ranges may be made immediately from the ranges given).
- General trend of elements throughout storm for H, Z, and D, or for X, Z, and Y.
- Character of movements and times of their occurrence. (Movements to be described as small violent, large violent, bays, general drift, etc.).
- Value of H or X at end of storm as compared with value before.
- Description of any sudden commencement in accordance with remarks in later section on these phenomena.

As a sample description of a magnetic storm, the following is suggested. It is taken from the description of magnetic activity at the Watheroo Magnetic Observatory. The storm selected represents the greatest type of storm and consequently is very fully described.

May 13-17, 1921 — At $13^{d}\ 13^{h}\ 9^{m}$ (GMT) a sudden commencement (approximately $+80\gamma$ in H, $+1'$ and $-3'$ in D, and -32γ in Z) marked the beginning of the greatest storm recorded at the Watheroo Magnetic Observatory up to that time. Comparatively small movements, during which the value of H decreased 100γ below its initial value, continued until $19^{h}\ 17^{m}$ when a sudden movement in all three elements initiated a period of large violent movements in which ranges of 224γ in H, $39'$ in D, and 221γ in Z were recorded. These rapid movements continued until about 8^{h} May 14, being followed by large movements, the elements hovering close to their pre-storm values, the value of H being about 40γ low. At $14^{d}\ 22^{h}\ 15^{m}$ a second sharp movement initiated a second period of violence, more severe than the first. The spots were swept across the full range of the recording paper so rapidly that it was difficult to identify them. The minimum in H for the storm occurred during these movements. Between 8^{h} and 9^{h} May 15 the violent motions ceased and H began to rise. By 2^{h} May 16 H had recovered to about 100γ below its pre-storm value. Movements during the latter part of this recovery-period were small but violent, culminating in another downward excursion of H and a considerable increase in the value of Z, both elements reaching their extreme values about 9^{h}. During the next ten hours the mean value of H increased over 200γ. Rapid movements of all elements continued until 8^{h} May 17, which may be taken as the end of the storm, when H was about 100γ below its pre-storm value. The times of maximum and of minimum and the ranges for the elements were:

Element	Maximum	Minimum	Range
H	13d 13h 16m	15d 04h 21m	1156γ
D (west)	15 03 25	14 23 24	96′
Z (upward)	15 04 30	14 22 32	453γ

Non-storm activity, bays

Times of beginning, end, and maximum in days, hours, and minutes. (The maximum to be taken as the maximum of the element showing the greatest departure; the beginning and end to be taken for the element showing the most clearly defined movement).

Direction of vector representing bay, north, south, east, or west, and up or down. (The vector to be taken as the difference of the values of the elements at time of maximum as compared with the average value at the beginning and the end).

Magnitude of departure. (The length of the vector representing the bay in gammas which usually may be adequately represented by the departure in the element most affected; exactly, it is $\sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$).

Non-storm activity, pulsations

Time of beginning and end of larger pulsations in days, hours, and minutes.

Amplitude of pulsations in element most affected. (Since pulsations are such common phenomena, it seems advisable to note only large ones; if it is desirable to note smaller ones, apparently all that can be done with reasonable simplicity would be to indicate whether they occurred in morning or evening).

Non-storm activity, sudden commencements

Time of occurrence in days, hours, and minutes. (The time to be that measured when the effect is first perceptible).

Amount of change in each element. (The change to be reckoned only for the rapid portion of the motion and not for the longer period during which H seems to approach a value asymptotically; when the sudden commencement is a composite of several motions, each of them to be measured separately and, if this involves too much labor, the total movement, algebraically, to be given with indication that the motion is complex).

Sudden commencement marking beginning of a storm. (The time of sudden commencement to be included in description).

Quiet-day variation

Character of the diurnal variation of each particular day which is not a storm-day. (For each day which is not a storm-day, state whether trace is unusually smooth, whether trace is disturbed by minor irregularities, whether general character of the characteristic diurnal variation is preserved, and whether the amplitude of the diurnal variation is unusually large or small).

Washington, D.C., February 20, 1936.

APPENDIX 5

International code and agreement for descriptions of magnetic conditions

By H. F. JOHNSTON

The merit of an international agreement on code for descriptive features of magnetic conditions is self-evident. It will be of great assistance to investigators of particular problems if complete detailed descriptions are furnished not only of major disturbances, namely, those designated as "principal magnetic storms" but also of all disturbances occurring on those days of magnetic character "1". It is to be stressed, however, that in a particular study the original magnetograms must be consulted and that the preliminary descriptions will serve chiefly as guide-posts to investigators.

It would appear advisable that at this time only a preliminary program be formulated. This program, if carried out for a few years by a small number of observatories — really enthusiastic on the subject — would enable the Committee to draw up a final program. Such a scheme for initial trial is not new as it has been used many times previously in international cooperative problems.

Looking toward finalization of a definite scheme at the next international assembly in 1939, three or four observatories might cooperate in supplying preliminary descriptions and data quarterly for publication either in the Journal of Terrestrial Magnetism and Atmospheric Electricity or by the Central Bureau of the Association. For the period of such a trial it would appear wise to stress "over detail" rather than "under detail". In fact, should the three or four observatories be so selected as to cover all varieties of magnetic conditions over the world, these observatories might be the "master" reporting observatories for the future with all the other observatories giving abridged reports only.

Observatories for selection may be suggested as follows: Sodankylä, Sitka, or Rude Skov for polar conditions; Potsdam for nothern middle magnetic lalitude; Batavia, Honolulu, or Huancayo for equatorial conditions; Watheroo for southern magnetic latitude. The burden of preparation would not appear to be heavy for any one observatory.

As is apparent from the above, I believe the reports should be a running commentary on the magnetic traces paying particular attention to bays (B), gradual commencements (G), oscillations (O), pulsations (P), and sudden commencements (S), with an intensity-scale of 0, 0.5, 1, 1.5, and 2, that is, five classes and not three, namely, 0, 1, and 2, as at present; such an enlargement of classes would have the advantage of not disturbing the 3-character system so long used.

In addition to the notes from the four observatories, Potsdam might be willing to supply a monthly hourly-value sheet on which would be entered in simple code, based on above numbers and figures, the magnetic conditions recorded for every hour of the day.

Washington, D. C., May 18, 1936.

APPENDIX 6

Comments regarding uniform methods and codes to adequately describe magnetic records

By N. H. HECK

In the matter of description of magnetic conditions, two problems have been raised by those discussing the matter: (1) The better description of magnetic storms so that the descriptions will be reasonably uniform (this refers to descriptions such as might be published in the Journal of Terrestrial Magnetism and other contributing mediums); (2) the indication by symbols, or otherwise, of the magnetic conditions at various hours in the published results for observatories. These are quite different problems and must be approached from different viewpoints.

There is no question as to the need for better descriptions of magnetic storms. I feel that the best approach is indicated by Mr. McNish and that his suggestions could well be expanded. A brief publication should be prepared indicating the type of information desired and the most satisfactory methods of expression, and then perhaps ten descriptions covering all kinds of magnetic disturbance, including bays, should be made available.

I do not think that this would be so arduous that it would be necessary to follow Mr. Johnston's suggestion that the matter be tried out at a very few observatories. If there are, however, to be only three, I would suggest that for diplomatic reasons, which can well be considered provided scientific requirements permit, they be Sodankylä, Honolulu, and Watheroo. If the number is to be greater, and I see no reason to the contrary, there need be no consideration of the particular organizations and countries in the matter.

As to the other proposition to indicate by symbol or otherwise on the published record the magnetic character of individual hours, I find myself only in theoretical accord. As representing an organization which, with limited personnel, is charged with preparing the publication of results for five magnetic observatories, it seems to me that the outstanding need is to curtail the work of preparation of results in so far as practicable in order to give more time to interpretation of results. It seems to me that the same result might be accomplished by publishing reproductions of more magnetic storms and of bays in further reduced form than at present. At the present scale, the reproductions serve no other purpose than to indicate character of disturbance, that is, no measurements can be made from them and still further reductions would probably not defeat this purpose if suitable precautions are taken. If any investigator is to really study a magnetic storm he should secure original records or accurate photographic copies. Seismologists in a similar problem have universally come to this conclusion and they in no case depend upon a published description of a record or even on published measurements if their investigation is to be at all exhaustive.

As to characterization of conditions only by the magnetic character-numbers 0, 1, 2, this is not close enough for many purposes. It is, however, to be noted that this characterization has many uses and is quite valuable if two precautions are taken, namely, (1) that observers who are definitely out of step should be notified and (2) that it should always be remembered that the characterizations are relative and not absolute. On the whole, numerical methods are preferable and it is to be hoped that one of the methods that has been tried will prove so satisfactory that it can be universally adopted.

It seems to me that if it were not too costly, a suggestion by Mr. Hartley, Librarian of the United States Coast and Geodetic Survey, might well be followed, namely, that for each storm or other disturbance a copy of the record be sent to the Central Bureau and that it issue for each important storm the reduced records for all the contributing observatories.

Washington, D. C., May 27, 1936.

REPORT ON UNIFORM CONVENTION REGARDING THE SENSE OF EARTH-CURRENT COMPONENTS

At the Warsaw meeting of the International Commission of Terrestrial Magnetism and Atmospheric Electricity in September 1935 there was appointed a Subcommittee to discuss the sense of earth-currents, with the request that it report to the Central Bureau of the International Association of Terrestrial Magnetism and Electricity before that Association's Edinburgh Assembly (Procès-Verbaux Réunion de Varsovie, Comm. Mag. Terr. Électr. Atmos., Organisation Mét. Internat., No. 30, pp. 20, 25, 45, 1936). Those appointed on this Subcommittee were O. H. Gish (Chairman), A. Nippoldt, and A. Romaña.

A circular letter of comment and inquiry was sent by the Chairman on March 18, 1936, to the other members of the Subcommittee, and as a result of discussions by mail the Subcommittee suggests that there be presented for consideration at the Edinburgh Assembly of the Association the following resolution:

Resolution

The Association of Terrestrial Magnetism and Electricity recommends that conventions for expressing the sense of the field-intensity components, which represent the electric current in the Earth, shall be determined in accordance with the following:

(a) A field-intensity component shall be taken as positive when it corresponds to a flow of current either toward the north or toward the east.

(b) The symbols used to represent these components shall always be the letters N and E for the component directed toward the north and for that directed toward the east, respectively.

(c) When the current is flowing toward the south or west, the minus sign (—) is to be placed before the numerical values.

The reasons for suggesting this resolution are well expressed in a communication from Dr. Romaña. Dr. Romaña there suggests a convention for expressing the azimuth of the vectors of earth-current intensity, which may be included as a fourth item of the proposed resolution. Although this Subcommittee was not specifically instructed to discuss and report on a convention for expressing the azimuth of earth-currents, yet, since this seems to be an associated matter, the Subcommittee ventures to call attention to it as a possible fourth item of the resolution. However, Professor Nippoldt suggests that the sense of rotation be taken opposite to that suggested by Dr. Romaña, namely, clockwise instead of counter-clockwise. Referring to this question of azimuth, he says: "Sollte sie in Edinburgh angeschnitten werden, so bin ich dafür, dass wir von Nord über Ost, Süd bis 360° durchzählen, weil das die gewohnte Art auf anderen Gebieten des Erdmagnetismus ist (Azimute, magn. Vektoren, Deklination, usw.) und der Erdstrom durchaus nicht immer induktorisch mit dem Erdmagnetismus verbunden ist." The other members accept Professor Nippoldt's modification. Therefore, it is recommended that the resolution contain an additional item as follows:

(d) The azimuth of the resultant earth-current intensity-vector is to be always reckoned from 0° to 360°, the origin being the semi-axis which corresponds to a positive northward (N) intensity-component. Values of azimuth measured from that origin in a clockwise sense, that is, from north to east to south, etc., are to be designated positive.

In such situations where words are preferred to the symbols N and E as defined in the resolution, the words *northward* or *eastward,* followed by component or current as may be required, are apparently the most satisfactory terms available in the English language. As to corresponding verbal expressions in German, Professor Nippoldt writes: "There may be some difficulty in translating the proposed designations into the German language. We are accustomed to speak of a *Nordkomponente* which, however, implies no direction sense. We can say *Nordwärtskomponente,* but it is not customary to do so. *Nordwärtige Komponente* would be grammatically better, but this also would not be good usage. In analogy to our German *Rückwärtsbewegung* we German magneticians ought indeed to bring into usage the term *Nordwärtsstrom.*" No suggestion of short expressions of correspondingly precise significance in other languages have been received.

Washington, D. C., August 15, 1936.

O. H. GISH, *Chairman*
For the Subcommittee

REPORT ON INTERNATIONAL MAGNETIC CLASSIFICATION OF GREENWICH DAYS PRIOR TO 1906

By E. van EVERDINGEN

Prof. Chapman proposed to the Commission on Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization, at its meeting in September 1935, at Warsaw, to consider whether the international classification of Greenwich days according to their magnetic activity should be extended backwards from the period when the existing scheme began to the early days of magnetic observatories.

At the meeting of September 5th a Sub-Commission on International Magnetic Classification of Greenwich days prior to 1906 was appointed (Members: S. Chapman (Chairman), J. Bartels, G. van Dijk). The Sub-Commission had to send a report to the Bureau of the Commission before the end of 1935. Dr. la Cour, Secretary of the Commission, sent this report, in which the Sub-Commission proposed that two requests should be sent out from De Bilt asking for volontary collaboration in the extension of the classification to years before 1906, to me and asked me on behalf of the Commission to be kind enough to issue the said requests.

Following the proposal 3 of the Sub-Commission, the Bureau of the Commission will ask the Magnetic Association to vote a subvention to cover the cost of publication and distribution of the character figures in question.

In complying with the wish of the Secretary of the Commission, I have distributed a circular letter, dated January 1936, inviting all observatories concerned to send their answers to De Bilt before July 1, 1936. In the beginning of July it appeared that several observatories had not yet answered; July 14, the circular letter has been sent once more to those observatories, which were supposed to possess magnetic records for years before 1906, with the invitation to send their answers if possible before August 15, 1936.

Below I give a summary of the tables with character figures, received up to now, and of the magnetic records available:

Tables received: Baldwin 1900-1905, Barrackpore 1903-1905, Batavia 1880-1905, Bochum 1895-1905, Bombay 1895-1905, Cheltenham 1901-1905, Dehra Dun 1902-1905, Greenwich 1895-1905, Honolulu 1902-1905, Kodaikanal 1902-1905, Manila 1895-1905, Melbourne 1895-1906, Parc St. Maur 1883-1905, Pola 1896-1905, San Fernando 1895-1905, Sitka 1901-1905, Toronto 1895-1905, Toungoo 1905, Vieques 1903-1905, Zikawei 1890-1908.

Records available: Bombay from 1872, De Bilt from 1891, Greenwich from 1848, Los Angeles 1882-1889, Manila form 1890, Melbourne from 1868, Potsdam from 1890, San Antonio 1890-1895, Stonyhurst from 1867, Toronto from 1880, Zikawei from 1877.

Pavlovsk has promised to send tables for the period 1895-1905. Several observatories, which are supposed to possess magnetic records for years prior to 1906, did not yet answer. Some observatories have remarked, that the classification would require much time or be rather impossible, owing to shortness of staff for doing the work.

De Bilt, August 24, 1936.

REPORT TO THE INTERNATIONAL COMMISSION OF TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY PRESENTED BY THEIR SUB-COMMISSION ON THE UNIFORMITY OF MAGNETIC CHARTS

At a meeting in Leningrad, February 1936, the Sub-Commission adopted the following resolutions:

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 pecularities of secular variations in certain regions, more frequent observations at repeat-stations are necessary.

3. To make these magnetic world-charts, it is recommended that systematic magnetic measurements be taken, even in countries where such investigations cannot be carried out without international encouragement and assistance.

In the process of making magnetic charts, it appears that methodological investigations with the question of how to separate the different parts of the earth's magnetic field, viz. the normal, regional and local components, and lastly the field of "grosse Anomalien" (anomalies of continental extension) are of fundamental importance. It is therefore desirable to emphasize the necessity of such researches.

4. Although a corresponding fundamental methodology has not yet been adopted, its necessity for practical purposes is already acknowledged.

To attain a possible uniformity in the representation of the distribution of magnetic elements on magnetic charts, the following points of view should be taken into consideration, viz.

(a) Since the density of magnetic stations is insufficient to represent the *true* distribution of magnetic lines in all known regional magnetic surveys, and since these lines are too confused even where the net of stations is sufficiently dense, it is recommended that the distribution of magnetic elements in separate regions be represented by means of the smoothed isomagnetic lines with conventional symbolic indication of the departures of the values observed from the values derived from these smoothed lines.

(b) The magnetic charts of separate countries should be made so as to render it possible to obtain charts of wider regions by means of the simple juxtaposition of the charts of adjacent countries.

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 1932-1933, 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.

The most convenient situation for this bureau would appear to be either in *Copenhagen,* in connection with the Secretariat of the International Magnetic Association, or at *De Bilt,* in connection with the Secretariat of the International Meteorological Organization.

J. KERÄNEN. Gustaf S. LJUNGDAHL. N. ROSE.

PART V

COMMUNICATIONS

A. Terrestrial Magnetism.

INTERCOMPARISONS OF MAGNETIC STANDARDS AND CONTROL OF STANDARDS

By J. A. FLEMING

It is important that accurate determinations be made of possible systematic errors and corrections for the standard instruments at different observatories. It is probably more important as regards the scientific use of data accumulated by observatories that constancy of absolute standards be maintained. There are many excellent reasons that whenever possible, and so far as possible, the method of intercomparison of instruments by observers at observatories and visiting observers, with interchange of stations and instruments such as those of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in the past 30 years, should be continued. That experience has indicated emphatically that contact of observers is invariably helpful in ironing out difficulties and differences of procedure and at the same time is of mutual stimulating value in the interchange of ideas. Questions such as the exchange of stations and of instruments are vital in such intercomparisons; thus significant differences of the three magnetic elements at individual observing piers have been found.

While horizontal intensity is the element requiring particular control, it is necessary, in view of the many different types of instruments and methods used at various observatories, that definite controls be had for vertical intensity, to a considerable extent for inclination when vertical intensity depends upon inclination as determined by an inductor and especially if a dip-circle is used, and to a lesser degree for declination. Earth-inductors have not always been found in proper adjustment, sometimes mechanically and upon several occasions as regards meridian-setting. Dip-circles have always been and, under the circumstances of their mechanical design, must *always* be uncertain — indeed, the dip-circle should, except possibly under extreme conditions of field-work, be entirely abandoned for any accurate control in observatory-work or in field-work. While *theoretically* earth-inductors (but not dip-circles) and declination-instruments can be adjusted to zero-correction by a skilful physicist, there is not always appreciation of the need of adjustment and there is very frequently disinclination to attempt any adjustments. Frequently instruments, even those by the best manufacturers, do contain magnetic impurities which are not found by the observer since he usually places his reliance upon the reputation of the manufacturer and feels that there can be no question regarding the non-magnetic quality of the materials used.

Thus satisfactory intercomparisons and maintenance of international magnetic standards must depend, to a considerable degree, upon actual intercomparisons with instruments and observers. On the other hand, any plan, such as the admirable one proposed by Dr. la Cour — being carried on with the Association's sanction and aid — of sending regularly, on fixed circuits of observatories, groups of three instruments such as the Quartz Horizontal-Force Magnetometer (designated as QHM) and the Balance Magnétométrique (designated BM) upon its better development, is intrinsically sound and valuable for control-purposes during the longer intervals between actual visits of observers with absolute instruments for intercomparisons. The economy of such procedure must be regarded most favorably, especially as it is hoped the BM may be likewise successfully developed for transfer regularly by mail. Such comparisons at the Cheltenham Magnetic Observatory — with one instrument in February 1936 and with three instruments in July 1936 — the QHM's having been sent from Denmark through the mails by Dr. la Cour, show surprising agreement in each series. However, it is suspected there may be lack of constancy of performance with time and transportation. Thus any change in the magnetic moment of the magnet-system is all-important. Constancy of magnetic moment may be assured as far as the materials used, machining, and heat-treatment permit; these demand the best possible magnetic steel with low temperature-coefficient and the proper heat-treatment and artificial aging. Whether serious uncertainties may result from shocks to which any package sent in the mails is necessarily subjected and possible magnetic effects arising from nearby dynamos while in transit, can be determined only from long series of intercomparisons such as proposed by Dr. la

Cour. As in all relative methods depending upon constancy of magnetic moment, it is realized that no method of intercomparison which does not involve absolute determinations may be entirely relied upon.

The necessity of effective control in inclination or vertical intensity is readily apparent from the relationship between the three elements expressed by

$$\Delta Z = \tan I \ \Delta H + H \sec^2 I \ \Delta I$$

where Z and I represent vertical component of the Earth's field and angle of inclination, respectively. Thus for an error on standard of 1′, that is, $\Delta I = 1'$, typical values of ΔZ are: Cheltenham 55γ, Watheroo 38γ, Huancayo 8γ. The need for control in inclination is evidenced by results of comparisons at one of our principal observatories where a modern earth-inductor and methods are used and for which the observatory standard gave value of (IMS − observatory) = +1.′1.

Three precautions must be taken when magnetometric methods of observation are used for the control of constants. These are: (1) Redeterminations of moment of inertia of the magnet-system from time to time to control changes due to oxidation and wear of the magnet as well as of its suspension-arrangements; (2) suitable provision to protect the deflecting magnet during observations of deflection and also to protect the deflection-bar against sudden or irregular changes of temperature; and (3) means by which the effective deflection-distances may be invariable for the same instrument.

As examples of changes in inertia which are typical of the majority of the results obtained for the various instruments used by the Department both at the observatories and in the field may be indicated the following:

Magnetometer	Interval between comparisons in years	Observed differences from earlier to later comparison: Correction on IMS	Observed differences from earlier to later comparison: Correction for inertia-change
9	4.3	-0.00058H	-0.00064H
13	12.7	-0.00090H	-0.00078H
24	2.8	-0.00106H	-0.00094H
27	1.2	-0.00006H	-0.00008H

The evidence of such results certainly is positive and may be taken not only as confirmation of actual change in inertia but also as indication that no changes have taken place in the other constants concerned in determinations of intensity for the respective instruments.

Uncertainties must be reduced to a minimum during observation as regards temperature-readings and especially as regards any lag of temperature. Thus, for most magnetometers, uncompensated differences of 0.°2 C in temperature produce quite appreciable differences in the resulting values of the distribution-coefficients as determined from observations at three distances.

While it has been the practice to make dimensions of short and long magnets of magnetometers such that theoretically the value of the first or of the second distribution-coefficient would be zero, it is found in practice that the coefficients differ from the theoretical values. Thus for instruments in which the second coefficient should be theoretically zero the first coefficient is generally different from the theoretically calculated value — often as much as five or ten per cent — while the second distribution-coefficient often has a sensible value. It has been found that the use of an equivalent coefficient for the two distribution-coefficients meets all practical requirements both in the field and observatory within the limit of accuracy which may be reasonably expected by the magnetic method, namely, about 0.00015H (see *Res. Dep. Terr. Mag.*, v. 4, pp. 395-475, 1921). It therefore appears that, for magnets made of high-grade homogeneous magnet steel and properly treated when originally magnetized, the distribution-coefficients, assuming ordinary care in transportation and in handling, are sensibly constant over long periods. The apparent deviations from constancy indicated at times by compilations are often caused by uncertainties in temperatures. The compilations of observations made during 15 years with a typical CIW magnetometer — total number of sets of deflection-observations at three distances each about 1300 — for the deviation of computed values of H, using each year's averaged distribution-coefficients, from the value that would have resulted had the average distribution-coefficient for the entire period been used, show mean values of this deviation for successive years to be: −0.00015H, −0.00004H, −0.00024H, +0.00003H, +0.00005H, +0.00004H, −0.00006H, 0.00000H, +0.00003H, +0.00008H, +0.00002H, +0.00002H, −0.00002H, +0.00001H, +0.00001H; the weighted mean value for $\Delta H/H$ from all is −0.000006H! This certainly indicates real constancy of distribution-coefficients.

As with the magnetometer, the constants of the electromagnetic instruments and of their appurtenances must be carefully controlled. Thus there is possible change with time of the electromotive forces of the standard cells used, particularly for the non-saturated type of cell. After one year's use of three unsaturated standard cells with the sine-galvanometer at the Cheltenham Magnetic Observatory, calibrations by the National Bureau of Standards showed that the electromotive forces of all had decreased 7 parts in 100,000, making necessary a correction to the values of horizontal intensity originally computed of about -0.1γ per month; in view of the great accuracy of electromagnetic determinations, this constitutes an important correction within three or four months. With the saturated types of standard cells there is less danger of such change but, on the other hand, temperature-changes must be very carefully controlled. Other tests and calibrations should be made from time to time to check against possible changes in the resistance of the coils of the instrument and of the standard resistances used. (See communication to the Association by S. E. Forbush and E. A. Johnson on "Results of international comparisons of magnetic horizontal-intensity with CIW sine-galvanometer 1").

While the corrections of declinometers with collimating optical systems theoretically may be made entirely negligible, there is ample evidence that declination-standards should be checked by intercomparisons wherever possible. Thus there may be magnetic material in the instrument itself which causes an incorrect value. For example, at one observatory a correction on standard of nearly 3′ was found; at another an indicated error of several minutes of arc because of erroneous azimuth was corrected only after intercomparisons had shown such serious disagreement.

In the past 30 years the Department of Terrestrial Magnetism of the Carnegie Institution of Washington has obtained intercomparisons at over 40 of the principal observatories of the world in some 25 countries in all continents and on islands as follows:

Abinger, succeeding Greenwich
Adelaide
(Algiers or Bouzaréah)
Alibag
Antipolo
Apia
Batavia
Cape Town
Cheltenham
Christchurch or Amberley
Coimbra
De Bilt
Dehra Dun
Dombås
Ebro
Eskdalemuir
Falmouth (discontinued)
Helwan
Hongkong
Honolulu
Huancayo
Kakioka
Kew (discontinued)
Mauritius
La Quiaca
Lukiapang, succeeded by Zikawei and Zosé
Pilar
Pola
Potsdam, succeeded by Seddin and Niemegk
Rude Skov
(Rome or Terracina)
San Fernando
San Juan
San Miguel, Azores
Sodankylä
Stonyhurst
Tananarive
Teoloyucan
Toolangi
Uccle
Val Joyeux
Vassouras
(Washington)
Watheroo

At many of the observatories listed above two or more series of intercomparisons were obtained. Those stations which are enclosed in parentheses are not, in the full sense, observatories but involve national standards.

Provisional International Magnetic Standards, based on the earlier intercomparisons, were adopted by the Department (see

Res. Dep. Terr. Mag., v. 2, pp. 211-278, 1915, and v. 4, pp. 395-475, 1921) before development of means to accurately measure electric currents and of standard cells needed for electromagnetic methods of determining the Earth's field. This wide experience developed in the course of years a procedure for intercomparisons of magnetic instruments and standards based upon magnetic observations either by magnetometer, dip-circle, or earth-inductor. So far as intercomparisons with electromagnetic instruments are concerned, it is to be remarked that all of the precautions indicated in this procedure have been found to apply in the work done in more recent years. (See communication to the Association by S. E. Forbush and E. A. Johnson cited above.) Therefore, a copy of the standard instructions issued to Department observers for intercomparisons of magnetic instruments is given in Appendix 1 below.

APPENDIX 1

Procedure of Department of Terrestrial Magnetism, Carnegie Institution of Washington, for intercomparisons of magnetic instruments and standards at observatory- or field-stations

Preliminary. — After the necessary arrangements have been made and facilities obtained from the proper authorities to carry on the work, it should be determined whether any pronounced local magnetic disturbance exists in the neighborhood of the proposed stations. This may be readily done by getting the magnetic bearing of a line at different points by the compass-attachment of the dip-circle, or by the magnetometer. If there is any considerable local disturbance and other sites cannot for any reason be chosen, particular care must be exercised to see that the magnetic systems of the various instruments will be in the same horizontal plane at the same station; in case this is not possible, the height should be noted and recorded from a suitable reference point, for example, the top of a stake driven into the ground, and determinations made subsequently at different heights at both stations to find if there is a measurable local magnetic disturbance in the vertical. Full notes and records should be made of any such preliminary work.

Stations. — Generally but two stations should be used for intercomparison work; these, unless they are already named, as may be the case at observatories, should be designated as "A" and "B". For observatory-work "B" should be the auxiliary station and "A" the regular observatory-pier; at some observatories different piers or stations are used for different elements, and intercomparisons for each particular element should be made accordingly. The azimuth-lines for both stations should be referred to the same determination of azimuth (in particular in those cases, as stated later, where there may not be an interchange of stations). Where possible, it is preferable that both stations be in a line of determined bearing from one of them and that the same mark be used for the work at both. When azimuths are accepted as determined for one station by the authorities of the observatory, the azimuth used at the auxiliary station should be invariably referred to the former by setting the auxiliary station in line of observatory-station and mark, or of observatory-station and an auxiliary mark, the bearing of the latter being determined by angular measurement at the observatory-station. Triangulation between stations should be resorted to only when necessary, as it is not in general in this work a satisfactory method, owing to the fact that one side of the triangle involved, namely, the side from station to station, is comparatively very short and the sights involved accordingly less accurate.

Exchange of stations and simultaneity of observations. — For the most reliable results it is desirable that simultaneous determinations be made with the instruments being compared, and also that there be an exchange of instruments between stations; in this way the data for the determination and elimination of any station-difference are secured. At observatories where the regular pier or piers used in determining the magnetograph base-lines may be observed upon and the observatory absolute reductions from magnetograms supplied promptly, there would be no necessity for an exchange; this condition is, however, not often met with as the final determinations of the base-lines are usually a year or more behind current work. In some cases it will be found that previous thorough examination on the part of the authorities indicates no measurable local magnetic disturbance; it is, however, even in such cases desirable that an exchange of stations be effected as there are frequently unsuspected sources of disturbance formed and placed subsequent to the original examination. Exchange of stations at the time of the comparisons takes but a short while and makes certain the elimination of any possible station-difference.

The observations should be made as nearly simultaneously as is possible; the local mean times of declination-determinations should agree within one minute of time; those for horizontal-intensity determinations and inclination-determinations within two to four minutes of time. With care, these limits can be easily attained.

Observations. — There should be with each instrument at least 12 complete determinations of declination, six at each station; six complete determinations of horizontal intensity, three at each station (one determination with a magnetometer consisting of two sets of oscillations and two sets of deflections at three distances); and at least six determinations of inclination (when dip-circle is used, six determinations with each needle), three at each station. The observations should be made with different orientations of the foot-screws of the instruments, preferably such that there will be an equal number of observations at each station for foot-screw *A* south, foot-screw *B* south, and foot-screw *C* south. The work for any one element should not be done upon one day but distributed over several days to eliminate any possible effect due to magnetic storms. Where there is not an exchange of stations, at least the same total number of determinations for each element should be made.

Miscellaneous remarks. — Particular care must be used to see that the instruments are in good working order; before leaving the station the computations should be carried out to determine that there have been no blunders or errors of any kind. In case there is reason to suspect any of the observations, such should be repeated.

In some cases it is not possible that simultaneous observations be made owing to lack of time or assistance at the observatory; in such a case the observations should be carried out alternately at each station by the same observer, thus with the two instruments 1 and 2, and the stations "A" and "B": Observations with 1 at "A"; with 2 at "B"; 2 at "B"; 1 at "A"; 1 at "A"; 2 at "B"; 2 at "B"; 1 at "A"; and so on. The instruments should then be exchanged and observations made with 2 at "A"; 1 at "B"; 1 at "B"; 2 at "A"; 2 at "A"; 1 at "B"; 1 at "B"; 2 at "A". The attempt should be to have as little time as possible between the determinations at the two stations to eliminate effects of diurnal variation. With the number of determinations called for above, this scheme of observation, while not giving as good results as simultaneous intercomparisons, will suffice.

Full notes should be made invariably by the observer as follows: Official designation of the observatory; auspices under which operated; director or presiding officer; names and official position of those directly in charge of the magnetic work; names of observers; makers and numbers of instruments used by the observatory in the comparisons with such remarks regarding their construction and method of observation as may seem desirable; detailed information with sketches showing relation of stations, marks, etc.; detailed information regarding variation-instruments and methods followed.

At observatories a list of the local mean times should be left with the request that the office be supplied at the earliest possible moment with the observatory-results and any pertinent data such as corrections adopted by the observatory, etc..

The greatest care should be exercised to see that there is no artificial local disturbance present, such as magnets of other instruments and the like. This has been at times a source of considerable trouble in comparison work, and has practically vitiated the results.

At observatories where it is impossible to remove the regular instruments it is desirable, in case there is no positive assurance that no local disturbance exists in the neighborhood of the auxiliary station, that a second auxiliary station be established.

Where instruments are fixed on the piers and cannot be removed, it is desirable that some observations be made for determining whether there is any local disturbance in the immediate neighborhood of the observatory and auxiliary stations. This can be determined by establishing one or two additional stations and obtaining, say, two sets of simultaneous observations with the observatory-instrument. The resulting difference between standards of course should be the same as determined at the first auxiliary station. In case there is evidence of disturbance, the observations which may be necessary to determine it must be determined upon by the observer locally, as it is impossible to give directions that apply to more than one case.

The above remarks have been made as applying generally to observatory-work, but intercomparisons of instruments in the field should be carried out in general along the same lines. It should be noted that the exchange of stations involves also the exchange of the tripods belonging to each instrument.

Dep. Terr. Magn., C. I. W., August 15, 1936.

RESULTS OF INTERNATIONAL COMPARISONS OF MAGNETIC HORIZONTAL INTENSITY WITH CIW SINE-GALVANOMETER 1

By S. E. FORBUSH and E. A. JOHNSON

Sine-galvanometer 1 of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington was assigned for absolute observations (S. J. Barnett, *Res. Dep. Terr.*

Mag., v. 4, pp. 373-394, 1921) of magnetic horizontal-intensity (H) in the cooperation of the United States Coast and Geodetic Survey and the Department as the standard at the Cheltenham Magnetic Observatory, where it has been so used since August 1935. This had not been possible previously as the Observatory had not until 1935 the necessary supply of electrical current and other facilities which were provided by the improvements and added observing facilities made there in 1934-35. Thus as regards the United States there has been undertaken the important and long-contemplated step of transferring to Cheltenham the provisional International Magnetic Standards (L. A. Bauer and J. A. Fleming, *Res. Dep. Terr. Mag.*, v. 2, pp. 211-278, 1915, and J. A. Fleming, *Res. Dep. Terr. Mag.*, v. 4, pp. 395-475, 1921) of the Department of Terrestrial Magnetism and complete realization of the Association's resolution 4 at Rome in 1922 and items a and b of resolution 5 at Prague in 1924.

Care was taken, in adapting CIW sine-galvanometer 1 for absolute control-observations at Cheltenham by the Department of Terrestrial Magnetism, to reduce the observational errors of the electrical measurements so that, except for possible systematic errors, the probable error of a single determination of the base-line of the photographic record is that arising from errors in scaling of the magnetograms. Provided they are marked at the time of measurement, the probable error of a single base-line determination is $\pm 0.4\gamma$ in a field of $18{,}500\gamma$, or approximately one part in 50,000. The measurement of current in the Helmholtz coils is made to one part in 100,000. If the magnetograms are not marked, the probable error is increased to $\pm 0.7\gamma$.

The original apparatus for the measurement of current and the routine of measurement were simplified so that a determination of H is reduced to less than two minutes; the complete observation is done by one observer. Some six to eight minutes suffice for adjustment of current and for the computations. Such rapid measurement of intensity with the sine-galvanometer and its accuracy make this instrument superior to a magnetometer, for which the probable error of a determination is about $\pm 3\gamma$ under similar conditions. Furthermore, the accuracy of sine-galvanometer values is such that they may be used to determine the scale-values of the H-variometers.

Current is measured in the usual way using a standard resistance, a potentiometer, and a set of three saturated standard-cells. The current is always set at the same value and a circuit is provided to adjust the current to one part in 100,000; the design of circuit permits reversing the current without appreciable change in magnitude. It is necessary to reduce possible slow changes in current, arising from drift of battery-voltages, to a minimum and to eliminate the effects of ambient

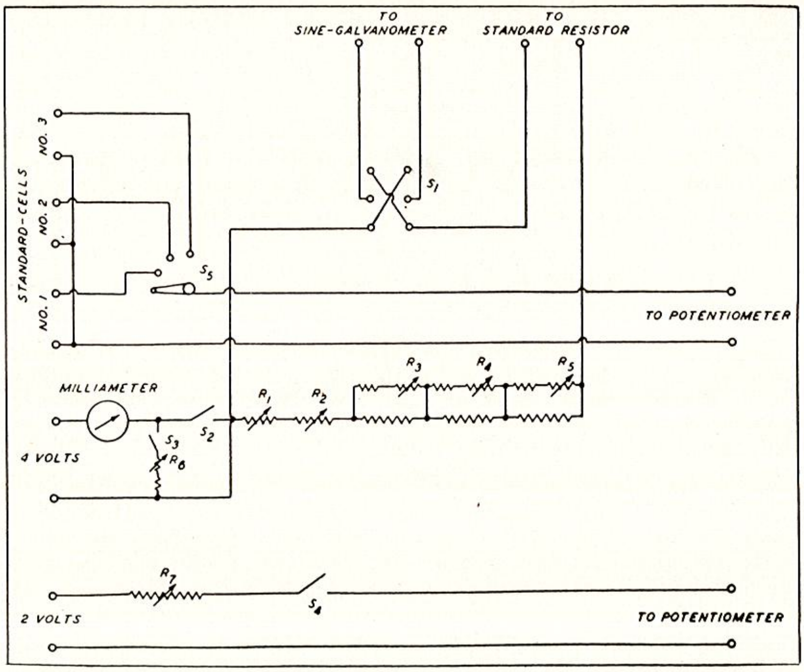


Fig. 1. — Wiring Diagram of Sine-Galvanometer Control-Panel.

temperature-variations on the electromotive forces of the batteries.

The circuit is shown diagrammatically in Figure 1. The reversing switch 5, of very low contact-resistance, has six contacts in each pole. Its wiring is so arranged that the resistance is equal in both positions. The resistances, R_1 to R_5, control the current and give successively finer control, so that R_5 permits adjustment to five parts in 1,000,000. These resistances were chosen so that any contact-resistance of the variable arm is negligible. Switch S_2 is an on-off switch; switch S_3 and resistance R_6 allow aging the batteries without passing the current through the sine-galvanometer. Switch S_4 and resistance R_7 control the battery-supply for the potentiometer. Switch S_5 permits selection of any one of the three standard cells for use with the potentiometer. All materials are as free from magnetic materials or effects as possible. The circuits are arranged so that no parasitic thermoelectric or galvanic effects are present.

It was found that if the batteries were exposed to ambient temperatures, battery-drifts were excessive. Since, for accurate measurements, standard cells must be kept at constant temperature, standard cells, standard resistance, and the two batteries supplying current to the Helmholtz coils and to the potentiometer are enclosed in a constant-temperature cabinet with alternating-current heaters. Eveready air-cells are used as they were found to be superior to storage-batteries for this purpose. Thus battery-drifts are approximately only one part in 100,000 per minute after aging for about two hours, which is adequate. The temperatures of the standard cells and standard resistance — mounted with a thermometer inside an inner, well-insulated compartment — are observed with a telescope extending into the cabinet. The galvanometer for detecting current, of the CIW astatic-field type, is mounted on top of the cabinet together with an alternating-current light-source and suitable optical system to make readings on a ground-glass scale.

Figure 2 shows the control-panel and Figure 3 the cabinet. The cabinet is mounted on piers without contact with the floor and is about 20 feet from the sine-galvanometer which is mounted on a pier in an adjacent room.

The values of standard cells, standard resistance, and potentiometer are known to one part in 100,000, and the absolute value of current in terms of these quantities is known to about two parts in 100,000. The correction-factor to reduce international amperes to absolute amperes is 0.99993. Since the standard resistance and potentiometer-setting are fixed in value,

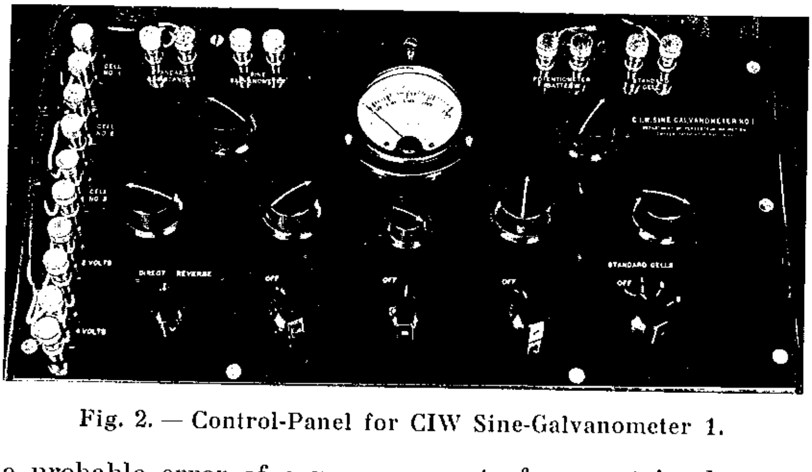


Fig. 2. — Control-Panel for CIW Sine-Galvanometer 1.

the probable error of a measurement of current is about one part in 100,000, although the systematic error may be as large as three parts in 100,000 in absolute value. The coil-constant (G) of the Helmholtz coils is known to one part in 30,000 (S. J. Barnett, *Res. Dep. Terr. Mag.*, v. 4, pp. 373-394, 1921). Consequently the probable error of a single determination of H is approximately five parts in 100,000, whereas the observed observational error is about two parts in 100,000.

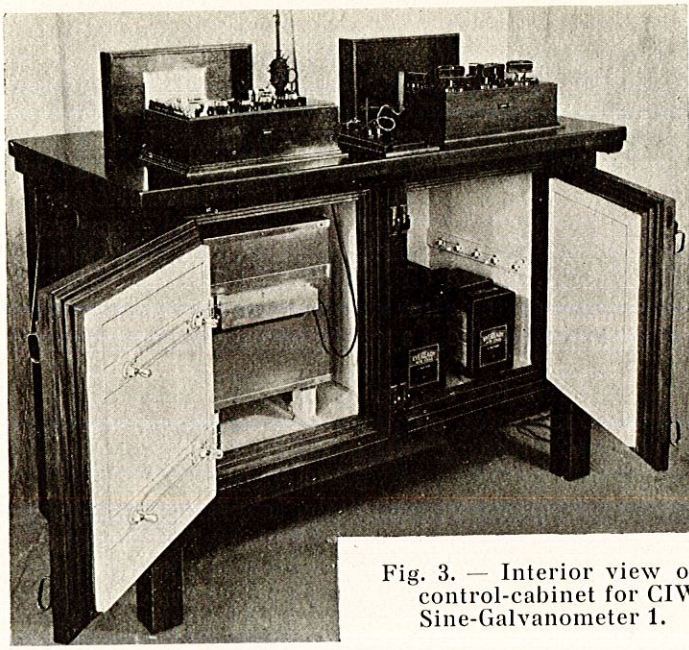


Fig. 3. — Interior view of control-cabinet for CIW Sine-Galvanometer 1.

The current chosen is such that, for values of H near 18,300γ the sine-galvanometer has a sensitivity of 1.5γ per minute of arc. Since the horizontal circle may be read easily to 10″, the probable observational error in reading the angle is about 0.3γ. Consequently the observational error should be about 0.4γ for any single observation, which agrees with the observed probable error.

The formula by which H is obtained from the known coil-constant, coil-current, and double deflection-angle of the suspended magnet can be put into the form (see reference first cited above)

$$H = GI/\sin\ [(\Theta + \Theta' + \gamma - \gamma')\,(1/2)]$$

where Θ and Θ' are the two angles read on the circle and γ and γ' are the small angles, read on a scale, by which the mirror *is ahead of* the coil in azimuth. Since G and I are fixed, a table of Θ against GI/sin Θ is used in obtaining H from the measured angles. The temperature-corrections, always small, are also found from convenient tables.

An observation proceeds as follows: The standard cells are checked against each other. (1) The current through the coils is then adjusted to the correct value; (2) the sine-galvanometer coil is adjusted so that the cross-hair in the telescope coincides with the index on the scale and the horizontal circle is read; (3) the current is readjusted to the exact value and the value of γ is read on the scale; (4) the current is reversed and the procedure repeated for the second angle; (5) the value

$$\varphi = (\Theta + \Theta' + \gamma - \gamma')\,(1/2)$$

is computed and H is determined from the table.

Figure 4 shows, as a typical example, the base-line values resulting from sine-galvanometer observations of November 21,

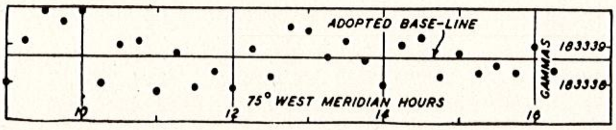


Fig. 4 — Base-line of Cheltenham H-Variometer 1 from Sine-Galvanometer observations, November 21, 1935.

1935. Since accurate sine-galvanometer measurements had shown the magnet of the variometer to be slightly displaced from the magnetic prime-vertical, these results are corrected

Table 1 — Results of horizontal-intensity comparisons, USCGS magnetometer 26 and CIW sine-galvanometer 1 at Cheltenham Magnetic Observatory, July 1935

Date	75° west mean time		Hor. int. obtained[a]		(SG 1—Cheltenham)
	From	To	Cheltenham[b]	SG 1	
1935	h m	h m	γ	γ	γ
July 8	15 29	16 33	18350	18355	+5
9	11 09	12 06	336	332	—4
9	13 01	13 54	356	357	+1
9	13 59	14 50	363	364	+1
9	15 01	15 53	362	364	+2
10	9 24	10 20	299	302	+3
10	10 26	11 22	306	309	+3
10	11 33	12 29	323	325	+2
10	13 38	14 35	345	347	+2
10	14 42	15 39	347	350	+3
11	11 32	12 24	321	324	+3
11	13 04	13 55	361	361	0
Mean value of (SG 1—Cheltenham)................					+1.7[c] or +0.00009H

[a]Values obtained with SG 1 at Pier 8 referred to Pier 3, when USCGS 26 was used, by station-difference (Pier 3 — Pier 8) = +0.7γ.

[b]Cheltenham = (USCGS 26 — 0.00100H) as adopted by the Survey in 1913; each value by 26 results from one set of deflection-observations at two distances, preceded and followed by one set of oscillations.

[c]Probable errors: Single observation, ±1.5γ; mean value, ±0.4γ or ±0.00002H.

Table 2—Results of horizontal-intensity comparisons, CIW magnetometer 3 and CIW sine-galvanometer 1, at Cheltenham Magnetic Observatory, July 1935

Date	75° west mean time		Hor. int. obtained[a]		(SG 1—CIW 3)
	From	To	CIW 3[b] = IMS	SG 1	
1935	h m	h m	γ	γ	γ
July 15	11 14	12 08	18346	18341	—5
15	13 10	13 47	345	352	+7
15	14 26	15 03	354	355	+1
15	15 41	16 13	345	350	+5
16	10 16	10 56	311	307	—4
16	11 21	11 57	308	308	0
16	13 02	14 09	348	344	—4
16	14 32	15 07	351	357	+6
16	15 29	16 02	360	362	+2
17	10 10	10 47	298	304	+6
17	11 27	11 58	307	308	+1
17	12 49	13 23	318	327	+9
17	13 47	14 21	338	339	+1
17	14 38	15 10	351	357	+6
17	15 28	16 29	359	361	+2
18	10 07	10 43	282	289	+7
18	14 03	14 39	350	351	+1
18	15 01	15 32	364	369	+5
18	15 50	16 26	372	376	+4
19	12 13	12 45	304	310	+6
19	13 04	13 35	316	323	+7
19	13 39	14 12	338	342	+4
19	14 42	15 14	345	350	+5
19	15 18	15 51	350	357	+7
Mean value (SG 1—IMS)					+3.3[c] or +0.00018H

[a]Values obtained at Pier 8 referred to Pier 3 by station-difference (Pier 3—Pier 8) = +0.7γ; CIW 3 was at Pier 8 with SG 1 at Pier 3 through the morning of July 19 and at Pier 3 with SG 1 at Pier 8 for the remaining observations.

[b]Each value by CIW 3 which is equivalent to IMS, that is, (IMS—CIW 3) = 0.00000H, results from one set of oscillations and one set of deflections at three distances.

Probable errors: Single observation, ±2.6γ; mean value, ±0.5γ or ±0.00003H.

for the effect of declination. Especially quiet conditions prevailed November 21, 1935; consequently the scaling-error is reduced to a minimum. The calculated probable error of a single observation for these data is ±0.4γ which agrees very well with the expected probable error when the scaling-error is considered. On disturbed days the probable error of a single observation is increased on account of the increased scaling-error. However, it is seldom greater than ±1.0γ, so that the base-line may always be known to this accuracy.

Table 3 — Results of horizontal-intensity comparisons, CIW magnetometer 18 and CIW sine-galvanometer 1 at Cheltenham Magnetic Observatory, August and October, 1935.

Series	Date	75° west mean time		Hor. int. obtained		(SG 1—CIW 18)
		From	To	CIW 18[a]	SG 1[b]	
	1935	h m	h m	γ	γ	γ
I	Aug. 8	14 10	14 55	18368	18369	+ 1
	8	14 59	15 37	360	367	+ 7
	9	10 27	11 04	318	313	— 5
	9	11 06	11 41	315	317	+ 2
	9	13 04	13 41	332	344	+12
	9	13 45	14 22	350	349	— 1
	9	15 01	15 37	355	354	— 1
	9	15 40	16 16	355	352	— 3
	12	10 45	11 24	321	323	+ 2
	12	11 29	12 09	339	345	+ 6
	12	13 17	13 54	376	372	— 4
	12	13 58	14 31	368	369	+ 1
Mean value series I of weight 7 of (SG 1—CIW 18)						+1.4[c] or +0.00008H
II	Oct. 1	11 08	11 59	18302	18312	+10
	1	12 54	13 40	323	325	+ 2
	1	13 47	14 35	337	334	— 3
	1	14 40	15 27	335	340	+ 5
	1	15 29	16 11	330	338	+ 8
	2	10 29	11 21	293	295	+ 2
	2	11 26	12 12	293	299	+ 6
	2	12 43	13 25	308	315	+ 7
	2	13 33	14 16	315	315	0
	2	14 18	14 57	319	326	+ 7
	2	14 59	15 40	332	336	+ 4
	2	15 42	16 23	332	337	+ 5
Mean value series II of weight 10 of (SG 1—CIW 18)						+4.4[d] or +0.00025H
Weighted mean value of (SG 1—CIW 18)						+0.00018H[e]

[a]Observations with CIW 18 on Pier 1 in August and on Pier 8 in October; station-differences as determined from observations with sine-galvanometer are: (Pier 4—Pier 8) = —1.5γ; (Pier 4—Pier 1) = +0.6γ.

[b]Determined by scalings of magnetograms using base-line value from sine-galvanometer observations at Pier 4 to which all data of Table are referred by above station-differences.

[c]Probable errors: Single observation, ±3.3γ; mean value, ±1.0γ.

[d]Probable errors: Single observation, ±2.5γ; mean value, ±0.7γ.

[e]Probable error of mean, ±0.00005H.

To control the transfer of standard from that set by magnetometer 26 previously used for control at Cheltenham to that of CIW sine-galvanometer 1, intercomparisons were made at Cheltenham with CIW standard magnetometer 3, CIW magnetometer 18, and USCGS magnetometer 26. The results of these intercomparisons obtained by S. E. Forbush, E. A. Johnson, and J. W. Green are given in Tables 1 to 3.

The Institution is under obligation for the courtesy of Admiral R. S. Patton, Director of the United States Coast and Geodetic Survey, and especially of Captain N. H. Heck, Chief of the Division of Terrestrial Magnetism and Seismology, as well as to the members of staff at Cheltenham, for their devoted cooperation which has made possible experimental developments and improved observational technique in the maintenance of observatory standards.

Table 4 — Results of horizontal-intensity comparisons, CIW magnetometer 16 and Agincourt Schuster-Smith coil-magnetometer, at Agincourt Magnetic Observatory, December 1933

Date	75° west mean time		Hor. int. obtained[a]		(IMS—Agincourt Schuster-Smith)
	From	To	CIW 16 corrected to IMS[b]	Agincourt Schuster-Smith[c]	
1933	h m	h m	γ	γ	γ
Dec. 19	14 46	15 43	15445	15443	+2
20	9 43	10 34	425	427	—2
20	10 25	11 18	422	422	0
20	11 08	12 23	413	420	—7
20	12 36	13 28	422	428	—6
20	13 19	14 11	422	433	—11
20	14 02	14 54	433	440	—7
20	14 45	15 40	435	444	—9
21	10 17	11 05	424	427	—3
21	10 56	11 43	421	423	—2
21	11 34	12 21	421	423	—2
21	12 11	12 54	415	425	—10
Mean value of (IMS—Agincourt Schuster-Smith)..					—4.8[d] or —0.00031H

[a]Station-difference = 0.0γ.

[b](IMS—CIW 16) = —0.00016H, or —2.5γ at Agincourt — determined at Washington, October 16-18, 1933, in comparison with CIW standard magnetometer 3; the series at Agincourt with CIW 16 consisted of alternate sets of oscillations and deflections at three distances, each value resulting from computations for each set of deflections using preceding and following sets of oscillations.

[c]Determined from magnetograms for which base-line controlled by Schuster-Smith magnetometer.

[d]Probable errors: Single observation, ±2.8γ; mean value, ±0.8γ or ±0.00005H.

Through the courtesy of Director J. Patterson of the Meteorological Service of Canada, comparisons of CIW magnetometer 16 with the Schuster-Smith coil-magnetometer at the Agincourt Observatory were obtained in December 1933 by J. W. Green of the Department of Terrestrial Magnetism and W. E. Ross and F. Furnell of the Observatory. The results are summarized in Table 4.

Upon the conclusion of a long field-trip in southern, eastern, and northern Africa, R. Mansfield of the Department of Terrestrial Magnetism made observations at the Abinger Magnetic Observatory in July 1935 through the courtesy of the Astronomer Royal; from these there followed an intercomparison with the standard Schuster-Smith coil-magnetometer of that Observatory, the results of which are given in Table 5. Mr. Mansfield also obtained in July 1935 observations with CIW magnetometer 16 at the Adolf Schmidt Magnetic Observatory at Niemegk through the courtesy of Dr. A. Nippoldt; from these we have a comparison of the standard magnetometer at Niemegk through the magnetograms there, the results of which are given in Table 6.

Table 5 — Results of horizontal-intensity comparisons, CIW magnetometer 18 and Abinger Schuster-Smith coil-magnetometer, at Abinger Magnetic Observatory, July 1935

Date	Greenwich mean time		Hor. int. obtained[a]		(SG 1—Abinger Schuster-Smith)
	From	To	CIW 18 corrected to SG 1[b]	Abinger Schuster-Smith	
1935	h m	h m	γ	γ	γ
July 17	13 15	14 10	18546	18543	+3
17	14 18	15 09	547	546	+1
18	8 45	9 32	524	519	+5
18	9 37	10 25	521	514	+7
18	13 46	14 38	527	529	—2
18	14 43	15 26	534	528	+6
19	8 32	9 19	526	528	—2
19	9 25	10 11	525	524	+1
19	13 42	14 29	538	534	+4
19	14 34	15 16	542	540	+2
19	16 00	16 45	542	538	+4
19	16 48	17 31	531	535	—4
Mean value of (SG 1—Abinger Schuster-Smith)...					+2.1[c] or +0.00011H

[a]Station-difference = 0.0γ.
[b]After taking account of gradual change in moment of inertia of magnet and suspension-system during field-work, (SG 1—CIW 18) = +0.00018H or +3.3γ at Abinger.
[c]Probable errors: Single observation, ±2.3γ; mean value, ±0.7γ or ±0.00004H.

Table 6 — Results of horizontal-intensity comparisons, CIW magnetometer 18 and standard magnetometer of the Adolf Schmidt Magnetic Observatory at Niemegk, July 1935

Date	Greenwich mean time		Hor. int. obtained[a]		(SG 1—Niemegk)
	From	To	CIW 18 corrected to SG 1[b]	Niemegk magnetometer[c]	
1935	h m	h m	γ	γ	γ
July 5	8 58	10 02	18452	18455	—3
5	10 07	10 52	452	456	—4
5	14 08	14 53	494	495	—1
5	14 58	15 43	503	500	+3
5	16 23	17 08	501	503	—2
5	17 13	17 53	499	499	0
6	8 19	9 02	467	462	+5
6	9 06	9 46	455	457	—2
6	10 45	11 29	471	468	+3
6	11 34	12 11	470	473	—3
6	13 46	14 28	484	488	—4
6	14 33	15 18	503	497	+6
Mean value of (SG 1 — Niemegk)					—0.2[d] or —0.00001H

[a]CIW 18 at Pier 5; station-differences between Pier 5 and other piers used by Observatory standard instruments are 0.0γ.

[b]After taking account of gradual change in moment of inertia of magnet and suspension-system during field-work, (SG 1 — CIW 18) = +0.00018H or +3.3γ at Niemegk.

[c]Values determined through magnetograms by Observatory staff.

[d]Probable errors: Single observation, $\pm$2.3γ; mean value, $\pm$0.7γ or $\pm$0.00004H.

From Tables 1 to 6 we arrive at an intercomparison of three electromagnetic standards used by the United States, Canada, and England, of the magnetometric standard used by Germany, and of the provisional International Magnetic Standard of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington as shown in Table 7.

The agreement, not only between the sine-galvanometer and the two Schuster-Smith coil-magnetometers but also between the sine-galvanometer and the standard magnetometer of Germany, is striking. The larger probable errors in the case of the comparisons at Agincourt, Abinger, and Niemegk are partially because the comparisons were indirect; in any case they are to be regarded as estimates because of the limited number of observations.

The results also confirm, within the limits of observational error, the provisional International Magnetic Standard adopted by the Department of Terrestrial Magnetism of the Carnegie

Table 7 — Summary of horizontal-intensity comparisons, direct and indirect, CIW sine-galvanometer 1 with other standards

Reference	Comparisons			Resulting mean difference on sine-galvanometer 1	
	During	At obs'y	With standard	Mean ΔH	Probable error of mean
Table 1	July 1935	Cheltenham	Magnetometer 26[a] of Observatory direct	+0.00009H	±0.00003H
2	July 1935	Cheltenham	Magnetometer CIW 3[b], which is IMS, direct	+0.00018H	±0.00003H
4	Dec. 1933	Agincourt	Schuster-Smith coil-magnetometer of Observatory, through CIW 16 and IMS[c]	−0.00013H	±0.00005H
5	July 1935	Abinger	Schuster-Smith coil-magnetometer of Observatory, through CIW 18	+0.00011H	±0.00004H
6	July 1935	Niemegk	Wanschaff magnetometer of Observatory, through CIW 18	−0.00001H	±0.00003H
Vol. 4[d]	June 1921 / Aug. 1921	Washington	Magnetometer CIW 3, which is IMS, direct	+0.00004H	±0.00003H

[a]Until use of CIW sine-galvanometer 1 as standard at Observatory beginning in August 1935, USCGS magnetometer 26 with a correction from 1913 of −0.00100H was used.

[b]The instrument on which the provisional International Magnetic Standard of the Carnegie Institution of Washington is based (see v. 2 and 4, Res. Dep. Terr. Mag., pp. 211-278, 1915, and 395-475, 1921) and for which correction is 0.00000H, that is, (IMS−CIW 3) = 0.00000H).

[c](IMS−Agincourt) = −0.00031H as observed at Agincourt using CIW 16 whence, since (SG 1−IMS) = +0.00018H, (IMS−Agincourt) = −0.00013H.

[d]See J. A. Fleming, Res. Dep. Terr. Mag., v. 4, pp. 467-470, 1921.

Institution of Washington in the published results of its many series of comparisons at a great number of magnetic observatories throughout the world during 1906 to 1921 (see volumes 2 and 4, *Res. Dep. Terr. Mag.*, 1915 and 1921, and the unpublished results of such work from 1922 to 1935).

Dep. Terr. Magn., C. I. W., July 31, 1936.

TRIALS MADE WITH THE QHM BY THE DANISH METEOROLOGICAL INSTITUTE

Communications Magnétiques, etc., No. 15, pp. 11-21.

Communications Magnétiques, etc., No. 16, pp. 1-11.

Communications Magnétiques, etc., No. 17, p. 13.

Preliminary results of comparisons between the Standard Magnetometer (K-std.) and 3 Q.H.M. at Kakioka Magnetic Observatory, September 1936

Report submitted by S. IMAMITI, dated Kakioka, September 15, 1936.

Q. H. M.$_{18}$

date 1936	time	temp.	mean φ(a) for 4π torsion	Hori. int. by		ΔH (K-std)-Q.H.M.$_{18}$
				Q.H.M.(b)	K-std.	
	h m	°	° ′	γ	γ	γ
Sept. 1.	13 18.4	28.50	74 18.88	29712.3	29728.8	+16.5
	13 24.6	28.62	74 19.50	29712.0	29728.9	+16.9
	13 30.5	28.66	74 19.13	29712.9	29729.9	+17.0
	13 49.0	28.81	74 18.88	29715.2	29732.3	+17.1
	13 56.2	28.86	74 18.88	29715.9	29732.5	+16.6
	14 04.2	28.91	74 18.88	29716.3	29732.4	+16.1
	14 23.3	29.00	74 19.75	29715.1	29732.1	+17.0
	14 30.2	29.02	74 20.00	29714.7	29731.6	+16.9
	14 36.9	29.09	74 20.48	29714.3	29730.6	+16.3
	14 59.9	29.13	74 21.33	29712.6	29729.2	+16.6
	15 07.6	29.12	74 21.00	29713.2	29729.5	+16.3
	15 15.1	29.09	74 21.00	29712.9	29729.4	+16.5
					mean	+16.7

(a) declination changes are corrected.
(b) using formula

$$\log H = 9{,}45249 - \log \sin \varphi + 0.000143\, t - 0.00137\, H \cos \varphi.$$

Q. H. M_{17}

date 1936	time	temp.	mean $\varphi^{(a)}$ for 4 π torsion	Hori. int. by		Δ H (K-std)-Q.H.M_{17}
				Q.H.M.(b)	K-std.	
	h m	°	° ′	γ	γ	γ
Sept. 2.	11 23.2	28.41	75 28.20	29701.3	29717.8	+16.5
	11 31.1	28.48	75 28.40	29701.7	29717.7	+16.0
	11 39.9	28.57	75 28.70	29702.0	29718.0	+16.0
	13 35.9	28.81	75 26.88	29708.7	29725.3	+16.6
	13 44.5	28.84	75 27.05	29707.9	29725.3	+17.4
	13 53.4	28.87	75 26.60	29710.8	29727.1	+16.3
	14 20.4	29.12	75 26.03	29714.1	29730.7	+16.6
	14 26.8	29.19	75 26.03	29714.8	29731.4	+16.6
	14 35.6	29.21	75 25.48	29716.3	29732.3	+16.0
	15 40.8	29.44	75 25.93	29718.4	29734.7	+16.3
	15 48.6	29.55	75 26.45	29717.9	29734.7	+16.8
	15 57.0	29.55	75 26.13	29718.6	29734.8	+16.2
					mean	+16.4

(a) declination changes are corrected.
b) using formula

$$\log H = 9.45428 - \log \sin \varphi + 0.000161\ t - 0.00261\ H \cos \varphi.$$

Q. H. M_{12}

date 1936	time	temp.	mean $\varphi^{(a)}$ for 4 π torsion	Hori. int. by		Δ H (K-std)-Q.H.M_{12}
				Q.H.M.(b)	K-std.	
	h m	°	° ′	γ	γ	γ
Sept. 3.	10 21.2	28.26	75 09.58	29693.5	29710.3	+16.8
	10 30.2	28.37	75 09.00	29695.9	29711.7	+15.8
	10 40.2	28.48	75 09.00	29697.1	29713.6	+16.5
	11 02.0	28.63	75 08.83	29699.0	29715.4	+16.4
	11 09.6	28.66	75 08.88	29699.2	29716.2	+17.0
	11 17.6	28.72	75 08.88	29699.9	29716.9	+17.0
Sept. 4.	10 24.4	28.00	75 10.40	29690.0	29706.7	+16.7
	10 31.7	28.19	75 10.85	29689.9	29707.1	+17.2
	10 38.5	28.22	75 10.95	29690.0	29706.6	+16.6
	11 01.1	28.38	75 11.83	29689.2	29706.0	+16.8
	11 08.7	28.41	75 11 98	29689.8	29706.2	+16.4
					mean	+16.7

(a) declination changes are corrected.
(b) using formula

$$\log H = 9.45375 - \log \sin \varphi + 0.000150\ t - 0.00080\ H \cos \varphi.$$

SHORT-PERIOD MAGNETIC PULSATIONS AT THE WATHEROO MAGNETIC OBSERVATORY

By H. F. JOHNSTON

The minute short-period oscillations that are observed in the magnetic elements have excited interest and provoked discussion from an early date. The earliest published reference to these waves is in all probability that by Balfour Stewart *(Phil. Trans. R. Soc.,* pp. 423-430, 1861). Since then many studies (see list by Bruno Rolf, *Terr. Mag.,* v. 36, pp. 9-14, 1931) of these oscillations have been made by numerous investigators. W. van Bemmelen (Amsterdam, *Proc. Sci. K. Akad. Wet.,* pp. 202-211, 1899) was, however, the first to refer to these oscillations as "pulsations". It is to be noted that "period" of pulsation as used in this paper is the time-interval from crest to crest.

Pulsations with periods varying from 60 to 180 seconds were analyzed by F. Lubiger *(Zs. Geophysik,* v. 11, pp. 116-126, 1935) to determine their diurnal, seasonal, and secular variations. As had been previously found for Samoa, the registrations at Potsdam, Batavia, Buitenzorg, and Zi-ka-wei for eight years from 1913 to 1920 indicated that the numbers of pulsations showed a sharp maximum around 23^h local mean time and a minimum in the sunlit hours. In addition, all these observatories confirmed the finding that the equinoctial seasons were clearly more favorable for the production of pulsations than the solstitial seasons. It was also concluded that there were more pulsations in quiet than in active years. In regard to the period of the pulsations, the Samoan records for 1920 showed that on the average the period was shorter in the night hours than in the sunlit hours by approximately one-fourth, that short-period pulsations occurred one-third oftener than long-period pulsations, and that 90-second period pulsations occurred much more frequently than others. At Batavia, pulsations of minimum period occurred at midnight, which is also the time of their greatest frequency during the day. During December the average period of pulsation was shorter than in other months; December records show also the greatest frequency of pulsations. Hence Lubiger concluded that the smaller the period, the more frequent were the pulsations.

A distinct opportunity for further study of pulsations has been offered by the records obtained at the many world-distributed magnetic observatories of the Second International Polar Year. Rapid-run recorders of the la Cour type were operated at a number of these; the length of record per hour with these is 180 mm, thus insuring good resolution of the pulsations. In addition, the magnets in the declination and horizontal-intensity variometers of these magnetographs had small moments of inertia and registrations of pulsations of quite short period are recorded.

A study has been begun of the pulsations in the rapid magnetic registrations for the year 1933 at the Watheroo Magnetic Observatory of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Some records for December 1932 have not been considered since the magnetograph was then in the course of adjustment. The average scale-values per millimeter of ordinate for 1933 were: Declination, 1.′04; horizontal intensity, 4.6 gammas; vertical intensity, 2.3 gammas.

Since previous analyses dealt largely with pulsations having periods of from 90 to 180 seconds, this examination was confined to pulsations having shorter periods of 20 to 80 seconds. For a period of 20 seconds, 15 complete waves occur in 300 seconds of time — corresponding to 15 millimeters of trace — for practical purposes the limit of resolution of the magnetogram. The magnetograms were examined for the appearance of sustained oscillations. Days were regarded as "pulsation-days" when there were several repetitions of the trains of oscillations during the day. After selection these days were divided into two clas-

Table 1 — Short-period pulsations of period from 20 to 80 seconds recorded at Watheroo Magnetic Observatory during each month of 1933

Month	Group	Number of days on which pulsations occurred with periods in seconds of		
		20 to 80	20 to 30	31 to 80
Jan.	I	10	4	8[a]
Feb.	I	9	5	4
Mar.	II	13	7	7[a]
Apr.	II	20	12	8
May	III	15	9	8[a]
Jun.	III	13	3	11[a]
Jul.	III	20	4	16
Aug.	III	14	4	11[a]
Sep.	II	22	7	15
Oct.	II	17	5	13[a]
Nov.	I	8	7	3[a]
Dec.	I	12	2	10
Totals				
Group	I	39	18	25[a]
Group	II	72	31	43[a]
Group	III	62	20	46[a]
Year		173	69	114[a]

[a]Indicates months in which pulsations with periods both of 20 to 30 seconds and of 31 to 80 seconds occurred on the same day; the total number of such days during 1933 was ten.

ses, namely, (1) those for which period of pulsation was very short (20 to 30 seconds) and for which the record showed fine serrations, and (2) those with medium short periods of 31 to 80 seconds for which the magnetogram showed fairly regular sinusoidal waves. The results are shown in Table 1. Short-period pulsations appeared on 173 days, very short-period pulsations appeared on 69 days, and medium short-period pulsations appeared on 114 days, there being 10 days on which both very short-period and medium short-period pulsations occurred. Dividing the months into the equinoctial and solstitial seasons, it is apparent that the equinoxes were the most favorable for

Table 2 — Comparison of International magnetic character-figure and occurrence of pulsations of period from 20 to 80 seconds recorded at Watheroo Magnetic Observatory in 1933

Type of day	Average character-figure	Total number days	Number of days and percentage of totals for which pulsations occurred with periods in seconds of					
			20 to 80		20 to 30		31 to 80	
				per cent		per cent		per cent
Quiet	0.0 to 0.3	130	44	34	1	1	44	34
Fairly quiet	0.4 to 0.7	85	41	48	8	9	35	41
Transitional	0.8 to 1.1	88	52	59	31	35	25	28
Disturbed	1.2 to 1.5	50	32	64	25	50	10	20
Much disturbed	1.6 to 1.9	12	4	30	4	30	0	0
Totals		365	173	47	69	19	114	31

Table 3 — Summary of recorded very short-period pulsations (20 to 30 seconds) showing recurrences at intervals of 27 days at Watheroo Magnetic Observatory in 1933

Month	Initial dates and dates of recurrence																	
January	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
January	28	29	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	24	25	22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March	23	24	21	20	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April	19	20	17	16	8	10	18	21	23	..	..	..	..	..	..	..	..	..
May	16	17	..	..	5	7	15	18	20	..	..	..	..	..	..	..	..	..
June	..	..	..	..	1	..	..	14	..	30	..	..	..	..	..	..	..	..
July	..	..	..	..	..	..	..	..	..	27	18	23	..	..	..	..	..	..
August	..	..	..	..	..	..	..	..	..	23	14	19	24	..	..	..	..	..
September	..	..	..	..	..	..	..	..	..	19	10	15	20	17	..	..	..	..
October	..	..	..	..	..	..	..	..	..	..	7	..	..	14	9	25	..	..
November	..	..	..	..	..	..	..	..	..	..	..	..	..	10	5	21	7	8
December	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	5

pulsations, the winter was less favorable, and the summer was least favorable, the predominance of the equinoxes being most marked for the very short-period pulsations.

The occurrence of the pulsations in regard to magnetic activity was also examined. It appeared questionable to assess magnetic activity only on the basis of the Watheroo magnetograms, and accordingly their occurrence was referred to the average daily International magnetic character-figure from 49 observatories. The days of the year were divided into five types of average magnetic character-figure, namely: Quiet, 0.0 to 0.3; fairly quiet, 0.4 to 0.7; transitional, 0.8 to 1.1; disturbed, 1.2 to 1.5; and much disturbed, 1.6 to 1.9. The occurrence of pulsations on days of the five types are shown in Table 2, as well as the percentage of occurrence for each type. It is evident that short-period pulsations are less likely to occur on quiet and much-disturbed days than other days, that pulsations of very short period appear most often on transitional and disturbed days, and that pulsations of medium short period appear more often on quiet than disturbed days.

The days of pulsations were also examined to determine if they reappeared at definite intervals. The recurrence of the pulsations with very short period was found to be quite marked after a 27-day interval, 53 out of a total of 69 being such recurrences. Table 3 enumerates the days which were recurrences. The recurrence of pulsations of medium short period was not quite so marked, 70 of the 114 being 27-day recurrences. Since the pulsations of medium short period covered the wide range from 31 to 80 seconds, it is considered that they offer comparatively small evidence of the 27-day recurrence so well shown by the short-period pulsations.

Dep. Terr. Magn., C. I. W., July 31, 1936.

CONCERNING NON-CYCLIC CHANGE

By A. G. McNISH

Application of a correction to magnetic diurnal variations for non-cyclic change has received considerable attention during recent years. Uncertainty as to the best methods for determining and applying the correction has at times become so great as to create doubt as to the fundamental reality of the phenomenon itself. It is the purpose of this communication to discuss the nature of the phenomenon without making any recommendations as to its determination and application.

Non-cyclic change is defined as the algebraic excess of a variable at the end of a period as compared with its corresponding value at the beginning of that period. In terrestrial-magnetic practice it is commonly determined by comparing the mean of the two-hour interval centered on the end of the day with the mean of the corresponding interval centered on the beginning of the day. Simple considerations clearly require that if the course of the variable through the day is to be represented by a series of trigonometric terms it is necessary to allow for this non-cyclic change in order that the coefficients should not be affected by it. Failure to distribute the change throughout the day is equivalent to ascribing it all to one infinitesimal interval of time, like a sudden offset in the record.

Some contention has arisen over the fact that the non-cyclic change is derived from data which are not a part of the series to which it is applied. Assuming that the non-cyclic change occurs uniformly throughout the series, it is possible to derive it from the series itself by fitting the data by least squares to an equation of the form

$$y_t = a_o + kt + \Sigma\, a_n \cos nt + \Sigma\, b_n \sin nt$$

This is of course open to the objection that the amount of the change will be dependent on the number of terms carried in the series and also that the coefficients will vary with the number of terms carried. Some values of non-cyclic change in horizontal intensity for the internationally selected quiet days at the Watheroo Magnetic Observatory for the entire year, determined by end-differences and by least squares, are shown in Table 1.

Table 1. — Comparison of average non-cyclic change in horizontal intensity during internationally selected quiet days at Watheroo as determined by different methods

Method	1920	1921	1922	1923	1924
	γ	γ	γ	γ	γ
End-differences	+4.7	+5.3	+3.6	+2.7	+3.5
Least squares, using four waves	+4.9	+4.2	+4.4	+3.8	+3.7

The nature of non-cyclic change — Over any long period the average non-cyclic change in any element is necessarily the secular change in that element if all days are included in the reckoning. During days selected for unusually quiet or unusually disturbed conditions an entirely different phenomenon comes into play. It is well known that during magnetic storms the value of horizontal intensity in middle and low latitudes usually decreases, the decrease being greatest near the magnetic equator. Reverse effects occur in vertical intensity, the greatest change being in high latitudes. For this reason a lower value of horizontal intensity is to be expected at the end of a disturbed day and a higher value, numerically, in vertical intensity. During quiet days the elements tend to return to their normal values so that the changes on quiet days are in general of opposite sign to those on disturbed days. Since disturbed days are ordinarily much fewer than quiet days the changes on disturbed days are necessarily greater than on quiet days in order that the two effects should compensate.

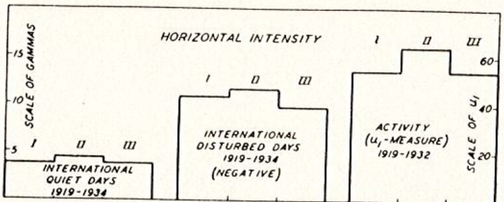


FIG. 1—AVERAGE DAILY NON-CYCLIC CHANGES, WATHEROO MAGNETIC OBSERVATORY, AND WORLD-WIDE MAGNETIC ACTIVITY BY SEASONS
I = JAN, FEB, NOV, DEC; II = MAR, APR, SEP, OCT; III = MAY, JUN, JUL, AUG

Seasonal and secular distribution — The close association of non-cyclic change with magnetic activity leads to the expectation of a seasonal and secular distribution of the phenomena parallel to that of magnetic activity. The seasonal distribution of non-cyclic change in horizontal intensity during the internationally selected quiet days and disturbed days at Watheroo from 1919 to 1934 is represented in Figure 1 together with world-wide magnetic activity (the u_1-measure – see J. Bartels, *Terr. Mag.*, v. 37, pp. 1-52, 1932, and v. 39, pp. 1-4, 1934) for the years 1919 to 1932. A comparison of the annual values of the same data is shown in Figure 2. The conclusions are obvious. It is not at all remarkable that this similarity should appear because the value of the non-cyclic change taken from the daily means of all the days without regard to sign is the basis of the u_1-measure of magnetic activity.

Separation of non-cyclic change into portions of external and internal origins — Since the principal feature of world-wide magnetic storms is represented by the first zonal harmonic about the axis of the Earth's uniform magnetization, the phenomenon of non-cyclic change over the entire Earth should be representable by a variation in this harmonic. Also, as magnetic storms are primarily of external origin associated with electric currents induced within the Earth, it should be possible to resolve the non-cyclic change into those two portions.

For this purpose the non-cyclic changes in horizontal and vertical intensity were extracted for the internationally selected quiet and disturbed days at the magnetic observatories of the

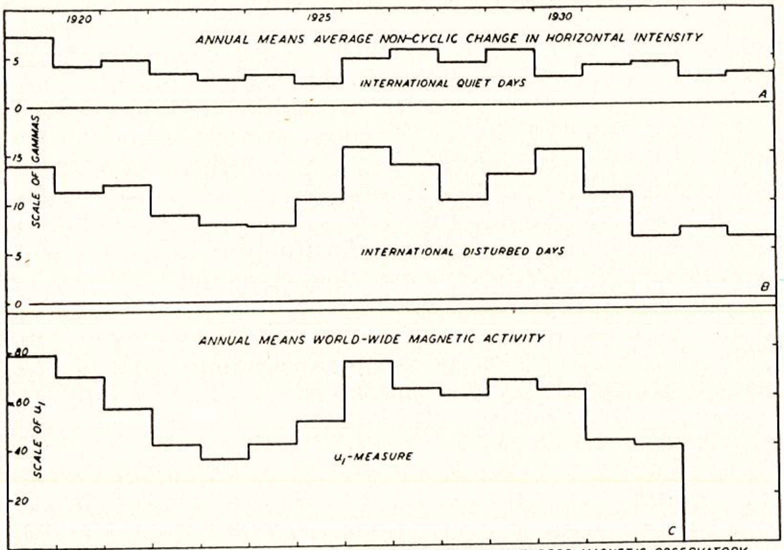


FIG. 2—COMPARISON ANNUAL VALUES NON-CYCLIC CHANGES AT WATHEROO MAGNETIC OBSERVATORY (A & B), AND WORLD-WIDE MAGNETIC ACTIVITY (C)

Department of Terrestrial Magnetism of the Carnegie Institution of Washington and at those of the United States Coast and Geodetic Survey. The years selected for study were the quiet year 1923 and the disturbed year 1926. It was assumed that the values observed at these stations were typical of the entire Earth for corresponding geomagnetic latitudes, that the phenomenon was symmetrical with respect to the geomagnetic equator, and that the non-cyclic changes were derivable from a potential varying with universal time. The average non-cyclic change occurring during a day was fitted to the harmonic

$$a\,[E\,(r/a) + I\,(a/r)^2]\,\sin\Phi$$

in which a is the Earth's radius, r is the radial coordinate, and Φ is the geomagnetic latitude, the horizontal-intensity and

Table 2. — Coefficients of the potential of average non-cyclic change due to external and internal causes at Sitka, Cheltenham, Tucson, Vieques, Honolulu, Huancayo, and Watheroo

Harmonics	International quiet days		International disturbed days	
	1923	1926	1923	1926
	$\gamma \times$ cm	$\gamma \times$ cm	$\gamma \times$ cm	$\gamma \times$ cm
External (E)	+3.1	+4.5	—8.9	—15.0
Internal (I)	+0.7	+1.2	—2.6	— 3.9
Ratio (I/E)	0.23	0.37	0.34	0.38

vertical-intensity changes being fitted separately. In this way it was possible to separate the non-cyclic change into the portions due to external and to internal causes. The coefficients derived and the ratios of the internal to the external coefficients are shown in Table 2, in which a plus sign for E and a minus sign for I imply that the change corresponds to a decrease of the flux-density through the Earth parallel to the Earth's axis.

Special attention is called to the ratios of the internal to the external portions. The mean value of this ratio is 0.33. Chapman *(Phil. Trans. R. Soc.,* v. 219, pp. 1-118, 1919) has found the corresponding ratios for the solar-diurnal and lunar-diurnal variations to be 0.39 and 0.44, respectively. The closeness of this agreement argues that it did not arise through accident. Without speculating as to the more intimate nature of its cause, the non-cyclic change on quiet days may be regarded as due to an increase in a current flowing in the upper layers of the atmosphere from west to east, the density of which is proportional to the cosine of the geomagnetic latitude, accompanied by a corresponding increasing current within the Earth, about one-third as great and oppositely directed. The density of this current is about five amperes per kilometer in equatorial regions. Non-cyclic change on disturbed days may be attributed to a reverse effect of approximately three times this magnitude. From another point of view, the change on disturbed days may be regarded as the building up of such a current while the quiet-day phenomenon may be regarded as the decay of the current built up on disturbed days.

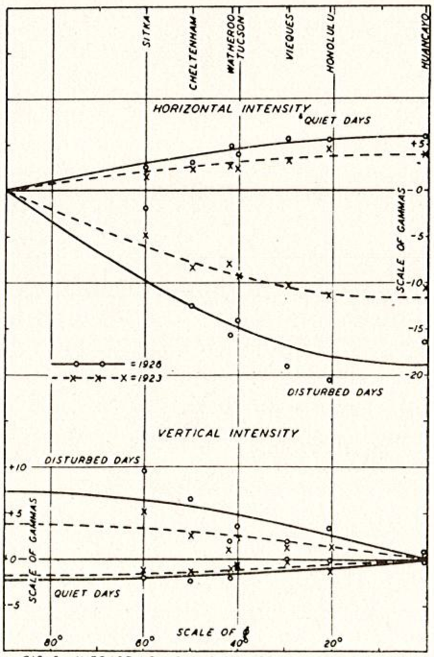


FIG. 3—AVERAGE NON-CYCLIC CHANGE DURING INTERNATIONAL SELECTED DAYS AS FUNCTION OF GEOMAGNETIC LATITUDE

The extent to which this harmonic representation fits the observed data is shown in Figure 3, in which the observed values of non-cyclic change are plotted against the geomagnetic latitude. The smooth curves represent the harmonic coefficients from which the values in Table 2 were derived.

Linearity of non-cyclic change — An important consideration regarding the non-cyclic change is the distribution of the change throughout the period during which it occurs. In order to investigate this aspect for horizontal intensity on quiet days the daily mean values of horizontal intensity at Watheroo were recorded for days selected by the Department of Terrestrial Magnetism and the United States Coast and Geodetic Survey as being very quiet and which immediately preceded or suc-

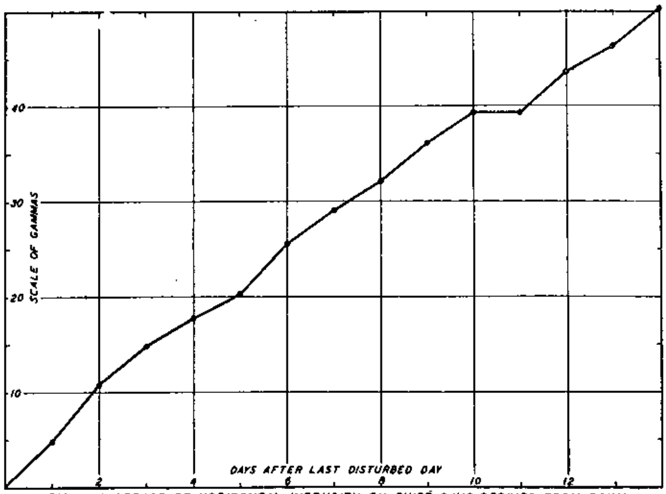


FIG. 4—INCREASE OF HORIZONTAL INTENSITY ON QUIET DAYS DERIVED FROM DAILY MEANS, WATHEROO MAGNETIC OBSERVATORY, 1919, AND 1925-1929

ceeded internationally selected quiet days. Each mean was assigned a number representing the interval of time elapsing since the last internationally selected disturbed day. The difference between the means of each series was then obtained and the sums of the differences between correspondingly numbered means were derived. The sums were then divided by the number of differences entering into each. In this way a representation of the average increase in horizontal intensity after a magnetic storm as a function of time was obtained. The results for the years 1919 and 1925-29 at Watheroo are shown in Figure 4. The trend of the recovery in horizontal intensity appears to be substantially linear. The slope of the recovery is about 4γ per day, substantially the value obtained by the end-differences on internationally selected quiet days.

Dep. Terr. Magn., C.I.W., July 31, 1936.

PROGRESS OF RESEARCH IN MAGNETIC DIURNAL-VARIATIONS AT THE DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON

By A. G. McNISH

The establishment of a magnetic observatory by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington near Huancayo, Peru, in geographic latitude 12.°0 south — geomagnetic latitude 0.°6 south — has led to the discovery of magnetic diurnal-variations markedly different [see 1 of "References" at end of paper] from those expected for such a region. The anomalous character of the diurnal variations at this station is most conspicuous in the extremely large range in horizontal intensity — for example, the range in this element was 106 gammas for the international quiet days of the equinox of 1923 as compared with 32 gammas observed for the same time at Samoa, in geographic latitude 13.°8 south and geomagnetic latitude 16.°0 south.

Examination of the variations observed at other stations in about the same longitude as Huancayo indicates that they exhibit certain features which seem to fit into the concept derived from examination of the Huancayo variations. With a view to more clearly understanding the variations of these stations in the Western Hemisphere, a spherical harmonic analysis of them was undertaken.

The stations used for this analysis were Agincourt (43.°8 north, 79.°3 west), Cheltenham (38.°7 north, 76.°8 west), Vieques (18.°2 north, 65.°4 west), Huancayo (12.°0 south, 75.°3 west), and Pilar (31.°7 south, 63.°9 west). The data were for the international quiet days of the equinox — March, April, September, and October — 1923. Because the data from these stations were more symmetrical with respect to the geomagnetic equator than with respect to the geographic equator, the analysis was referred to geomagnetic coordinates. The further assumption was made that the diurnal variations are a function of geomagnetic time, roughly, and that the variations observed at these five stations are typical for the entire Earth. No assumption was made regarding symmetry with respect to the equator.

The justifiability of these assumptions is questionable, but they were necessary in order to fit the data without employing harmonics which would produce unreasonable values for the variations in other latitudes. It was found necessary to carry a large number of terms in the harmonic series in order to closely approximate the values, four harmonics being used for each wave of the diurnal variation. It should be remarked that the harmonics of degree (n + 2) were found to be small and could have been neglected. Coefficients of the potential-function were obtained by least squares to give the best fit to the variations in both the northward and eastward components of magnetic intensity. A separate set of coefficients was obtained to fit the variations in vertical component. Thus, although the inclusion of one more term would have given a perfect fit to the vertical-intensity variations, six more terms would have been needed to fit completely the horizontal components. The usual separation of the potential of the variations into those portions due to internal and to external causes was made. The results of the analysis are shown in Table 1.

Table 1 — Amplitudes and phase-angles potential of magnetic diurnal-variation in Western Hemisphere, international quiet days, equinox of 1923.

(Time-origin is midnight 75° west meridian mean time)

Order	Degree	External		Internal		Ratio (I/E)	Difference (i-e)
		Amplitude, E	Phase-angle, e	Amplitude, I	Phase-angle, i		
		γ×cm	°	γ×cm	°		°
1	1	36.7	284	9.4	347	0.26	63
	2	45.6	94	18.7	115	0.41	21
	3	5.6	152	4.5	86	0.80	—66
	4	9.2	281	8.6	275	0.94	— 6
2	2	6.12	103	2.03	153	0.33	50
	3	6.06	279	2.88	292	0.48	13
	4	0.618	351	0.314	315	0.51	—36
	5	0.603	95	0.535	91	0.89	— 4
3	3	1.104	281	0.408	298	0.37	17
	4	0.546	103	0.285	105	0.52	2
	5	0.110	252	0.079	234	0.72	—18
	6	0.053	92	0.030	71	0.57	—21

It is gratifying, in view of the assumptions made, to observe that the external coefficients in all cases exceed the internal coefficients, although the fact that the internal harmonics sometimes lag behind the external harmonics in the higher degrees instead of leading them is somewhat disconcerting. The closeness with which the data are fitted by the harmonics used is shown in Figure 1, where the observed variations in the various components are plotted together with those computed from the constants in Table 1 and from the constants determined by Chapman [2]. Although the curves computed from the present analysis fit better than those computed from the older analysis, attention should be directed to the fact that the older analysis used fewer coef-

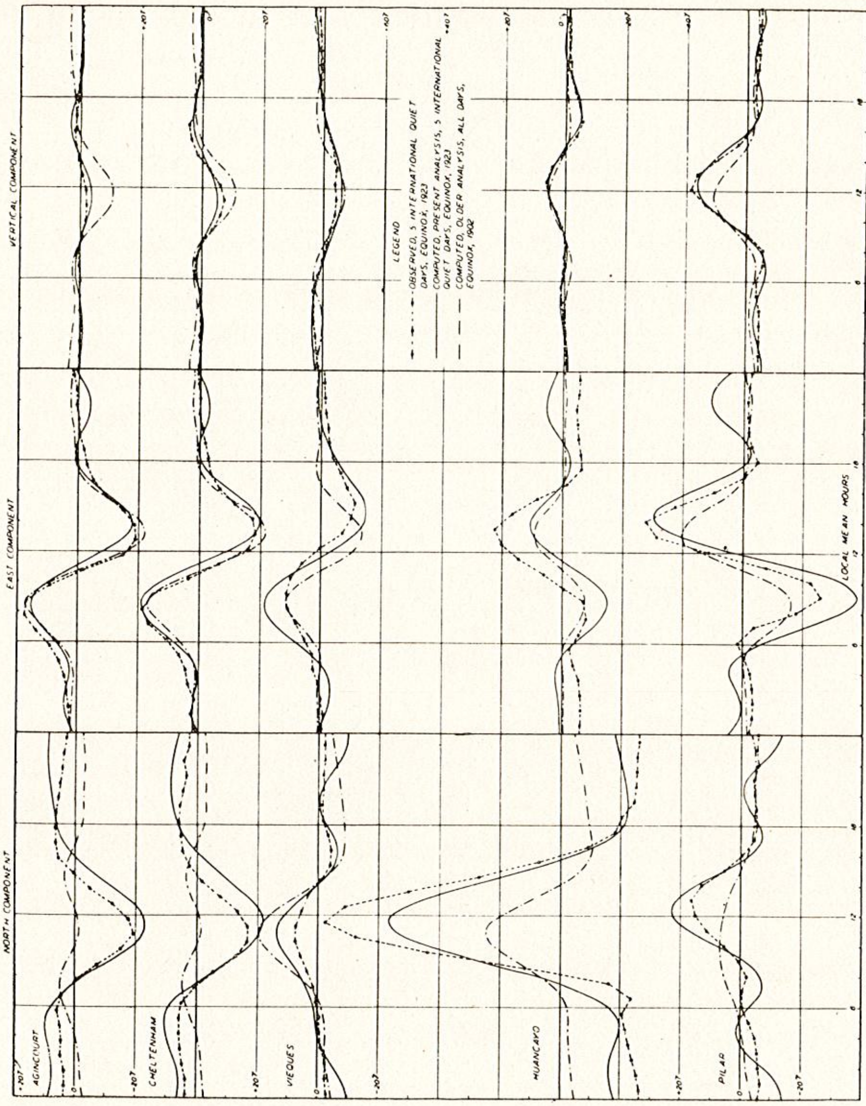


FIG 1—OBSERVED AND COMPUTED DIURNAL VARIATIONS, COMPONENTS OF MAGNETIC INTENSITY AT OBSERVATORIES NEAR MERIDIAN 75° WEST

ficients, attempted to fit the variations over the entire Earth, and did not take into account the anomalous variations at Huancayo, which had not been discovered at the time the analysis was performed. The Figure brings out the fact that the general system of the variations is displaced southward in the Western Hemisphere and its structure is much too fine to be fitted by the few harmonics used by Chapman. Were the variations in other portions of the world computed from the

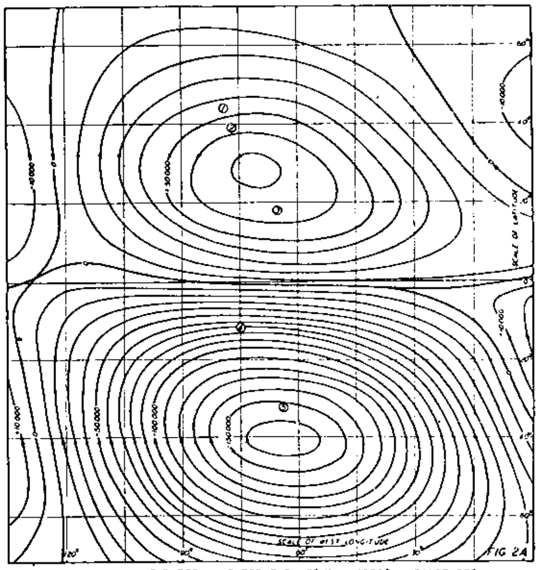


FIG 2A

ISOMETRICS OF EXTERNAL CURRENT-FUNCTION, WESTERN HEMISPHERE
AMPERES AT 11h 75° WEST MERIDIAN MEAN TIME, INTERNATIONAL QUIET DAYS, EQUINOX 1923
DEDUCED FROM MAGNETIC DIURNAL-VARIATIONS AT AGINCOURT (1), CHELTENHAM (2),
VIEQUES (3), HUANCAYO (4), AND PILAR (5)

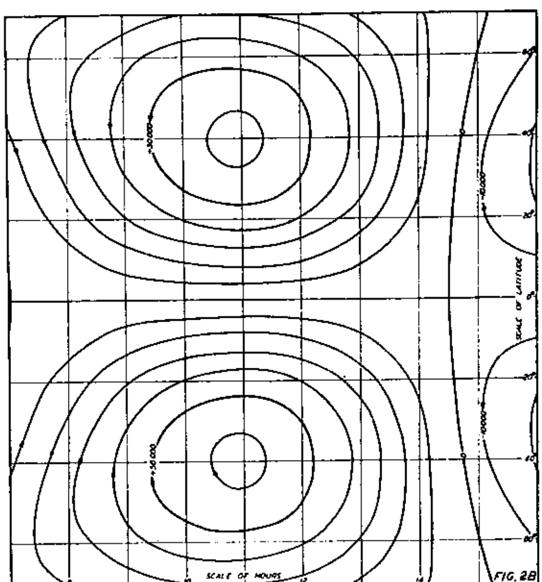


FIG. 2B

ISOMETRICS OF EXTERNAL CURRENT-FUNCTION, AVERAGE, ENTIRE EARTH
AMPERES ON DAYLIGHT SIDE OF EARTH AT INDICATED LOCAL TIMES, ALL DAYS, 1902
DEDUCED FROM MAGNETIC DIURNAL-VARIATIONS AT WIDELY SEPARATED STATIONS
(ORIGINAL DIAGRAM BY BARTELS USING CHAPMAN'S COEFFICIENTS)

coefficients in Table 1, a much poorer fit would be obtained and the superiority of the older analysis as a representation of world-wide conditions would be patent.

The significance of the assumptions on which the analysis was based will bear discussion. Were it possible to collect sufficient data, an analysis of the mean departures of the elements over the entire Earth for each hour of the day — 24 analyses in all — should be performed to clearly define the diurnal variation. It is evident that the diurnal variations are not a function of local time and geographic coordinates alone, and that the potential-system from which they arise changes during its apparent migration around the Earth.

Since the greatest departures from the average magnetic potential at any point on the Earth in middle latitudes occur approximately between 6^h and 18^h local time, that is, when the ordinary diurnal-variation is least active, the magnetic potential in the region near the 75° west meridian, say, at about 11^h local time may be considerably greater than the magnetic potential near the 105° east meridian at the corresponding local time, while the magnetic potentials in the same two regions at their respective midnights may differ but slightly. Thus the magnetic potential of the diurnal variations deduced from the coefficients in Table 1 for 11^h local time at the 75° west meridian may be considered a fairly accurate representation of the diurnal-variation potential over the entire Earth at that time, but if evaluated for a time 12 hours later it would be a very inaccurate representation.

The current-system over the Western Hemisphere evaluated from the coefficients of Table 1 for 11^h, 75° west meridian mean time, is shown in Fig. 2A. A similar current-system for the entire Earth computed by Bartels from Chapman's coefficients is shown in Fig. 2B for comparison. Schuster [3] has pointed out that the obliquity of the Earth's magnetic axis with respect to its rotational axis should give rise, on the basis of the Stewart-Schuster theory of the magnetic diurnal-variations, to harmonics in the potential of the magnetic variations which do not vary with local time. One of these is of the form $(1/2)\ (3 \cos^2 \Theta - 1)$ and varies as sin t, t being the time at some fixed meridian and Θ being the polar distance. The presence of such a harmonic might give rise to the current-system pictured in Figure 2A. A careful examination of the local distribution of the diurnal variation with a view to detecting these harmonics suggested by Schuster has not been undertaken, but the results from the analysis in the Western Hemisphere indicate that such are quite likely present.

A less mathematical examination of the problem has been undertaken. In Fig. 3 are shown the air-motions of the semidiurnal solar tide in the atmosphere computed from constants

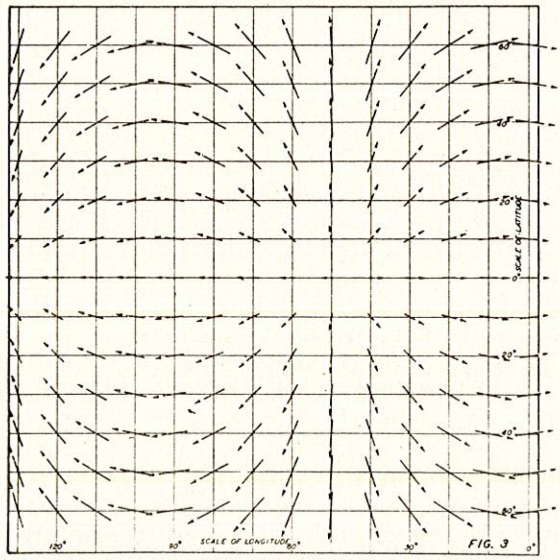


FIG. 3

AIR-VELOCITIES ARISING FROM SEMI-DIURNAL ATMOSPHERIC TIDES IN WESTERN HEMISPHERE AT 11h 75° WEST MERIDIAN MEAN TIME, TYPICAL OF THOSE OCCURRING ANYWHERE AT THE SAME LOCAL TIME

SCALE 0 50 CENTIMETERS PER SECOND

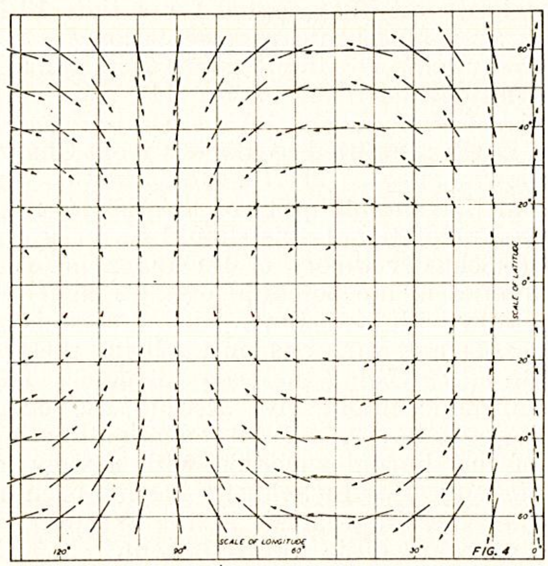
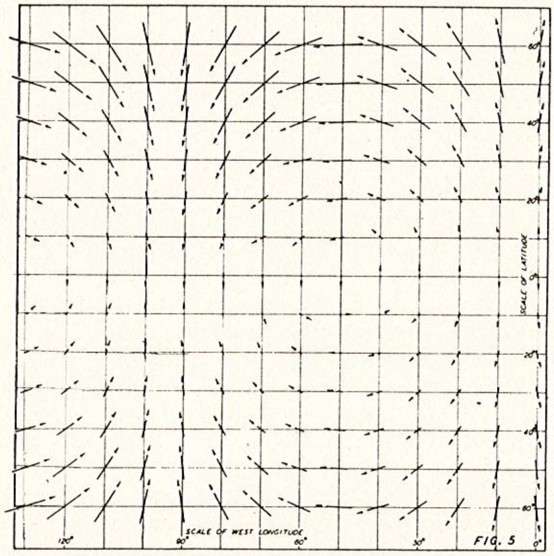


FIG. 4

ELECTROMOTIVE FORCES IN ATMOSPHERE OF WESTERN HEMISPHERE CAUSED BY SEMI-DIURNAL ATMOSPHERIC TIDES AT 11h 75° WEST MERIDIAN MEAN TIME, ASSUMING VERTICAL MAGNETIC FORCE CONSTANT ALONG EACH PARALLEL OF LATITUDE

SCALE 0 0.03 VOLT PER KILOMETER

given by Bartels [4]. The electromotive forces in the atmosphere created by the horizontal motions of the air across the vertical component of the Earth's permanent field, assuming average values of vertical intensity along given parallels of latitude, are shown in Fig. 4. These electromotive forces, according to the Stewart-Schuster theory, give rise to the cur-



ELECTROMOTIVE FORCES IN ATMOSPHERE OF WESTERN HEMISPHERE
CAUSED BY SEMI-DIURNAL ATMOSPHERIC TIDES AT 11^h 75° WEST MERIDIAN MEAN TIME
SCALE 0 — 0.03 VOLT PER KILOMETER

rent-function of the diurnal variation. In equatorial regions the electromotive forces are opposed to the flow which the currents must have in order to close, the closure occurring through the accumulation of electric charge and consequent electrostatic gradients. The electromotive forces in the Western Hemisphere differ from those shown in Fig. 4. In Fig. 5 the electromotive forces in the Western Hemisphere have been computed from the observed values of vertical intensity which are quite anomalous in that region. At about 10° south the electromotive forces are not in opposition to the flow of the current but are so directed as to augment it; this is the region of most dense current-flow as indicated in Fig. 2A.

Without making a quantitative study of the matter, this condition suggests itself as the explanation of the more intense current-circulation south of the equator in the Western Hemisphere. Of course, analogous conditions must exist on the other side of the Earth where the magnetic equator is north of the geographic equator, but as the distance between the two is less there the effect should not be so pronounced. Although the computed electromotive forces in equatorial regions are small, it should be remembered that observation indicates the periodic winds in the north-south direction which give rise to the east-west electromotive forces may be of considerably greater magnitude than is deduced from the velocity-potential indicated by the barometric tide.

In spite of the faults of the assumptions on which the above analysis was based, it seems to the writer that the results are a strong indication in favor of the Stewart-Schuster theory of the solar-diurnal magnetic variations. None of the other theories which have been proposed seems sufficiently elastic to account for the phenomena observed in the Western Hemisphere. Whether the electric conductivity of the upper atmosphere is adequate for the operation of the Stewart-Schuster theory must be considered. Radio investigations so far have failed to supply adequate information from which to form a definite opinion on this matter and, since the fund of information is rapidly growing, any attempts to arrive at a definite value of the conductivity are premature at the present time. The region of highest direct-current conductivity is undoubtedly the E-region at about 100 km. Although radio investigations indicate that electrons may be the principal cause of the reflection-phenomena observed, no evidence has been presented so far which precludes the possibility that the density of heavy ions in that region may be as great or even greater than 10^8 per cc, owing to the fact that the efficiency of ions as reflectors of radio waves is four orders of magnitude lower than the efficiency of electrons.

Another feature of considerable interest revealed by the observations at the Huancayo Magnetic Observatory is that the character of the diurnal variations in vertical intensity has been undergoing a gradual change during the past eleven years [5]. This change is clearly brought out in Figure 6.

Shortly before the Observatory was established in 1922 the magnetic equator was slightly north of its location. The variations in vertical intensity recorded in 1922 exhibited predominantly southern characteristics throughout the year. Rapid secular change in vertical intensity caused the magnetic equator to shift south of the Observatory. Associated with this shift was a change in the character of the diurnal variation in vertical intensity, the variation during the months of May, June, July, and August becoming of a distinctly northern type. Thus during the early years of the Observatory's operation the circuit-lines of the average southern current-system of the diurnal variation passed over the Observatory throughout the year. With the shift of the magnetic equator, the northern and southern current-systems in that region were shifted southward so that during the northern summer when the northern system is most intense and extensive the circuit-lines of that system passed over the Observatory, the southern system still predominating during southern summer.

This change in the diurnal variation in vertical intensity indicates a strong dependence of the magnetic diurnal-variations

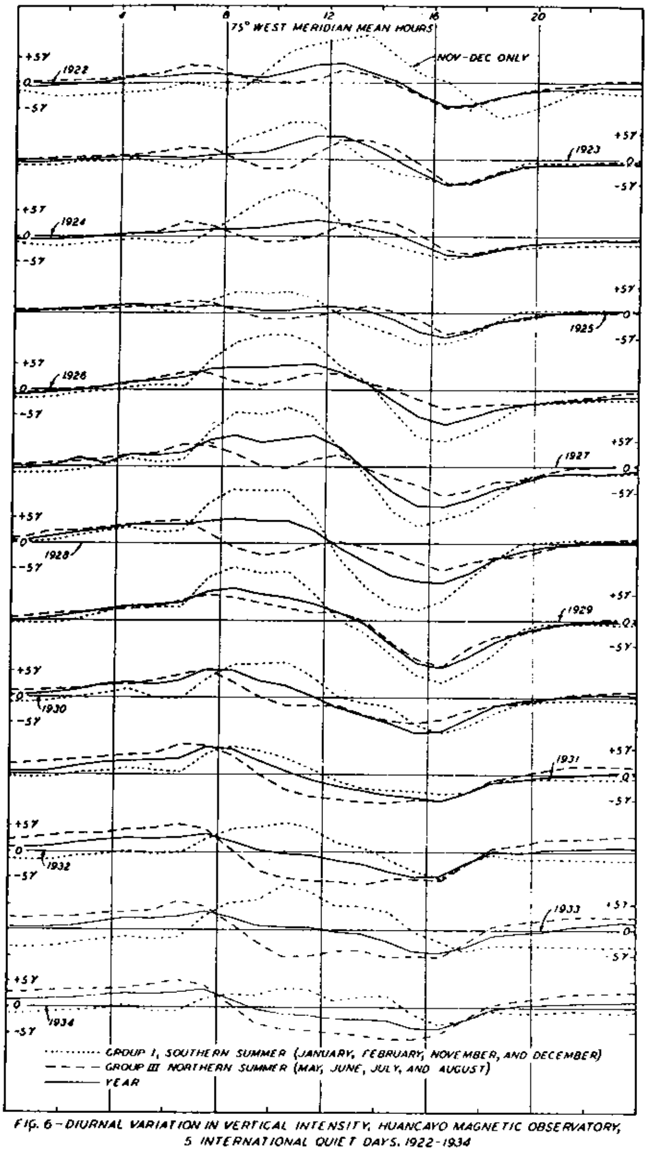


FIG. 6—DIURNAL VARIATION IN VERTICAL INTENSITY, HUANCAYO MAGNETIC OBSERVATORY, 5 INTERNATIONAL QUIET DAYS, 1922-1934

on the permanent magnetic field of the Earth. The change in the permanent field, however, was not great enough to cause one to anticipate such an effect — the values of vertical intensity and inclination being 1107 gammas and 2° 08′ in 1934, characteristic of the Northern Hemisphere. This leads to the conclusion that the diurnal variations in the Western Hemisphere depend very closely on the permanent field and that the shift from positive to negative diurnal-variation potential occurs over a very narrow region near the magnetic equator.

Similar changes in the character of the diurnal variation in horizontal intensity are not to be expected because its variation with latitude is very slight in equatorial regions. The diurnal variation in declination also indicates the change but the effect is less pronounced. If, as has been remarked previously, the diurnal variation involves zonal harmonics which vary in intensity according to the time at some fixed meridian, such changes in vertical intensity could occur without concomitant changes in declination.

The changes in character of the diurnal variation in vertical intensity at Huancayo during the past eleven years is an indication of the high complexity of the diurnal-variation phenomena. A theory which attempts to explain them must allow such changes to occur. This is in accord with the Stewart-Schuster theory according to which, as has been pointed out, the diurnal variation may be very sensitive to displacements of the magnetic equator with respect to the geographic equator through the generation of favorable electromotive forces in the equatorial regions where the currents must close.

References

[1] H. F. Johnston and A. G. McNish, C. R. Cong. Internat. Electricité, Paris, v. 12, pp. 41-52, 1932.
[2] Trans. R. Soc., A, v. 218, pp. 1-118, 1919.
[3] Trans. R. Soc., A, v. 208, pp. 163-204, 1908.
[4] Wiem-Harms, Handbuch der Experimentalphysik, v. 25, I, pp. 163-210, 1928.
[5] A. G. McNish, Terr. Mag., v. 40, pp. 151-158, 1935.

Dep. Terr. Magn., C.I.W., July 31, 1936.

THE NEW CIW VERTICAL-INTENSITY INDUCTION-VARIOMETER

By A. G. McNISH

Difficulties commonly encountered in the operation and reduction of results of ordinary magnetic balances have led to the development of a new type of vertical-intensity variometer by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Although some recent improvements in design of magnetic balances have resulted in markedly better performance of these instruments, many magneticians have realized that complete elimination of frictional contacts would be a step forward in instrumental development. A satisfactory variometer should have (1) a constant scale-value, (2) freedom from erratic changes in base-line, (3) negligible temperature-sensitivity, (4) independence of all components of magnetic intensity except the one it is set up to measure, and, in addition, numerous other qualities of a practical nature such as suitable size, etc. The new CIW induction-variometer completely fulfills these requirements.

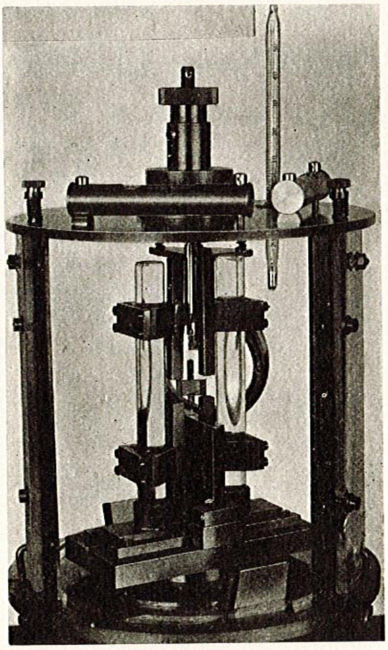


Fig. 1. — Close-up view CIW vertical-intensity induction-variometer.

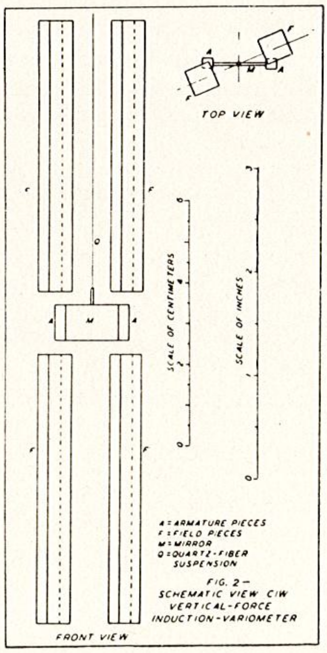


Fig. 2. — Schematic view CIW vertical-force induction-variometer.

Similar designs have been attempted before by Kashiwagi (Kyoto, *Mem. Coll. Sci.*, v. 1, No. 3, pp. 217-227, 1906-7) and by Venske (Berlin, *Veröff. Met. Inst.*, No. 290, pp. 55-67, 1916), neither of whom succeeded in producing a completely satisfactory instrument. Both of these earlier attempts involved the use of soft iron. The material employed in the CIW induction-variometer is baked perminvar — an alloy of 45 per cent nickel, 25 per cent cobalt, and 30 per cent iron — which had been held at a high temperature for several hours after being fashioned into the necessary forms. The particular virtues of this alloy which recommended its use are that its permeability remains constant and its hysteresis-loss is negligible in fields up to three gauss.

The variometer has been in continuous operation at the Cheltenham Magnetic Observatory of the United States Coast and Geodetic Survey since August 1935, except for short intervals when special tests or adjustments were made. A more complete description of the instrument and its operation, together with a discussion of the theory underlying it, are given by the writer elsewhere (*Terr. Mag.*, v. 41, pp. 161-172, 1936).

Although the induction-variometer has proven satisfactory in its present form, the possibility of further improvements by refinement of design must be recognized. Even greater consistency of performance should result from such improvements. Other applications of the instrument suggest themselves and will be briefly mentioned. By alteration of design the instrument may be used as a horizontal-intensity variometer, having the distinct advantage that only one component of the field will be measured, regardless of the deflection. As a null-detector at the center of a vertically mounted Helmholtz coil, the device may serve as the basis of an absolute instrument for measuring vertical intensity. By suitable adjustments the instrument may be used as a regional variometer for vertical intensity and as an intercomparison-variometer for vertical intensity, similar to the QHM for horizontal intensity.

Dep. Terr. Magn., C. I. W., July 31, 1936.

INVESTIGATION OF MAGNETIC BAYS

By A. G. McNISH

Abstract: The magnetic disturbance-field associated with magnetic bays is discussed and possible current-systems which might give rise to them are surmised. These current-systems are tentatively attributed to intense flows of current westward along the auroral zone on the dark side of the Earth, produced by dynamo-action in regions where auroral particles are precipitated. Some evidence in support of this hypothesis is adduced from results of radio observations.

Even during intervals when the Earth's magnetism is otherwise quite undisturbed, remarkable changes in the magnetic intensity which last for about an hour are frequently observed at various places. On the photographic records of the Earth's magnetism on which magnetic intensity is co-ordinated with time these disturbances resemble indentations in a sea-coast and for that reason are called "bays." If attention is given to the locus of the end of the total magnetic vector at a given place during one of these bays, the metaphor is still more apt — the path described by the changing vector being a loop which ordinarily lies close to a plane. While such disturbances are being recorded in middle latitudes, less simple disturbances of greater amplitude are recorded in polar regions. The polar counterparts of the middle-latitude bays, because of the rapidity of the changes taking place, may be likened to the fiords of the northern coasts.

Much attention has been given to magnetic storms and special features of them, but little study has been given to bays. The little knowledge so far acquired scarcely defines their frequency of occurrence and typical form in middle latitudes. Investigations on these phenomena by Steiner *(Terr. Mag.,* v. 26, pp. 1-14, 1921), Lubiger *(Dissertation,* Göttingen, 1924), and Wiechert *(Mitt. Geophys. Warte Gr. Raum,* Königsberg, Pr., No. 22, 1934) neglected treatment of the aspects manifested in very high latitudes, and as a consequence probably fail completely in indicating their genesis. Birkeland *(The Norwegian aurora polaris expedition 1902-03,* Christiania, 1913) considers a type of phenomenon which he designates as a polar elementary storm, highly active in polar regions, but manifested as a bay in middle and low latitudes. The present investigation, attempting to derive some knowledge of the world-wide characteristics of bays from which a theory of their cause may be developed, indicates that the converse of Birkeland's discovery is also true — that every bay in middle latitudes is associated with a polar elementary storm.

The fact that well-defined bays occur when the Earth's magnetic field is otherwise quite undisturbed denotes a simplicity in their morphology which should facilitate the study of them. Furthermore, the repeated occurrence of bay-like movements during magnetic storms suggests that the major magnetic storms may consist largely of numerous bays accompanied by another distinct type of disturbance manifest in the general depression of horizontal intensity in low and middle latitudes. In view of the seeming simplicity of individual bays, several which were observed during the Second International

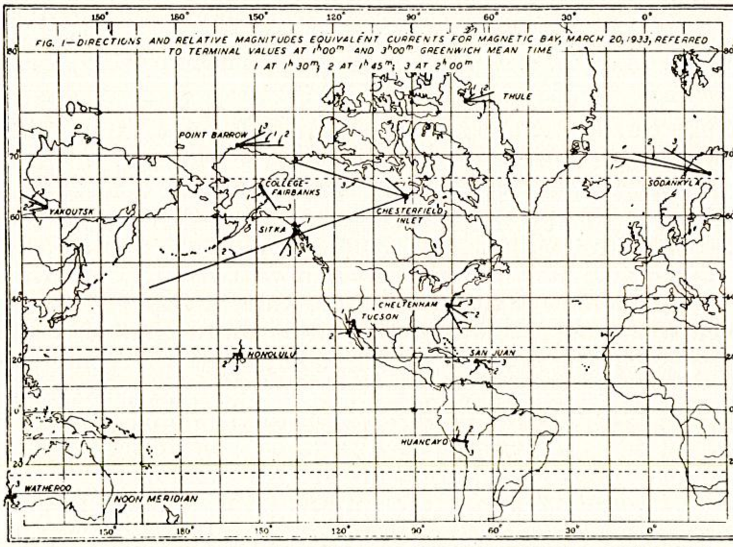


FIG. 1—DIRECTIONS AND RELATIVE MAGNITUDES EQUIVALENT CURRENTS FOR MAGNETIC BAY, MARCH 20, 1933, REFERRED TO TERMINAL VALUES AT 1^h00^m AND 3^h00^m GREENWICH MEAN TIME
1 AT 1^h30^m; 2 AT 1^h45^m; 3 AT 2^h00^m

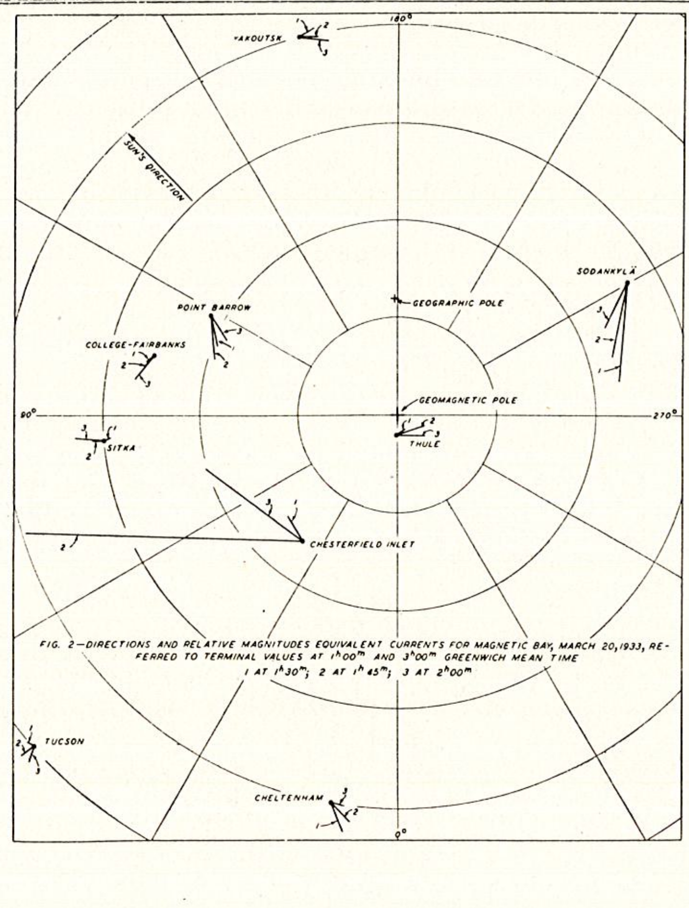


FIG. 2—DIRECTIONS AND RELATIVE MAGNITUDES EQUIVALENT CURRENTS FOR MAGNETIC BAY, MARCH 20, 1933, REFERRED TO TERMINAL VALUES AT 1^h00^m AND 3^h00^m GREENWICH MEAN TIME
1 AT 1^h30^m; 2 AT 1^h45^m; 3 AT 2^h00^m

Polar Year have been selected for investigation because the numerous observatories then in operation should furnish a fairly complete basis for mapping the perturbation-field.

Three of the bays studied are graphically represented in Figures 1 to 6. The lines drawn outward from each observatory show the direction and relative magnitude of an overhead current which would have produced the changes in horizontal magnetic intensity observed during the bay. This current is assumed to be flowing in a layer parallel to the Earth's surface. The changes in magnetic intensity were determined vectorially with reference to the mean magnetic intensity at the terminal times of the bay, namely, just before the bay began and just after the bay ended. The lines are for strictly simultaneous times at all the stations.

No attempt has yet been made to discriminate between those portions of the magnetic intensity due to internal and to external origins, although it is evident from the largeness of the horizontal components with respect to the vertical that the portion due to electric currents induced within the Earth must be considerable. Whether or not this separation will be possible has not been ascertained. It follows from the rapidity of the field-changes that the internal currents must be nearly as great as the external currents. Undoubtedly the structure of the internal system is not as fine-grained and is complicated by the distribution of land- and water-areas.

The greater intensity of action in high latitudes may be considered as due to a concentrated flow of electric current in the high atmosphere in general westward along the auroral zone with maximal intensity usually on the dark side of the Earth. In some cases this flow seems continuous around the zone, while in others an eastward current is observed on the side of the Earth opposite the region of maximal intensity. The configuration of the flow suggests that the primary cause exists where the flow is most dense, the remaining circulation being such as to fulfill the necessary conditions of continuity. Where adequate data exist the flow of current in middle latitudes seems to describe a loop — westward along the auroral zone, southward along the twilight portion of the terminator, eastward along the tropics, and northward along the dawn portion of the terminator, in the Northern Hemisphere. A mirror-image of this circulation in the Southern Hemisphere is suggested by the data. Thus the circulation in middle latitudes closely resembles the current-system of the magnetic diurnal-variations on disturbed days, but displaced somewhat in phase.

Birkeland has supposed that polar elementary storms are due to the direct magnetic effect of charged corpuscles from the Sun, deflected into the auroral region by the Earth's permanent field. Numerous investigators have concluded that

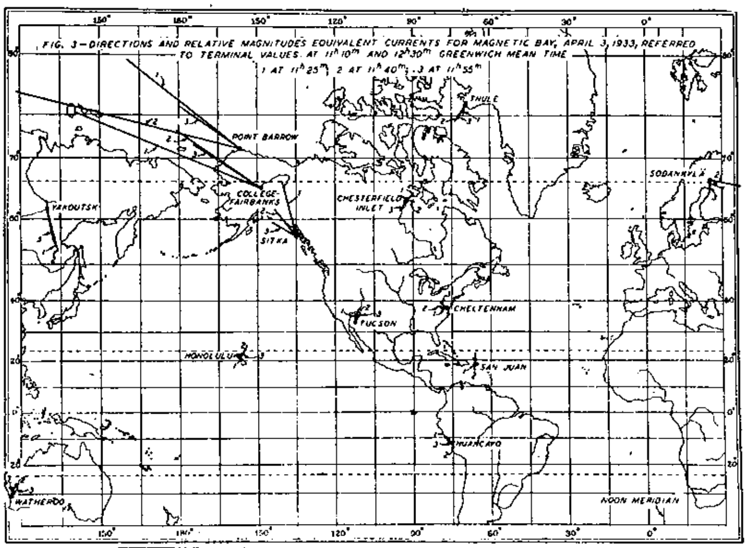


FIG. 3—DIRECTIONS AND RELATIVE MAGNITUDES EQUIVALENT CURRENTS FOR MAGNETIC BAY, APRIL 3, 1933, REFERRED TO TERMINAL VALUES AT 11^h10^m AND 12^h30^m GREENWICH MEAN TIME

1 AT 11^h25^m; 2 AT 11^h40^m; 3 AT 11^h55^m

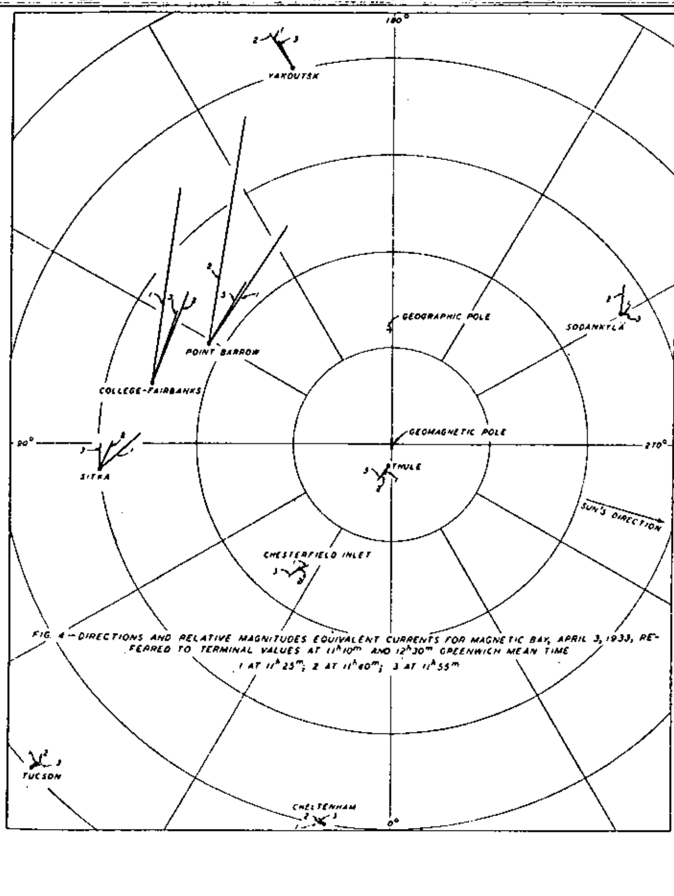


FIG. 4—DIRECTIONS AND RELATIVE MAGNITUDES EQUIVALENT CURRENTS FOR MAGNETIC BAY, APRIL 3, 1933, REFERRED TO TERMINAL VALUES AT 11^h10^m AND 12^h30^m GREENWICH MEAN TIME

1 AT 11^h25^m; 2 AT 11^h40^m; 3 AT 11^h55^m

corpuscular streams of proper composition for producing the magnetic effects by direct action could not be sufficiently coherent to traverse the distance from the Sun to the Earth because of mutual electrostatic repulsion. Any corpuscular streams entering the Earth's field must be electrically neutral, consisting of charged particles of different sign. The provisional assumption that the extra-terrestrial cause of magnetic disturbances is corpuscular radiation seems reasonable because the occurrence of these disturbances on the dark side of the Earth compels the conclusion that they are not due to electromagnetic radiation.

Ascribing the bays primarily to electric currents flowing westward along sections of the auroral zone invites speculation as to the mechanism which causes their flow. That they may be due to drift-currents arising from crossed gravitational and magnetic fields, such as have been suggested to explain the quiet-day magnetic diurnal-variations (S. Chapman, *Proc. R. Soc.*, v. 122, pp. 369-386, 1929), has been considered. Purely gravitational-magnetic drifts would cause eastward currents, however, and electric-magnetic drifts would produce no currents except possibly for the small currents resulting from differential drifts of ions and electrons. Diamagnetic effects (R. Gunn, *Terr. Mag.*, v. 34, pp. 17-22, 1929) have also been discarded because the magnetic fields that would be so produced do not appear to be the required form.

Another mechanism by which the necessary currents could be produced is dynamo-action. Motions of the high atmosphere with respect to the Earth's permanent field in the auroral region could give rise to electromotive forces impelling the flow of current. The required air-motions would have to be vertical or northward at the center of disturbance. The hypothesis is suggested that the precipitation of corpuscles in the auroral region has a twofold effect — it produces intense ionization of the region about 100 km above the Earth's surface and it warms the region so as to cause expansion. Accordingly, the principal motion is upward in the 100-km region where the collision-frequency of the ions is great enough to permit considerable direct-current conductivity, while the lateral motion occurs at greater heights where high direct-current conductivity is prohibited by low collision-frequency. The vertical motion acting in conjunction with the horizontal component of the Earth's permanent field, which amounts to about 0.1 Gauss in auroral regions, causes a westward current in the region of auroral precipitation, at a height of about 100 km. A hypothesis practically identical with this has been advanced by Chapman (*Proc. R. Soc.*, v. 95, pp. 61-83, 1918) to explain world-wide storms in which the assumption is made that the expansion takes place over the entire Earth, although in a later paper

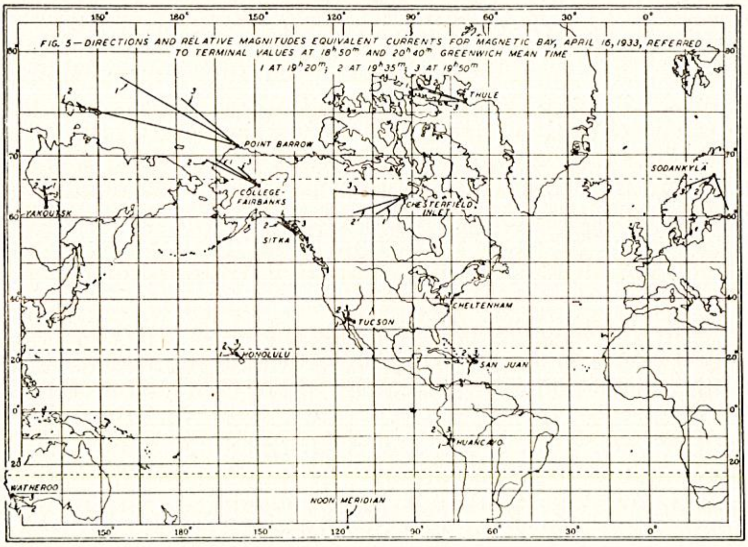


FIG. 5—DIRECTIONS AND RELATIVE MAGNITUDES EQUIVALENT CURRENTS FOR MAGNETIC BAY, APRIL 16, 1933, REFERRED TO TERMINAL VALUES AT $18^h 50^m$ AND $20^h 40^m$ GREENWICH MEAN TIME
1 AT $19^h 20^m$; 2 AT $19^h 35^m$; 3 AT $19^h 50^m$

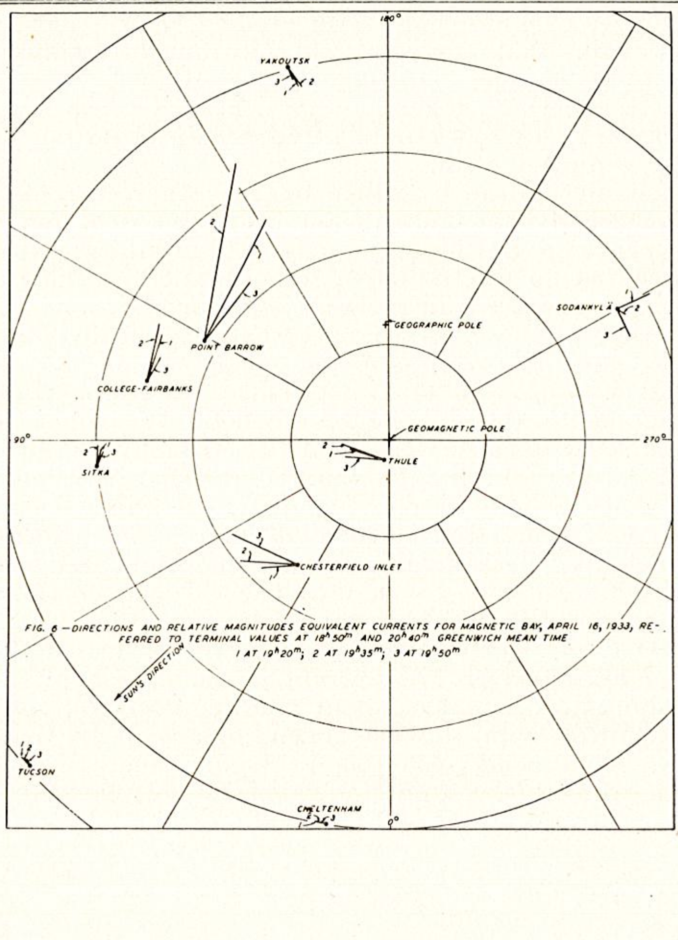


FIG. 6—DIRECTIONS AND RELATIVE MAGNITUDES EQUIVALENT CURRENTS FOR MAGNETIC BAY, APRIL 16, 1933, REFERRED TO TERMINAL VALUES AT $18^h 50^m$ AND $20^h 40^m$ GREENWICH MEAN TIME
1 AT $19^h 20^m$; 2 AT $19^h 35^m$; 3 AT $19^h 50^m$

(*Proc. R. Soc.*, v. 115, pp. 242-267, 1927) he expresses the feeling that the hypothesis in its first form must be abandoned. While the author is in agreement with the latter view, he believes that vertical motion of sufficient magnitude to produce the effects may occur in local regions.

The circulation in regions away from the center are not to be explained as inductive effects, in accord with Chapman's earlier theory, but as the necessary complementary flow in regions of poorer conductivity due to accumulation of electric charge at the extremities of the primary channel. Air-motions, either horizontal or vertical, in other regions will give rise to small electromotive forces and warp the current-flow considerably. The primary channel of circulation would be many hundreds of kilometers in length.

The above hypothesis must be regarded as suggesting one mechanism which might cause bays. An investigation of the adequacy of this hypothesis is being undertaken. Probably the same mechanism should not be called upon to explain all bays. High air-velocities in the auroral region may exist at times for quite different reasons, which, in the presence of sufficient ionization, could induce the required electric currents. Some collateral support for the general suggestions offered here has been presented in a paper by Leiv Harang (*Terr. Mag.*, v. 41, pp. 143-160, 1936). Reflections of radio signals from the E-region indicating abnormal ionization were observed at Tromsö while an auroral arc measured as 800 km long stretched across the sky. Accompanying these upper-atmospheric phenomena, magnetic disturbances were observed at the station, indicating a westward flow of current in the ionosphere. The phenomena occurred shortly before midnight, local time.

Dep. Terr. Magn., C.I.W., July 31, 1936.

THE FIELD OF MAGNETIC STORMS AS DEDUCED FROM THE MEAN DIFFERENCE OF MAGNETIC INTENSITY ON QUIET AND DISTURBED DAYS

By L. SLAUCITAJS and A. G. McNISH

This paper attempts to derive a more accurate quantitative conception of the field of magnetic storms from the study of the differences of magnetic intensities observed at various places on the Earth on internationally selected quiet and disturbed days. The treatment has been confined to what has been termed the world-wide features of the disturbance, that is, those which depend on universal time and latitude rather than local time and latitude. An attempt has been made by Chapman (*Terr. Mag.*, v. 40, pp. 349-370, 1935) to portray the features of world-wide disturbance in a recent paper. He did not separate the internal and external portions of the field, the assumption being made that the horizontal intensity at all points was a contribution from both causes and that the external portion was about 2.5 times as great as the internal portion, the ratio which had been obtained from analysis of the periodic diurnal-variation.

The validity of this assumption for certain of the harmonics has been borne out by the writers, but there is evidence of its inapplicability for other harmonics. More particularly the results of this investigation accentuate Chapman's wisdom in attempting no formal analysis of the data, for the roughness of fit which is achieved by harmonic analysis casts doubt upon the physical significance of the various harmonics. The results of the investigation will be presented for what they are worth, leaving to the individual reader the significance which his judgment attaches to them.

Data

The data selected for this study were the differences in magnetic intensity on internationally selected disturbed and quiet days derived from the daily means of a large number of observatories for the year 1927. The data are reasonably homogeneous, that is, in nearly all cases the same days were available for all observatories. For those observatories which published daily means according to local time, the hourly values were summed for this study according to Greenwich time. When the hourly intervals were not coincident with the Greenwich hours, the nearest hours were selected, thus introducing a slight inhomogeneity, which, however, was of no consequence. Since no records were available for the chosen interval from a station near the geomagnetic pole, the eight-month series from Refuge Harbor from November 1923 to June 1924 was used, corrections being made by comparison with other observatories in the same section of the Earth for the same interval to reduce the Refuge Harbor results to the epoch 1927. Many observatories fail to recognize the importance to theoretical studies of the mean values of the various magnetic elements for the different classes of days and consequently do not publish those means. This failure restricts the amount of data available to investigators, for the labor of extracting the necessary means for a large number of observatories for many years is great. The actual material used in this investigation is given in Table 1.

Table 1 — Differences in magnetic intensity for international disturbed days minus international quiet days, 1927

Group	Observatory	Coordinates					Intensity-differences		
		Geographic		Geomagnetic			North	East	Down
		φ	λ	Φ	Λ	ψ	X	Y	Z
		°	°	°	°	°	γ	γ	γ
0	Refuge Harbor[a]	+78.5	72.4	+89.6	267.8	+89.0	+ 7	+ 9	+17
1	Sodankylä	+67.4	26.6	+63.8	120.0	−26.7	−20	− 1	− 9
1	Lerwick	+60.1	358.8	+62.6	88.6	−23.6	− 7	+ 3	+ 4
1	Sitka	+57.0	224.7	+60.0	275.4	+21.4	−25	−10	−17
2	Seddin	+52.4	13.1	+52.5	97.1	−18.9	−13	+ 4	+ 5
2	Cheltenham	+38.7	283.2	+50.1	350.5	+ 2.4	−15	0	− 1
2	Sverdlovsk	+56.8	60.6	+48.6	140.4	−13.4	−14	+ 3	+ 4
3	Ebro	+40.8	0.5	+43.9	79.7	−15.0	−15	+ 3	+ 5
3	Tucson	+32.2	249.2	+40.4	312.2	+10.1	−17	− 2	+ 2
4	Kakioka	+36.2	140.2	+26.0	206.0	+ 6.2	−19	− 4	+ 3
4	Honolulu	+21.3	201.9	+21.0	266.5	+12.3	−22	− 4	+ 3
4	Lukiapang	+31.3	121.0	+20.0	189.1	+ 2.1	−24	− 1	+ 2
5	Bombay	+18.6	72.9	+ 9.5	143.6	− 7.2	−27	+ 4	− 1
5	Huancayo	−12.0	284.7	− 0.6	353.8	+ 1.3	−27	− 2	− 1
4	Apia	−13.8	188.2	−16.0	260.2	+11.7	−22	− 5	....
4	Batavia	− 6.6	106.8	−18.0	175.6	− 0.9	−22	0	− 4
3	Watheroo	−30.3	115.9	−41.8	185.6	+ 1.3	−18	− 2	− 5
3	Toolangi	−37.5	145.5	−46.7	220.8	+ 9.5	−16	− 4	− 2
2	Christchurch	−43.5	172.6	−48.0	252.6	+15.2	−14	− 7	− 3

[a]Observatory operated from November 1923 to June 1924; data given are reduced to epoch 1927.

A graphical representation of the data is given in Figure 1. The average storm-field, determined by the differences in magnetic intensity on the two classes of days, is represented by arrows. The horizontal component of intensity is represented by solid lines at all observatories, the lengths of which are proportional to the magnitude and the directions of which are the true directions of the horizontal component of the storm-field. The vertical or radial component of the storm-field is represented at all observatories by dotted lines — an arrow directed toward the east on the map signifies an algebraic increase in the vertical component, reckoned as positive in the Northern Hemisphere.

General description of the storm-field

As revealed by Figure 1, the horizontal component of the storm-field at all observatories closely parallels the geomagnetic meridians and is directed southward, representing a

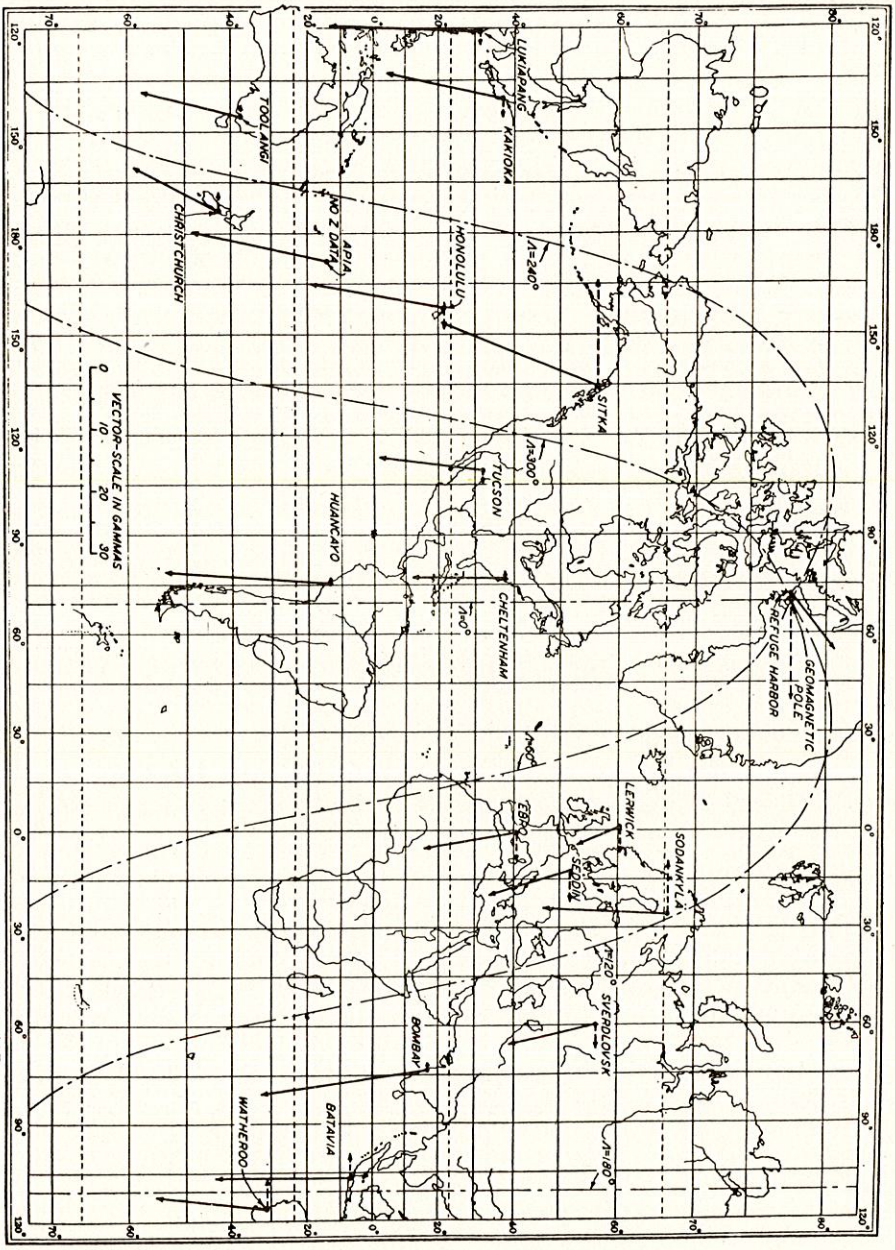


FIG. 1—MEAN VECTOR-DIFFERENCES MAGNETIC INTENSITY, FOR DISTURBED MINUS QUIET DAYS, 1927
——HORIZONTAL INTENSITY; - - -VERTICAL INTENSITY.

decrease in horizontal intensity. The numerical value of this horizontal component is greatest near the geomagnetic equator, decreasing in higher latitudes until a minimum is reached in about 45° geomagnetic latitude and again increasing toward the auroral zone. The distribution of the vertical component is more complex, being zero at the geomagnetic equator, attaining maximal values, positive north and negative south, in about 35° geomagnetic latitude, then reversing sign as the auroral zone is approached, and recovering to the same sign as in middle latitudes near the geomagnetic poles. The vertical component of the storm-field is of such a sense as to cause an increase in the numerical value of vertical intensity during storms in about 35° geomagnetic latitude both north and south of the equator. The direction and magnitude of the horizontal component at Refuge Harbor do not fit into the picture represented by the other stations. However, recognizing that it is quite near the geomagnetic pole from which the horizontal component diverges, the discrepancy may be attributed to a slight asymmetry in the storm-field as a function of the geomagnetic coordinate-system. In other words, perhaps the storm-field may not be most simply represented when referred to the magnetic field of the hypothetical centered doublet but should be referred to the magnetic field of the eccentric doublet. However, as the axis of the eccentric dipole intercepts the Earth's surface in latitude 80.°1 north, longitude 277.°3 east (J. Bartels, *Terr. Mag.,* v 41, pp. 225-250, 1936), the horizontal component at Refuge Harbor cannot be brought into complete agreement in this way although the anomaly is less outstanding. It is possible, however, to select an arbitrary pole for the origin of coordinates between the geomagnetic pole and the apparent magnetic pole (region of inclination = 90°) to bring all the stations into better agreement. Such a point may be the actual pole of magnetic disturbance, that is, the point about which the disturbance is most symmetrical.

Analysis of the data

Because of the comparative symmetry of the storm-field about the axis of uniform magnetization, the data in Table 1 were reduced to the components of intensity with respect to the geomagnetic coordinate-system by the formulae $X' = X \cos \psi + Y \sin \psi$ and $Y' = Y \cos \psi - X \sin \psi$, X′ and Y′ being the components of intensity in the horizontal plane parallel and perpendicular to the geomagnetic meridian, respectively, considered positive toward the north and east, and ψ being the angle of deviation of the geomagnetic meridian from the geographic meridian. The Y′-components were found to be negligibly small in nearly every case so that the data could be completely fitted by zonal harmonics about the axis of uniform magnetization. The data, as shown in Figure 2, were not found to be completely dependent on geomagnetic latitude, indicating that the structure of the storm-field is more complicated than would be suggested by simple theory. Thus Lerwick, the geomagnetic latitude of which lies between that of Sodankylä and

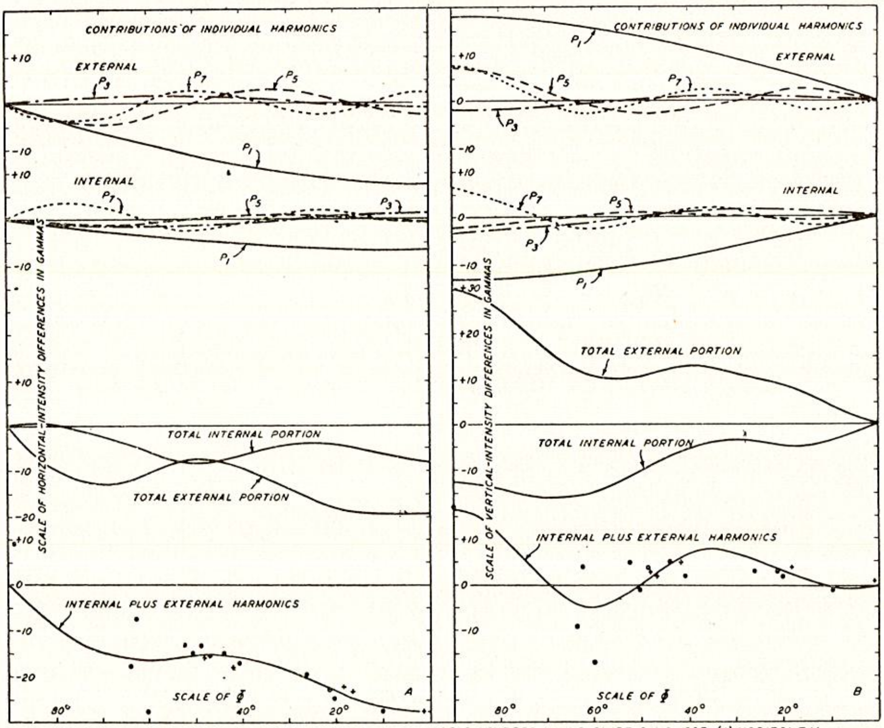


FIG. 2—AVERAGE DIFFERENCES IN MAGNETIC INTENSITY FOR DISTURBED MINUS QUIET DAYS, 1927; (A) HORIZONTAL INTENSITY, (B) VERTICAL INTENSITY
• = OBSERVED VALUES OBSERVATORIES NORTHERN HEMISPHERE; + = OBSERVED VALUES OBSERVATORIES SOUTHERN HEMISPHERE

that of Sitka, exhibits much smaller values of the storm-field in the horizontal plane than either Sodankylä or Sitka, while the vertical component of the storm-field at Lerwick is of the same sign as in lower latitudes although at Sodankylä and at Sitka the vertical component is of opposite sign. These differences are not peculiarities of the particular interval of time considered but are characteristic of the stations and would not differ markedly for other years as evidenced by the regularity of the data for individual months as well as for other years, which were examined.

In order to further simplify the analysis the data were arranged into groups as indicated in Table 1. It was assumed that the horizontal component of the storm-field is symmetrical with respect to the geomagnetic equator and that the vertical component is anti-symmetrical and therefore both are representable by the zonal harmonics of odd degree. The various groups were weighted in the adjustment of the parameters according to the cosines of their respective geomagnetic latitude so that each group was given a weight appropriate to the area of the Earth which it represents. This process of weighting tended to make the various harmonics orthogonal over the interval when adjusted by least squares since the product of two harmonics of different degree, integrated over the surface of a sphere, is zero. Group 0, including only the single station, Refuge Harbor, was given an arbitrary weight of one-half since it was taken to represent the entire region of the Earth lying within the auroral zone. Its contribution in determining the harmonics for the horizontal component was negligible but for the vertical-component harmonics it was of considerable importance. The harmonics of degree 1, 3, 5, and 7 were used in the analysis.

The effect of grouping the stations and of fitting the data by a harmonic series was to smooth out the storm-field, decreasing the sharpness of the auroral zone. Since the auroral zone itself is not sharply defined but actually appears to shift southward during times of intense magnetic disturbance, the storm-field given by the harmonic series may be considered in a true sense a mean storm-field. The internal and external portions of the field were obtained by the usual methods from the coefficients of the harmonics representing independently the horizontal and vertical components of the field. The coefficients of the harmonics representing the horizontal and vertical components of the field and the computed coefficients, I and E, representing the coefficients of the harmonics of internal and external origin, respectively, together with their ratios, are given in Table 2. The contributions of the separate harmonics to the horizontal components and vertical components of the storm-field are plotted in Figure 2.

Table 2 — Coefficients for zonal harmonics for differences in magnetic intensity for international disturbed days minus international quiet days, 1927

Degree	Intensity		Potential		Ratio (I/E)
	North	Vertical	Internal, I	External, E	
	γ	γ	$\gamma \times$cm	$\gamma \times$cm	
1	+24.7	+ 4.0	+6.9	+17.8	+0.39
3	+ 0.09	− 5.38	+0.81	− 0.72	−1.12
5	+ 1.74	+ 4.58	+0.37	+ 1.37	+0.27
7	+ 0.20	+13.42	−0.80	+ 1.00	−0.80

Discussion

It is quite evident that the storm-field is of both external and internal origin and that the external portion is greater than the internal. Regardless of theories of the origin of the external field, the most reasonable explanation of the internal field is that it is due to electric currents induced within the Earth by changes in the primary external field, an explanation which is by no means novel. Special attention must be directed to ratios (I/E) for the individual harmonics.

For the harmonics 1 and 5 this ratio is 0.39 and 0.27, respectively, quite in agreement with the observed ratios for the internal to the external harmonics in the solar and lunar variations, as well as for the first-degree harmonics used to fit the data of non-cyclic change in a paper presented at this Assembly by A. G. McNish. Thus, for the harmonics 1 and 5 of the storm-field the vertical component of the induced field tends to neutralize the vertical component of the inducing field, the two horizontal components augmenting each other, as is found for the other ephemeral variations. On the other hand, the ratios are negative and nearly unity for the harmonics 3 and 7, indicating that the augmentation takes place in the vertical component and the neutralization in the horizontal component. These effects are readily visualized from Figure 2, where it is shown that the internal portion contributes more to the horizontal component of the storm-field than does the external portion at about 50° geomagnetic latitude, while at about 60° geomagnetic latitude the internal portion actually over-neutralizes the external portion in its contribution to the vertical component.

At first sight the phenomenon exhibited by the harmonics 3 and 7 resembles a man's lifting himself by his boot-straps, so that there is need of considering the theory of induction of currents in a sphere. If the external harmonics of the storm-field are caused by systems of currents or their equivalents in the region about the Earth which develop and decay completely or nearly completely during the interval of the storm, then for a nearly perfectly conducting Earth the ratio (I/E) at the Earth's surface for the first harmonic will be nearly 0.50, approaching 1.00 for the harmonics of higher degree. These ratios imply that the vertical component of the external field is nearly completely neutralized by the vertical component of the internal field for all harmonics. A mathematical treatment of the problem of the induction of electric currents in a conducting, permeable sphere has been given by Chapman and Whitehead (Cambridge, *Trans. Phil. Soc.*, v. 22, pp. 463-482, 1922). For the determination of the ratio (I/E) they derive certain R-functions which contain the radius of the sphere, its permeability and conductivity, and the rate of change of the external harmonics. From a table appearing on page 477 of the paper cited they arrive at the conclusion (for the first harmonic) "that the internal component of the field may reinforce either the horizontal or the vertical component of the external field," depending on the rapidity of the change in the external field.

This table of Chapman and Whitehead indicates that the ratio (I/E) may vary between $\pm \infty$, although, as the writers

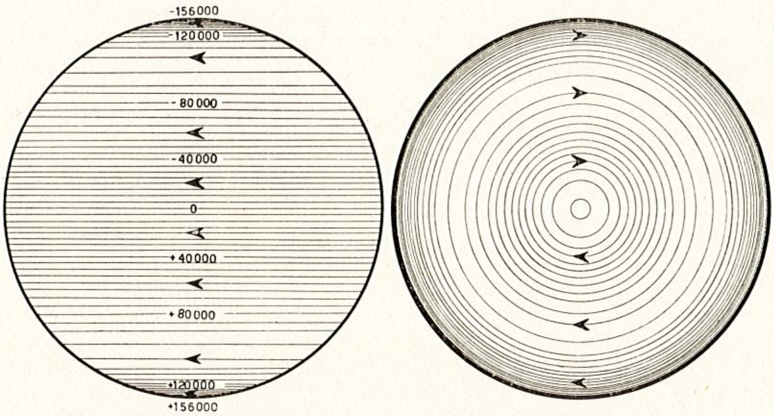


FIG.3A-VIEW FROM GEOMAGNETIC EQUATOR FIG.3B-VIEW FROM NORTHERN GEOMAGNETIC POLE

FIG.3-ISOMETRICS OF EQUIVALENT EXTERNAL CURRENT-FUNCTION IN AMPERES IN SPHERICAL SHELL 100 KM ABOVE EARTH'S SURFACE FOR MAGNETIC STORMS, DISTURBED MINUS QUIET DAY DIFFERENCES, 1927

point out, the boundary-conditions may be satisfied for the limiting ratio only if the field is entirely of internal origin. It seems to us that a negative ratio or a ratio greater than unity cannot be realized physically for the simple hypothetical form of the storm-field variations mentioned above. In more recent papers by Price (London, *Proc. Math. Soc.*, v. 31, pp. 217-224, 1929) and by Chapman and Price (*Phil. Trans. R. Soc.*, v. 229, pp. 427-460, 1930) it is pointed out that the conclusions reached by Chapman and Whitehead must be modified owing to their neglect of the initial conditions that the induced currents in the sphere must be zero when the time is zero. In the paper by Price it is pointed out that the value ∞ for the ratio (I/E) can never be physically realized owing to a finite limit approached by the combined fields due to the forced and free circulations within the sphere. It seems to us that the same considerations preclude the possibility of a negative value for the ratio (I/E), taken as the mean over the complete interval for a simple aperiodic fluctuation of E.

A different mechanism may be suggested for the negative ratio (I/E) obtained for the harmonics 3 and 7. If a given harmonic is built up in a circulatory system about a conducting sphere, a mode of circulation will be induced within that sphere such as to oppose the entry of the magnetic flux into that sphere, the induced circulation being entirely representable by the same harmonic. The ratio of the coefficients for the internal and external harmonics has its upper limit from 0.50 to 1.00, depending upon the degree of the harmonic. If through dissipation of energy the external harmonic decays at the same rate immediately after it has been built up, the internal harmonic will likewise decay. Assuming the conductivity of the

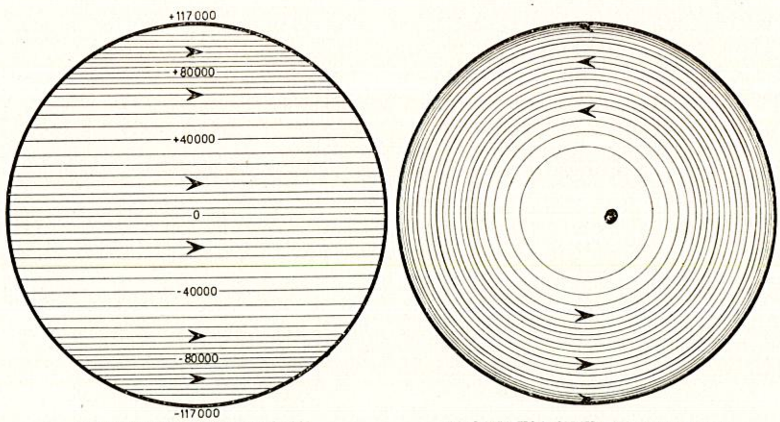


FIG. 4A–VIEW FROM GEOMAGNETIC EQUATOR FIG. 4B–VIEW FROM NORTHERN GEOMAGNETIC POLE

FIG. 4–ISOMETRICS OF EQUIVALENT INTERNAL CURRENT-FUNCTION IN AMPERES IN SPHERICAL SHELL 200 KM BELOW EARTH'S SURFACE FOR MAGNETIC STORMS, DISTURBED MINUS QUIET DAY DIFFERENCES, 1927

sphere to be sufficiently high, dissipation within it may be neglected, and the rate of change of the harmonic to be sufficiently rapid, the average value for the ratio (I/E) of the field at the surface of the sphere during the time the harmonic persisted will be approximately the same as its value at the time of maximum. If, however, energy is supplied to the external harmonic so as to sustain it, dissipation in the conducting sphere may not be negligible and at the end of a sufficient time only the external harmonic will be perceptible at the surface of the sphere. If at this time the energy-supply ceases and the external harmonic is permitted to decay, a harmonic will be induced in the sphere to sustain the magnetic flux which entered the sphere with the decay of the originally induced harmonic, and the sense of this second harmonic will be negative with respect to the first. If the rate of formation and of decay of the external harmonic is of a certain value, the mean value of the field at the surface of the sphere due to the external portion will have a definite value while that due to the internal portion will be zero, the contributions of the first and the second phases of the induction neutralizing each other. Thus, if the storm-field consists of both impulsive and sustained harmonics of the same degree, the impulsive harmonics being of one sign and the sustained harmonics of another, the ratio (I/E) for the mean value of the harmonics throughout the storm may be negative, the sustained and impulsive harmonics of the external field neutralizing each other in the mean. Such a situation might find its physical manifestation in a shifting of the auroral zone during the storm.

It must not be assumed that an explanation of the negative ratios is absolutely necessary as the values of the coefficients

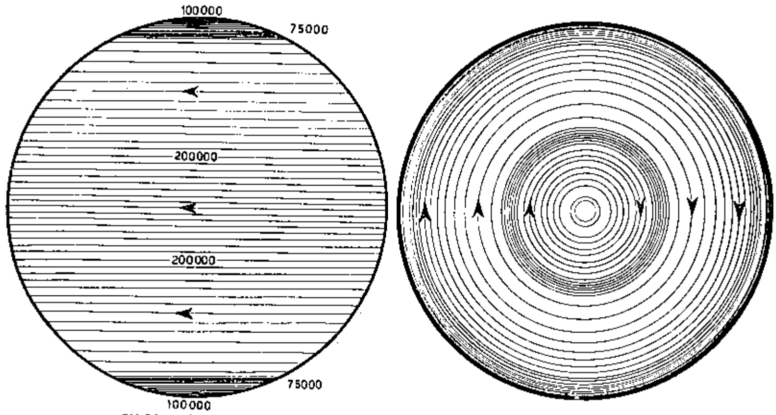


FIG.5A-VIEW FROM SUN FIG.5B-VIEW FROM NORTH POLE
FIG.5-CURRENT-SYSTEM FOR WORLD-WIDE COMPONENT OF MAGNETIC STORMS AS GIVEN BY CHAPMAN

obtained may be merely the result of the numerical adjustment due to the assumption that the field, both internal and external, is completely representable by zonal harmonics. The external field may be completely representable by zonal harmonics while the internal field may involve harmonics containing the geomagnetic longitude since the *Earth is not a uniformly conducting sphere,* although, as stated before, for a uniformly conducting sphere the induced field must be representable by the same harmonics as the inducing field.

Current-systems

Having the values of the coefficients for the various internal and external harmonics, charts may be constructed for current-systems in assumed regions which would produce the observed magnetic effects. Such charts are shown in Figures 3 and 4. In constructing the external current-system it was assumed that the current is confined to a very thin layer 100 km above the Earth's surface. In constructing the internal current-system it was assumed that the current is confined to a very thin layer 200 km below the Earth's surface. Although this assumption regarding the internal currents undoubtedly is an unreal one, the equivalent current-distribution in this hypothetical layer is of much interest. Three regions of maximal current are revealed in both the external and the internal systems — at the equator and near the auroral zones. In the external system the poleward maxima occur in about 70° geomagnetic latitude while in the internal system the poleward maxima are nearer the equator.

The individual current-system for a given instant of a magnetic storm undoubtedly is of much finer structure than the one depicted, which is the mean for a large number of disturbances during which the auroral zone shifted through a considerable distance. This shift of the auroral zone undoubtedly occurs and will form the basis for an interesting study. Many large magnetic disturbances at Cheltenham, which is ordinarily quite far from the auroral zone, exhibit magnetic phenomena which Birkeland has characterized as polar elementary storms.

The total current encircling the magnetic axis of the Earth from east to west in the mean external current-system is over 300,000 amperes while the current from west to east in the internal system is over 230,000 amperes. During the extreme intensity of the greatest magnetic storms recorded the currents probably exceed these figures by nearly two orders of magnitude.

For the purpose of comparison a diagram is reproduced in Figure 5 from the paper by Chapman previously cited. This is to be compared with Figure 3 of the present paper. Fairly good qualitative agreement between the two Figures is exhibited. In Figure 3 the current flowing between two of the isometric lines of the current-function is 5000 amperes, while in Figure 5 the current is 10,000 amperes. The reason for this difference is that Figure 5 is based on the maximal phase of a number of moderate magnetic storms while Figure 3 is, as previously noted, a mean current-system for the five most disturbed days of all the months of the year 1927.

Conclusion

The current-system derived from the spherical harmonic analysis of the disturbed-day minus quiet-day differences in magnetic intensity exhibits three regions of maximal intensity, near the equator and near the auroral zones. Fairly good agreement is noted between the system deduced and one previously deduced by Chapman without the use of formal analysis. The ratios of the internal to the external harmonics are not positive for all harmonics, indicating that the internal and external portions of the field are not both representable by the same harmonics, owing to the non-uniformity of the Earth's conductivity, or that the relationship between the external and induced internal portions is very complex.

One of the writers wishes to express his indebtedness to Dr. J. A. Fleming, Director, for making the facilities of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington available to him for study during his sabbatical leave from the University of Riga.

University of Riga (LS), Riga, Latvia,
Dep. Terr. Magn., (AGMcN), C. I. W.,
July 31, 1936.

THE ATTITUDE OF THE U. S. COAST AND GEODETIC SURVEY, WASHINGTON, TOWARDS FOUR BRANCHES OF INTERNATIONAL WORK IN TERRESTRIAL MAGNETISM

By J. HAWLEY

It seems well to state the attitude of this bureau towards international work in this field. There are four principal branches of the work in terrestrial magnetism in which it is primarily interested:

(1) Determination of magnetic secular variation. During recent years the Coast and Geodetic Survey has made original and repeat magnetic observations over an area nearly equal to 7½ % of the entire land area of the globe and has used standardized methods throughout.

The problem now is to find means, with limited personnel, to carry on the necessary repeat observations at regular intervals over this great area, and the specific problem is to continue this work without loss of efficiency but with a smaller number of stations.

(2) Magnetic Observatory instrumental work. The recent investigations, especially those at Cheltenham, have indicated the need of unceasing watchfulness and care in maintaining the required standards of accuracy. This is a matter, both of personnel and instruments. Improvement of instrumental results not only permits them to meet the need of investigation but reduces the work of the limited personnel at the observatories and also the very serious amount of work required to put the observations in form for students of the broader phases of terrestrial magnetism.

(3) Preparation of magnetic results for publication. The Coast and Geodetic Survey lacks only sufficient personnel to bring the records of its observatories up to date for the five observatories, which it keeps in continuous operation, but in view of the fact that the personnel is insufficient it believes that if possible the needs of investigators be reviewed so as to see whether the present information published is in excess of the demands.

Not only is it possible that the methods could be found for curtailing the necessary work but it may be that substitutions of other information for some of that now furnished might be desirable.

(4) The Coast and Geodetic Survey is interested in making a larger contribution towards the interpretation of the observatory results. With full recognition of the importance of the many lines of attack which are being undertaken by other organizations it still maintains that there is much valuable information to be obtained from existing records.

Therefore, owing to limited personnel it has made little contribution in this field but if the heavy load of carrying on magnetic and field observations and preparation of the results for publication could be curtailed in some measure it might become possible to do valuable work in this field.

All these activities are of course, part of the world-wide activities which are represented by the Association and comparatively little can be accomplished except by international agreement. It is felt that the Association could well give special attention to these subjects.

May 19, 1936.

NOTE SUR LES EFFETS DE L'ÉLECTRIFICATION DU CHEMIN DE FER PASSANT DANS LE VOISINAGE DE L'OBSERVATOIRE MAGNÉTIQUE DE COPENHAGUE

Par D. LA COUR et E. HOGE

Le chemin de fer passant près de l'Observatoire magnétique de Copenhague a été électrifié jusqu'à une station distante de l'Observatoire de 4 km env. L'énergie électrique nécessaire à la traction des trains est constituée par du courant continu qui passe par un conducteur aérien et retourne par les rails.

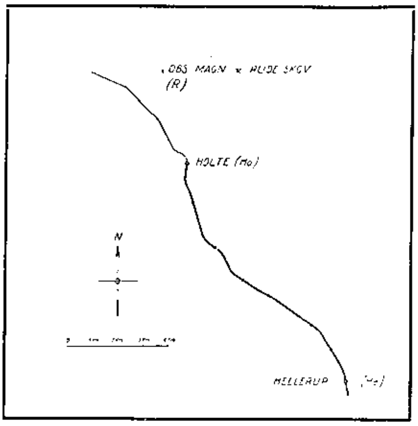


Fig. 1.

Les perturbations magnétiques dues à l'électrification de cette ligne ont heureusement atteint une grandeur beaucoup plus petite qu'on n'aurait pu le craindre. Dans la figure 1, Hellerup (He) et Holte (Ho) indiquent les deux terminus de la nouvelle ligne dont la longueur est de 10 km; R y indique la position relative de l'Observatoire, qui est séparé de Ho de 3.8 km seulement. Le courant électrique provient de deux transformateurs qui transforment des courants alternatifs à haute tension en courant continu de 1500 Volts et de 3000 Ampères maxima. Les deux transformateurs se trouvent l'un à He et l'autre à Ho.

On a commencé à utiliser le transformateur de He seulement; au cours de ces essais, des perturbations se sont montrées à l'Observatoire — surtout dans la force verticale. Les perturbations de cet élément atteignaient leur maximum (20γ env.) quand le train se trouvait à Ho (c. à d. près de l'Observatoire), et diminuaient graduellement quand le train s'approchait de He (voir fig. 2). Plus tard on a fait usage du transformateur de Ho seulement. L'effet de l'électrification fut alors le contraire. Les perturbations se manifestaient en sens inverse de ce qu'elles étaient auparavant; mais, ce qui était le plus frappant — au commencement du moins — c'était, comme on le voit d'après la figure 3, que l'effet était maximum quand le train était à

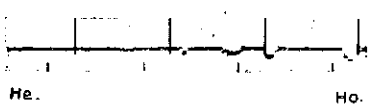


Fig. 2.

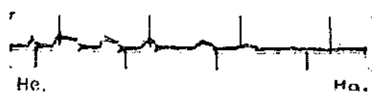


Fig. 3.

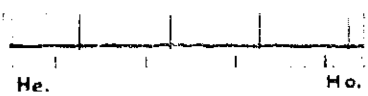


Fig. 4.

He et qu'il allait en diminuant quand le train s'approchait de l'Observatoire. Enfin, lorsque les transformateurs ont été utilisés tous les deux l'effet de l'électrification a pratiquement disparu comme le montre la figure 4.

Voici une explication probable de ces faits:

Supposons d'abord le transformateur T à He et le train en O, au milieu de la ligne (fig. 5). Le courant va du transformateur au train O par la ligne aérienne et retourne au transformateur par les rails non isolés (le sens du courant dans les rails n'est pas indiqué sur la figure). Or, pour faire passer un courant de, disons, 1000 Ampères dans les rails, il faut une certaine tension entre O et He, et cette tension donne aussi naissance à des courants vagabonds dans le sol. Imaginons que

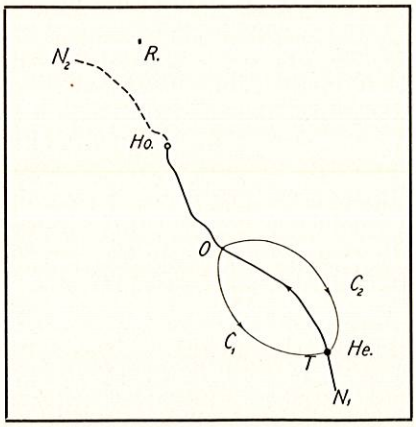


Fig. 5.

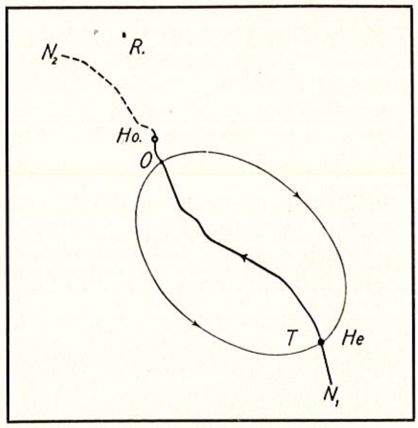


Fig. 6.

les courants près de la surface de celui-ci soient représentés schématiquement par les courbes C_1 et C_2, où le sens du courant est indiqué par une flèche (fig. 5). Dans ces conditions les forces magnétiques verticales, produites par les circuits TOC_1 et TOC_2, sont de sens inverses et il existe des courbes neutres N_1 et N_2 où la force verticale n'est pas perturbée quand le train se trouve à O.

La figure 6 montre les courants vagabonds probables quand le train se trouve près de Ho. La tension dans les rails entre le train O et le transformateur à He est alors augmentée jusqu'au double (si le courant est toujours env. 1000 amp.) et puisque les distances C_1 et C_2 sont aussi doublées les courants vagabonds ont gardé leur intensité. Il existe donc toujours des lignes neutres, mais comme l'Observatoire ne se trouve pas exactement sur une de celles-ci (d'ailleurs variable avec la position du train) les actions des aires plus grandes des circuits TOC_1 et TOC_2 ne se compensent pas, et on aura des perturbations assez grandes à l'Observatoire.

Les courants vagabonds pour le cas où le transformateur se trouve à Ho sont donnés par les figures 7a et 7b, qui montrent

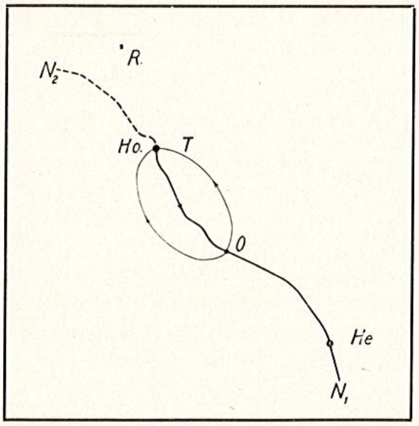


Fig. 7 a.

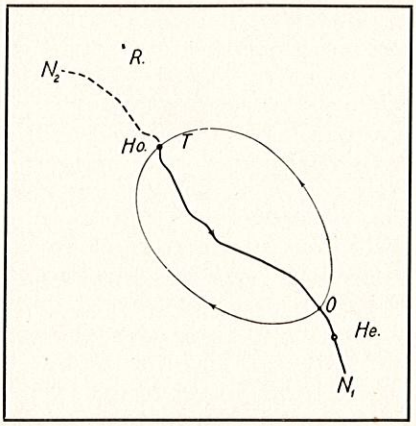


Fig. 7 b.

immédiatement pourquoi les perturbations à l'Observatoire sont les plus grandes quand le train se trouve près de He, c. à. d. le plus éloigné de l'Observatoire.

Les figures 8 et 9 se rapportent au cas actuel où les deux transformateurs sont en activité.

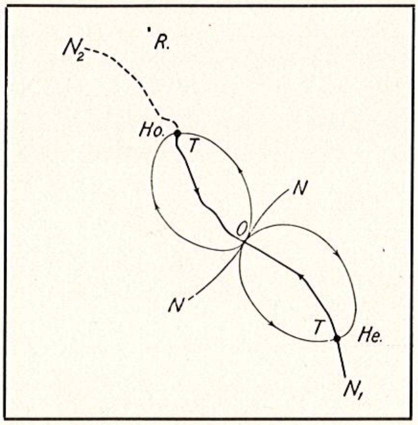


Fig. 8.

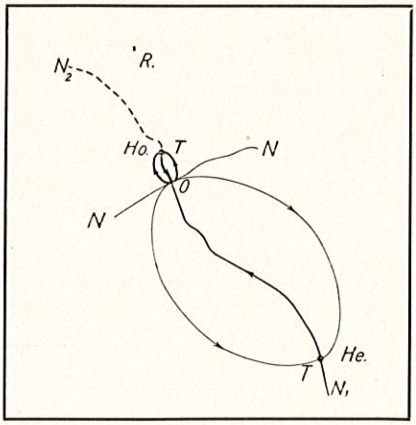


Fig. 9.

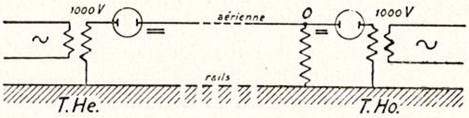


Fig. 10.

Quand le train (comme cela est indiqué sur la figure 10) se trouve près de Ho, le gradient de tension est beaucoup plus grand entre Ho et O qu'entre He et O; c'est pourquoi, c'est surtout le transformateur de Ho qui fournira de l'énergie au train. Il s'ensuit une répartition de l'énergie des courants vagabonds telle que celle qui est indiquée schématiquement sur la figure 9. Dans ce cas les grandes aires sont parcourues seulement par des courants faibles; de plus, la figure montre que les forces magnétiques produites par les courants des grandes aires sont opposées aux forces produites par les courants forts dans des aires petites.

On peut faire des remarques analogues relativement aux courants qui produisent des perturbations de la déclinaison et de la force horizontale à R.

Le résultat qui s'est montré si heureux, a été obtenu par hasard. A vrai dire, en vue d'éviter des perturbations à l'Observatoire de Copenhague nous n'aurions pas pu proposer un meilleur arrangement que celui qui est actuellement adopté. En donnant un compte-rendu de ces faits nous espérons que nos expériences seront utiles à d'autres qui seront forcés à s'intéresser aux perturbations magnétiques dues à l'électrification des chemins de fer de leur pays.

SUR L'EFFET DE L'ÉLECTRIFICATION DU CHEMIN DE FER HELLERUP—HOLTE PASSANT DANS LE VOISINAGE DE L'OBSERVATOIRE MAGNÉTIQUE DE COPENHAGUE

Par Edm. HOGE

Editorial note: Printed in *Communications Magnétiques, etc.*, No. 18, Danish Meteorological Institute, Copenhagen 1937.

DÉTERMINATIONS DE LA FORCE HORIZONTALE A L'AIDE D'UN QHM DANS LE VOISINAGE IMMÉDIAT D'UN CHEMIN DE FER ÉLECTRIQUE

Par Edm. HOGE

Editorial note: Printed in *Communications Magnétiques, etc.*, No. 18, Danish Meteorological Institute, Copenhagen 1937.

A YEAR'S COMPARISON OF TWO Z VARIOMETERS OF THE KNIFE-EDGE TYPE

By George HARTNELL

Introduction

The purpose of this paper is to describe the relative performance under observatory conditions, of two Z variometers of the knife-edge type, for a period sufficiently long to afford a satisfactory basis of comparison.

Instruments compared

The instruments compared were the Toepfer No. 5, made by Toepfer of Potsdam, and the la Cour Z variometer designed by la Cour of Copenhagen*). These two variometers were utilized in the paper entitled "A 42-Day Comparison of Four Vertical-Intensity Variometers of the Knife-Edge Type"**) where a more complete description of the magnet systems and details of mounting are given.

Brief Description of Variometers

Toepfer No. 5. — Suffice it to state that the Toepfer No. 5 variometer has a lozenge-shaped magnet about 10 cm long, which lies flat. It is provided with sensitivity and balancing poises, and is damped by copper boxes. Magnetic temperature compensation is used. The knife-edges are two fine pivots such as are used in delicate electrical meters, resting on agate planes. The magnet operates in air under ordinary conditions of room temperature and moisture, the magnet-house not being air tight.

La Cour Variometer. — The la Cour has a magnet of cobalt-steel, 6.4 cm long, the mirror, knife-edge and magnet proper being made from a single piece of steel. The knife-edge rests on two quartz cylinders. The variometer has two chambers. In the upper chamber is situated the temperature compensating device, which consists of a 45-degree prism suspended from a bi-metallic strip of silver and platinum. The magnet, which is undamped, operates in the lower chamber, which is evacuated to a pressure of about 10 mm. On account of the limited length of the bimetallic strip, the variometer was not completely compensated for temperature. Both the No. 5 and the la Cour were mounted in the same variation room, at a distance apart of 4 meters.

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*) Comm. Magn., etc., Danish Met. Inst., Copenhagen, 1930, No. 8.
**) Terr. Magn., vol. 41, 1936, pp. 65-73.

Hour selected for Comparison

The comparison is based on the scaling for some particular hour during the night when the magnetic elements are quiet and have the same values from day to day. As to the particular method of scaling, no difference was found whether the scaling was the average for the entire hour, or was for identical times. When disturbances existed, the nearest quiet hour was used, but this was seldom necessary. The 23-24 hour, Eastern Standard Time, was selected. Thus the variometers were compared at practically the same values of D and H. As a matter of fact, scalings were made at four hours each day, but of these only the 24th. hour fulfilled the condition for equality of D and H from day to day. The scalings were checked and corrected for shrinkage.

Level of Magnets

Effect of level. — If the magnets were not level, obviously any variations in the horizontal force in the direction of their axes would superpose additional effects on the true variation of Z. Thus the la Cour, with magnet pointing S. E. as referred to the magnetic meridian, would be affected by variations in both H and E intensities, that is, by variations in H and D. The Toepfer No. 5, with magnet pointing N, north end North, would be affected by variations in H alone. Since variations in H and E are of about the same magnitude at Cheltenham, the horizontal force was the same for both variometers.

Spurious effect. — If R is the resultant horizontal intensity along the axis of the magnet, and L the inclination,

$$\text{Spurious Effect} = R \tan L,$$

the sign depending on R and L. Taking R = 60 y, and L = 1°, the spurious effect would be one y per degree of inclination.

At Cheltenham, D reaches its minimum at 9 hrs. and its maximum at 14 hrs. H reaches its minimum at 11 hrs. and its maximum at 17 hrs. Hence a comparison of the two variometers for 10 hrs. and 24 hrs. when D and H are both low and high, should show a constant difference in the differences, provided both magnets are not out of level to the same extent and in the same direction. A comparison of the 12 hr. and 24 hr. differences for 95 days during June, July and August, 1935, showed that the absolute Z from the la Cour was 1γ less than that from the No. 5.

Experimental test of level

To test the level of each variometer magnet, an auxiliary magnet of known strength, say 7 to 8 thousand C. G. S. units, is placed with its axis in line with that of the variometer magnet, and at the same height. The auxiliary magnet was fastened on the base of a magnetometer having a horizontal circle, and could be leveled and reversed by turning the circle through 180°. Exposures on the gram were made for deflecting magnet north end N. (or north end pointing toward the variometer) and north end S., face marked "a" up. This was repeated for face "a" down. If L is the inclination of the variometer magnet, F, the field of the deflector, s, the scale values in gammas, and u is the deflection in mm.,

$$F = 2M/r^3 \text{ (or } M/r^3\text{, if magnets are perpendicular to line joing centers)}$$

$$\tan L = uxs/Fx10^5.$$

The individual deflections will show whether the north end of the variometer magnet is up or down. For example, if the positive direction of the field of the deflector points in the positive direction of the axis of the variometer magnet, an apparent increase in Z will indicate north end up. A field of 600 or 700 gammas is desirable.

Agencies affecting level

Secular change. — Even if the magnet of the variometer were exactly leveled, it would in the course of time get out of level, due to the secular change in Z. At Cheltenham where the annual decrease in Z is about 70γ, the change in level, for a scale value of 3.5γ, and 1 mm = 0.75′, would amount to 15′ per year.

Decrease of magnetic moment. — All magnets become weaker with age. Thus there would be an apparent decrease in Z, the positive ordinates on the gram becoming smaller. If magnetic compensation is used, the change of level is practically counteracted, since both the variometer magnet and the temperature compensating magnet weaken in the same proportion.

Diurnal variation. — The diurnal variation in Z changes the inclination of the variometer magnet, and so introduces a spurious effect. This effect, except under conditions of large variation and high sensitivity, may be neglected.

Temperature. — The largest effects on the inclination are caused by temperature changes, more particularly, by the annual temperature range in the variation room. For example, a temperature range of 20°, and a temperature coefficient of 17γ, will produce a change of level corresponding to 340γ. If the scale value is 3.4γ, and 1 mm = 0.75′, the change in inclination due to temperature is 1.25°. This applies to a simple uncompensated variometer.

We have to consider the temperature compensation method used. In the optical compensation, the inclination of the magnet is exactly the same as for an uncompensated variometer: changes due to temperature have their full effect. On the other hand, in the case of magnetic compensation, and also in the thermal expansion method, the inclination of the magnet remains unchanged, provided the compensation is complete. The magnitude of the level effects is proportional to the sensitivity of the variometer. The smaller the scale value, the greater is the range in ordinate and inclination, for a given variation in Z.

Results of level tests

The level tests showed that the inclination of No. 5 was 23′ north end up, and that the inclination of the la Cour was 38′, north end up, the relative inclination being 61′. Under these conditions, the effect of an increase in H (or R) of 60γ would be 60 x tan 1°, or 1γ, increasing Z for No. 5, and decreasing Z for the la Cour.

To see how the experimental results check up with the grams, the differences between the 12th. and 24th. hours were taken out for 95 days during the summer of 1935, when the average temperature was 25°. The test for level of the la Cour was made Apr. 2, 1936, at a temperature of 13°. The computed change in inclination due to 12° change in temperature was 58′. The relative inclination of the two variometer magnets would be 58′ plus 61′, or 2° nearly. The average difference in H for these two hours was 30γ. Hence the difference should be 30γ x tan 2° = 1γ. This was strikingly corroborated by the tabular differences between the 12th. and 24th. hours for the 95 days. The difference came out exactly 1γ.

Scale values

The scale values on both variometers were determined by a rectangular magnet as deflector, 23 cm long, magnetic moment 7400 units. The "B" position was used, that is, the deflector was vertical, in a vertical plane passing through the axis of the variometer magnet. The distance for No. 5 was 221.6 cm and 200.2 cm for the la Cour. Distribution effects were negligible, because of the ratio of the lengths of the magnets, and because of the long distances. The scale values are shown in table I.

Table I. Scale values
No. 5 and la Cour Z Variometers

Month	Scale Value No. 5	Scale Value la Cour	Month	Scale Value No. 5	Scale Value la Cour	Month	Scale Value No. 5	Scale Value la Cour	Month	Scale Value No. 5	Scale Value la Cour
1935	γ	γ	1935	γ	γ	1935	γ	γ	1936	γ	γ
Apr.		3.48	June		3.50	Aug.		3.54	Jan.		3.53
	3.90	3.47			3.51			3.54			3.54
May		3.46			3.50		3.93	3.55			3.53
		3.46			3.52	Sept.		3.55			3.53
		3.47		3.93	3.52		3.97	3.55		3.95	3.53
		3.48	July		3.54	Oct.		3.55	Feb.		3.53
		3.47			3.51		4.03	3.55		3.95	3.53
		3.48			3.54	Nov.		3.53	Mar.		3.54
		3.48			3.54			3.52		3.94	3.54
		3.47			3.52	Dec.	3.96	3.54	Apr.		3.55
		3.50		3.92	3.54	1936					3.57
	3.93	3.50			3.54	Jan.	3.95	3.54			3.57
June		3.50			3.54			3.54		3.91	3.55

Discussion of scale values

The scale values of the la Cour were especially satisfactory. There was a slight tendency toward increasing values during the lapse of time. It would appear that a cobalt-steel knife-edge resting on quartz cylinders is a very satisfactory combination for a knife-edge suspension. The scale values of No. 5 were not so uniform nor consistent, but yet very satisfactory when compared with the average knife-edge variometer. The scale values of the la Cour as shown by special deflections, were constant through the range covered by the gram, 2.5°. The la Cour is the only knife-edge variometer so far tested which has a constant scale value. This shows what may be accomplished by careful workmanship in shaping and grinding the knife-edge.

The No. 5 scale values, when plotted against ordinate, showed a parabolic curve, the change being, roughly, 0.2γ in a change of ordinate of 140 mm or 105′. For the small ordinates of No. 5, about 10 mm, this slight variation would produce no appreciable error in Z.

A good test for the performance of the knife-edge consists in making scale values with a short magnet, say 2.5 cm long, and M = 60, at two distances, say 30 and 40 cm, in the "B" position. The scale values will require a correction for distribution of the form $(1 - P/r^2)$. P is computed from the formula $P = \frac{3}{2} l_a^2 - 6\, l_s^2$, in which l_a is the pole distance of the deflector, and l_s is the pole distance of the variometer magnet.

The pole distance of a cylindrical magnet is 5/12 its length, and the pole distance of an elliptical or lozenge-shaped Z variometer is 2/5 its length. The interesting situation is this: When a magnet, suspended by a fiber, is deflected by a magnet, say 1/3 or 1/4 its length, the deflections for the "B" position will correspond to the theoretical value of P as given above. All the Schultze and Toepfer Z variometers in operation at the magnetic observatories of the United States Coast and Geodetic Survey, the variometer magnets being 10 cm long, show values for P ranging from 20 to 133, when deflected by a short magnet. On the other hand, two Z variometers, namely, the la Cour and the Askania, give the theoretical values for P. If these discrepancies are in some way caused by the knife-edge, deflections with a short magnet will provide a test of the quality of the knife-edge.

Shifts of zero

La Cour. During the entire period of the comparison no shifts or displacements of the zero of the la Cour variometer occurred, and no adjustments of any kind were necessary. Special test deflections for level were made on April 2, 1936. Deflections to determine change of scale value with ordinate were made April 3. Deflections with a short magnet were made April 25. The variometer was not displaced during any of these operations, which speaks well for its stability.

No. 5. Special scale value deflections on No. 5 to determine change of scale value with ordinate, were made March 11, 1936. During this operation the zero shifted 6γ. This was the only shift during the period of comparison.

Comparison of two fiber suspension H variometers

In order to form a reasonable estimate of the performance of the No. 5 and la Cour variometers, a brief comparison of two fiber suspension H variometers is here given. It has been thought that the differences noticed between Z variometers are due to the irregular action of the knife-edge caused by minute imperfections. Furthermore, it has been stated that filament suspensions, for example, two H variometers, would not show much differences. Fig. 1 shows a comparison of the H bifilar (silk fiber), and the unifilar H (quartz filament) at Cheltenham for the months of October, November, and December, 1935. The scalings were made on the 24th hour and all known corrections have been applied.

H is generally the most disturbed of the elements, and the sensitivity of the H variometer is usually greater than that of the D and Z variometers. Perfect agreement cannot be expected, even though the variometers are in perfect adjustment. Two instruments may differ in their response to variations, espe-

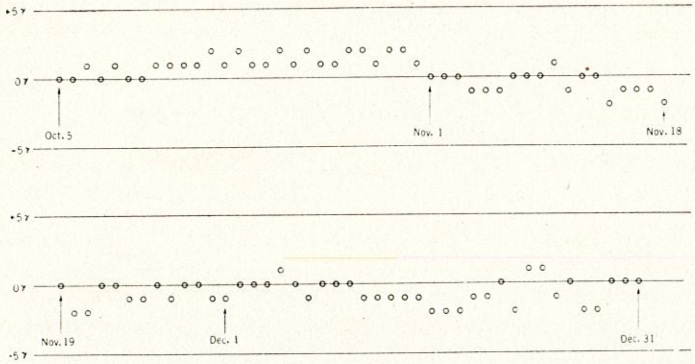


Fig. 1. — Comparison of Two "H" Variometers, Fiber Suspensions: "H" Adie, Bifilar, Silk, and "H" Toepfer, Unifilar, Quartz.

cially rapid variations. There may also exist actual differences in the elements recorded, even though the instruments are only a short distance apart.

The character of the H variations is well shown in Fig. 2, where two grams for the same day, September 29, 1934, are reproduced. One is reproduced by H No. 5, having a scale value of 0.4γ and the other by a special H bifilar, having a scale value of 0.4γ. Thus the H bifilar was eight times as sensitive as the other. It will be seen that minute variations are unrecognizable on the less sensitive gram: the average for short periods might not be the same.

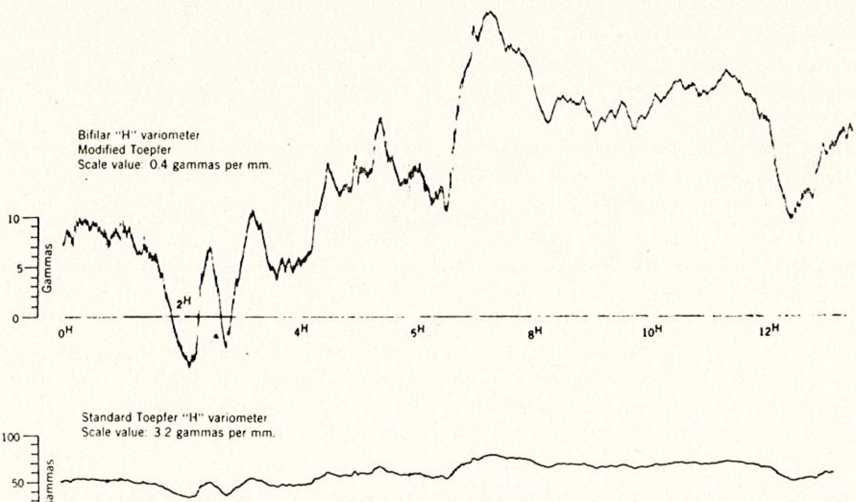


Fig. 2. — Comparison of Grams of "H" Toepfer No. 5, Quartz, and "H" Modified Toepfer Bifilar, Silk.

Operating conditions

La Cour Variometer. The magnet of the la Cour variometer operates in a vacuum, and as a further precaution, a tray of drier is placed in the magnet chamber. Under these conditions, the knife-edge is protected from dust, moisture, and absorption of gases.

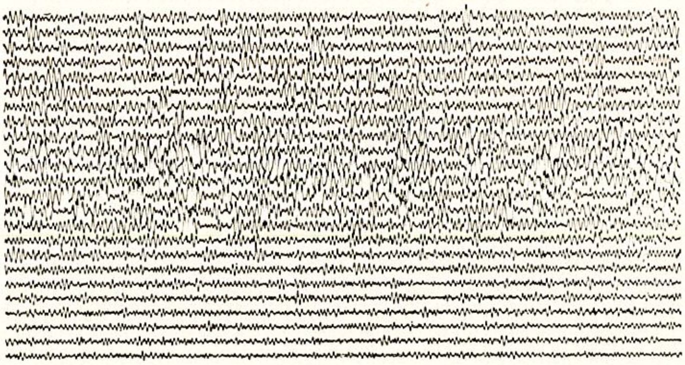


Fig. 3. — Ground Tremors or Microseisms, Magnification, 600.

No. 5 Variometer. The outside air has access to the magnet chamber through cracks around doors and other loose joints. If scale values are taken first in the normal position of the magnet and then repeated after the magnet has been deflected through a large angle, there is invariably a slight increase in sensitivity. Apparently, the knife-edge and planes become coated with some kind of film which is broken by a large deflection.

As is well known, the knife-edge variometer is very sensitive to jars and other mechanical disturbances. Another source of disturbance comes from tremors in the ground itself. No portion of the earth's surface is free from vibrations, as shown by seismometer records. Fig. 3 shows a portion of a gram recorded by a sensitive horizontal seismometer, magnification 600.

Method of comparison

In the comparison of the la Cour and the No. 5 variometers, the basic idea was a comparison of the grams under exactly the same conditions, or when the values of D and H are the same from day to day. The 24th hour fulfilled these conditions. The scalings were carefully checked, and are probably accurate within a gamma. The scalings in gammas were reduced to absolute Z.

For this reduction base-lines are required. Evidently, for a comparison involving differences of less than 5γ, base-lines obtained from earth inductors, especially where the Dip is high, would not be sufficiently precise. At Cheltenham, where the Dip is 71°, a change of 1′ means a change of 52γ in Z, or nearly 1γ per second. After a careful examination, it was concluded that the base-lines for both variometers were constant during the entire period of comparison, except when No. 5 suffered a small shift during some special deflections in April of 1936, near the end of the period.

The temperatures were derived from the curve on the gram according to the formula

$$t = 10.90^\circ - 0.392n$$

n being the ordinate measured from the base-line. There was every indication that the action of the bi-metallic strip was uniform throughout the range of 20° during the period.

The average value of Z in April, 1935, was 54080, and the average for Z for April, 1936, was 54050, thus indicating a secular decrease of 30γ. This is less than one-half the average annual decrease, which, for 26 years from 1902 to 1928, is 77γ.

The ordinates of Z No. 5 were small, about 15 mm in April, 1935, and 10 mm in April, 1936. Any possible uncertainty in scale value would have no appreciable effect. The la Cour ordinates in April, 1935, were about 25 mm, rose to 55 mm during the highest temperatures in August, 1935, and decreased to about 45 mm in April, 1936.

The temperature coefficient of No. 5 was zero. For the la Cour, 8.5γ was used. The base-lines were 54010 for No. 5, and 54210 for la Cour.

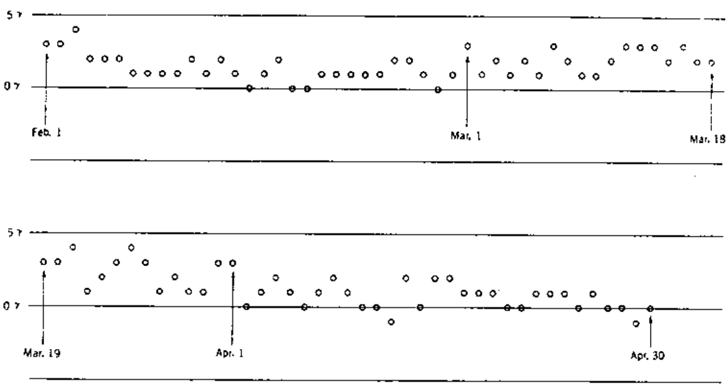


Fig. 4. — Comparison of Toepfer No. 5 (Q=0) and la Cour "Z" (Q=6.88).

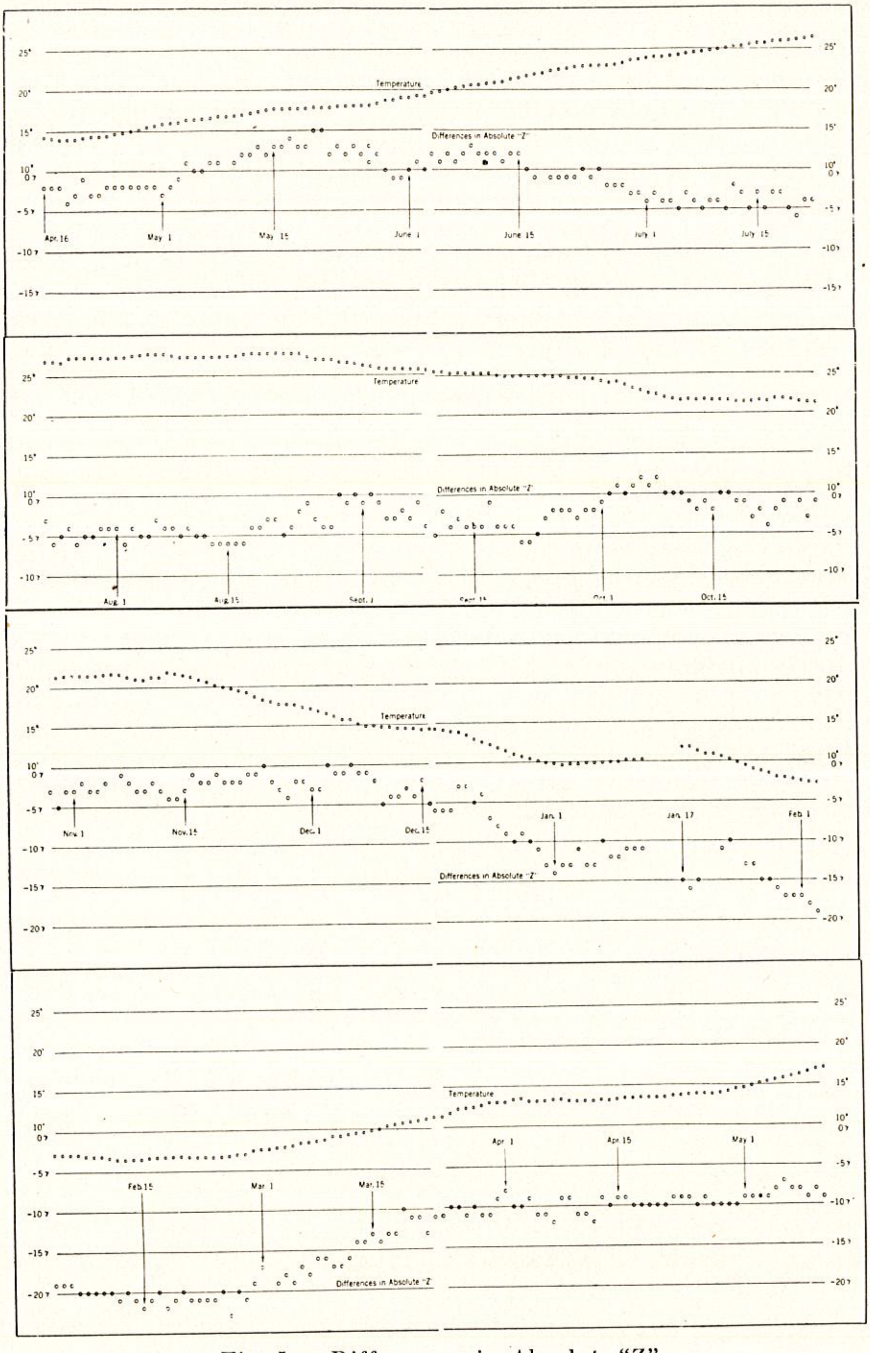


Fig. 5. — Differences in Absolute "Z"
Toepfer No. 5 (Q = 0) and la Cour "Z" (Q = 8.5).

The actual comparison consists in plotting the absolute differences in Z for the 24th hour of each day. On the same graph are shown the temperatures.

Discussion of the graph

Fig. 5 shows the individual differences of the two variometers in absolute Z at the 24th hour of each day. The differences are referred to a zero line, the points below the zero line indicating that the la Cour was lower than No. 5, and points above the zero line indicating that the la Cour was higher than No. 5.

Taking a general survey of the trend of the differences, there was an upward trend from May 1, 1935, to June 25. This was a period of rising temperatures, and one would look for a temperature effect of some kind, possibly involving a lag. It will be recalled that the bi-metallic strip of the la Cour is situated in the upper chamber of the variometer, at room temperature and pressure, while the magnet operates in the lower evacuated chamber. Also, the compensating magnet of No. 5 rests in a special holder below the magnet house. In either case, there might be a vertical gradient which would have opposite effects in the two variometers. However, a similar phenomenon was not noticed during falling temperatures. The interesting fact is that the trend cannot be eliminated by using another value for the temperature coefficient. From June 25 the differences were quite uniform until about December 12, 1935.

The question may be asked: Are these differences instrumental, or do they indicate real differences in Z at the stations occupied by the variometers? The evidence either way is not entirely conclusive, but it is safe to say they are not entirely instrumental. Since the variometers respond readily to forces of less than half a gamma, and show no permanent displacement after the field is withdrawn, certainly they can be depended on for variations of some 3γ.

Successive differences. Examining the differences from day to day, we note that two successive days seldom differ by more than two gammas. There was a change in the differences of 4γ August 28-29. This was apparently a temporary disturbance caused when the variation building was being wired for alternating current. September 17, 1935, was 3γ higher than the preceding and following days, and scalings for the intervening hours showed that the la Cour was higher during the entire day. On other days whenever the differences amounted to 3γ the scalings for the intervening 24 hours showed in every case a progressive change. This is an interesting fact, and tends to confirm the view of local differences in diurnal variations.

After December, 1935, we notice a conspicuous departure of the differences from their previous course. The differences were somewhat scattered from Jan. 11 to 21, 1936, when H No. 5 was being adjusted. This process required the use of electric lights and introduced some heat in the variation room as shown by the temperature curve, and emphasizes the importance of avoiding all disturbances and changes in operating conditions.

Continuing further, we notice that the differences follow the temperature coefficient. This was a puzzling phenomenon until it was discovered that the vacuum of the la Cour had been destroyed by a slow leak which began during the middle of December. Then a temperature coefficient of 6.88 instead of 8.50γ was tried. The results are shown in Fig. 4, which fully confirms the change in temperature coefficient. The explanation is that the temperature of the la Cour magnet when operating in a vacuum differed from that of the bimetallic strip which was at room temperature, but with no evidence of a lag as might be expected. In other words, the range of room temperature being 20°, the range of temperature of the la Cour magnet would be about 16°. At maximum and minimum temperatures, the temperature of the magnet would differ from that of the bi-metallic strip by 2°. Unfortunately, there was no thermometer in the magnet chamber to check this conclusion.

Attention is called to another interesting feature shown in Fig. 4. The average differences run higher than those before December by about 5γ. It seems that when the air filled the vacuum chamber of the la Cour there would be a loss of weight of the magnet due to buoyancy, and an apparent increase in Z. The effect computed from uncertain data was 8γ, which is in fair agreement with the observed results.

Summary

We have now compared two Z variometers of the knife-edge type for a period of some 385 days. Both of these variometers have given exceptionally fine performance.

The *Toepfer No. 5* has a comparatively heavy magnet, supported by instrument pivots resting on agate planes. It has all the accessories for balancing and sensitivity. Its temperature compensation by the use of auxiliary magnets has been very satisfactory. The magnetic and thermal expansion methods of temperature compensation have one great advantage in that the magnet maintains its level, and when once balanced and compensated, it is quite free from ex-level effects for a long period. The scale values of No. 5 were very satisfactory, but not all that could be desired; owing to the curvature of the knife-edges, they vary to some extent with ordinate. Very careful handling of the variometer is necessary to avoid shifts.

The *la Cour* has a comparatively light magnet of cobalt steel, the knife-edge being a part of the magnet and resting on quartz cylinders. It has no accessories for balancing, sensitivity and damping. Its scale values are wonderfully consistent, and are constant throughout the range of the gram. The optical compensation mechanism is more complicated than the other methods mentioned. Subjected to the full effect of temperature, the magnet, for a temperature range such as 20°, changes its level to such an extent that spurious ex-level effects are introduced. Its stability is exceptional; during a period of more than a year there were no shifts, and no adjustments were necessary. As regards the action of the knife-edges, more definite information might have been obtained had it been possible to operate the variometers at a sensitivity of about 2γ per mm.

The schemes of operating the magnet in a vacuum, thus eliminating moisture, dust and absorption, is fundamentally sound. There may be difficulty in maintaining a vacuum in a variometer, but the difficulty can be surmounted.

It is not unlikely that the Z variometer of the future will dispense with knife-edge suspension. Nevertheless, knife-edges are used in various other types of instruments, and will continue to be used in the future. Improvements in making knife-edges are possible and should be encouraged, and as seen in the comparison above, there is no better way of testing knife-edges than using them in Z variometers.

U.S. Coast and Geodetic Survey,
Washington, D.C., August 1936.

WORLD MAGNETIC CHARTS

By the U. S. Hydrographic Office
Navy Department, Washington, D. C.

The United States Hydrographic Office presents for the International Association of Terrestrial Magnetism and Electricity for the Edinburgh meeting in September, 1936, copies of its three world magnetic charts. These charts are constructed every five years and are designed primarily for the use of the mariner and aviator, and contain such data as are required for the correction of the ships' courses and for use in the practical compensation of the vessels' compasses. While good approximate values of variation, dip, and horizontal intensity may be obtained from these magnetic charts for scientific needs, yet it must be remembered that these charts are constructed solely for the use of the practical navigator at sea, hence there is shown a general smooth trend of the indicated curved lines of equal magnetic value.

Previous to the year 1900, difficulty was encountered in securing adequate magnetic observations and necessary material over the world seas, for construction, or correction of the magnetic charts to the required degree of accuracy. Numerous iron and steel ships in various localities of the world contributed the best results of their observations by swinging ship and other vessels of different types from all nations aided with many magnetic reports; however, the results were not always satisfactory and again large areas at sea remained untouched.

The Carnegie Institution of Washington, realizing that only a small part of the earth's surface was occupied by civilized nations and knowing that appropriations of money would not likely be made for magnetic surveys, undertook in 1904, a world magnetic survey. The ocean areas were included and three long voyages in the Pacific were made in the wooden brigantine *Galilee*. Later a special non-magnetic vessel, *Carnegie,* was built that sailed the world's seas on seven long successful voyages, supplying to all maritime nations on an equal basis the needed values of the magnetic elements for variation, dip, and intensity. They also occupied many repeat stations at sea for determining the amount of annual rate of change. Some idea of the magnitude of this work may be realized, when it is seen that they sailed over 400,000 nautical miles, circled the globe and covered all oceans from 70° N., to 60° S. Unfortunately, the *Carnegie* was destroyed in 1929 at Samoa. Since that date very few magnetic values have been supplied from ships at sea or from other sources, and magnetic charts require constant correction. Along the North Atlantic Lane Routes, values of variation are undergoing changes of one degree in eight years; in the South Atlantic a degree in five years and the same amount along the northern coast of South America. In the Indian Ocean the high rates of 12 to 14 minutes annually, show a rapid change in these isogonic lines in so short a period as three years.

Fortunately, the British Admiralty has completed the plans for a new brigantine-rigged non-magnetic ship, somewhat similar in design to the *Carnegie* and named the *Research.* This vessel is attached to the Admiralty Hydrographic Department and its first assignment in magnetic work will be in the waters of the southern Indian Ocean where values are needed. As oceanic areas are very large in extent and desired observations are many, there is also room for other nations to follow the example of the British Admiralty in the operation of magnetic vessels of this type for securing not only data on terrestrial magnetism, but at the same time data on oceanography, meteorology, and sonic soundings.

The world magnetic charts issued by this Office are:

H. O. Chart No. 2406, The Isogonic or Variation Chart
H. O. Chart No. 1700, The Isoclinic or Dip Chart
H. O. Chart No. 1701, The Isodynamic or Horizontal Intensity Chart

The Variation Chart shows lines of westerly variation over the waters of the earth for each degree in full lines and easterly variation in dashed lines. Over the land the variation curves are shown for every two degrees as an aid to the dirigible or aviator on flight courses. As a new feature, there is shown in red lines, the annual rate of change in minutes of arc for every locality. The full red line with plus numerals denote increasing variation and the dashed line with minus numerals denote a decreasing rate. There is also indicated for the first time the distribution and position of the different world magnetic observatories.

The Dip Chart shows lines of dip drawn for every two degrees both on land and sea. In the region of northerly dip, where the northerly needle end is drawn downward, the lines are full and for southerly dip, the lines are dashed. The rate of annual change in minutes of arc are indicated for all localities by figures in parentheses.

The Horizontal Intensity Chart is expressed in centimeters, gram and second units. The annual change is shown by figures in parentheses in units of the fourth decimal place, the plus sign denoting an increase in the annual rate value.

In the construction of the above described charts, the value of the magnetic elements were taken principally from the observations of the Carnegie Institution of Washington, and much information was supplied on the values for rate of annual change from data gathered by this institution. Other helpful aids on determining the annual rate of change were obtained from the repeat values at the different world magnetic observatories, and from the reoccupation of many repeat stations throughout the world. Advantage was taken of all exchange magnetic data from every foreign source, together with material from U. S. Naval Surveys, U. S. Army Engineers, and from the U. S. Magnetic Observatories and numerous repeat stations of the Coast Survey. In the vicinity of the poles, information obtained in the past from all Arctic and Antarctic expeditions of every nation were consulted.

PRELIMINARY SHORT REPORTS OF MAGNETIC AND ELECTRICAL OBSERVATIONS MADE IN THE FAR EAST DURING THE TOTAL ECLIPSE OF JUNE 19, 1936

By A. TANAKADATE

Editorial note:

The reports printed by the National Committee of Japan on Terrestrial Magnetism and Electricity were distributed as Document No. 41 at the Edinburgh Meeting. More explicit reports are printed in the *Japanese Journal of Astronomy and Geophysics,* 1937, Vol. XIV, No. 2.

A preliminary report on ionosphere observations in Peru and Australia during the eclipse of June 19, 1936 were presented at Edinburgh by L. V. BERKNER and H. W. WELLS for comparison with the data included in the reports from Japan.

LATEST ANNUAL VALUES OF THE MAGNETIC ELEMENTS AT OBSERVATORIES[a)]

Compiled by J. A. FLEMING and C. C. ENNIS

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
						c. g. s.	c. g. s.
Calm Bay	80°20′N	52°48′E	1933	21°10′.9 E	83°06′.7 N	.06598	.54611
			1934	21 27.8 E	83 08.0 N	.06567	.54529
Dickson	73 30 N	80 25 E	1933	28 31.6 E	83 05.0 N	.06971	.57430
			1934	28 29.4 E	83 06.8 N	.06909	.57208
Matotchkin Shar	73 16 N	56 24 E	1933	21 41.3 E	80 29.6 N	.09078	.54219
			1934	21 49.3 E	80 31.6 N	.09046	.54213
Tromsö	69 40 N	18 57 E	1930	4 07.7 W	....	.11567	....
			1931	3 59.6 W	77 02.6 N	.11548	.50198
			1932	3 49.0 W	77 05.8 N	.11499	.50195
			1933	3 37.3 W	77 07.7 N	.11472	.50203
			1934	3 25.9 W	77 10.0 N	.11441	.50223
			1935	3 14.3 W	77 12.6 N	.11407	.50246
Godhavn	69 14 N	53 31 W	1927	58 28.4 W	81 34.7 N	.08255	.55769
			1932	57 07.3 W	81 34.2 N	.08217	.55442
			1933	56 48.2 W	81 33.6 N	.08219	.55389
			1934	56 30.4 W	81 33.7 N	.08209	.55330
			1935	56 13.8 W	81 34.2 N	.08193	.55285
Sodankylä	67 22 N	26 39 E	1932	2 55.1 E	76 08.9 N	.12145	.49254
			1933	3 03.8 E	76 11.6 N	.12111	.49284
Lerwick[b)]	60 08 N	1 11 W	1932	13 46.1 W	72 43.5 N	.14495	.46608
			1933	13 34.0 W	72 44.6 N	.14477	.46605
			1934	13 21.9 W	72 48.4 N	.14463	.46744
Sloutzk (Pavlovsk)	59 41 N	30 29 E	1930	4 04.5 E	71 46.2 N	.15539	.47176
			1931	4 10.1 E	71 48.8 N	.15506	.47199
			1932	4 17.1 E	71 52.6 N	.15466	.47253
			1933	4 24.1 E	71 55.7 N	.15433	.47299
			1934	4 30.5 E	71 58.6 N	.15405	.47348
			1935	4 38.4 E	72 02.2 N	.15370	.47404
Lovö	59 21 N	17 50 E	1930	2 58.5 W	71 28.5 N	.15550	.46405
			1931	2 49.7 W	71 30.4 N	.15528	.46426
			1932	2 40.0 W	71 33.5 N	.15490	.46452
			1933	2 30.6 W	71 36.5 N	.15459	.46494

a) See also tables for previous and intermediate years in Terr. Magn., v. 4, 135; v. 5, 128; v. 8, 7; v. 12, 175; v. 16, 209; v. 20, 131; v. 22, 169; v. 23, 191; v. 25, 179; v. 26, 147; v. 27, 157; v. 29, 149; v. 31, 27; v. 32, 27; v. 33, 95; v. 35, 165; and C. R. Assemblée de Lisbonne, 1933; Union Géod. Géophys. Internat., Ass. Mag. Electr. Terr., Bull. No. 9, 213—218, 1934. Unless otherwise indicated, values are from continuous magnetograph records. Preliminary values, pending final reductions, are indicated by parantheses. Observatories marked by an asterisk *) are in regions of local disturbance.

b) Change to inductor standard in July 1935 produced discontinuity of +3′ in I and $+144\gamma$ in Z from January 1, 1934 as compared with published values for earlier years.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
				° ′	° ′	c. g. s.	c. g. s.
Sitka	57 03 N	135 20 W	1929	30 17.3 E	74 22.4 N	.15473	.55318
			1930	30 15.2 E	74 22.3 N	.15461	.55267
			1931	(30 13.1 E)	(74 21.5 N)	(.15454)	(.55194)
			1932	(30 10.9 E)	(74 21.0 N)	(.15450)	(.55150)
			1933	(30 08.5 E)	(74 20.5 N)	(.15450)	(.55118)
			1934	(30 05.6 E)	(74 20.5 N)	(.15454)	(.55129)
			1935	(30 02.7 E)	(74 20.1 N)	(.15450)	(.55090)
Sverdlovsk* (Katharinenburg)	56 50 N	60 37 E	1930	10 56.4 E	72 24.2 N	.16231	.51178
			1931	10 54.6 E	72 26.9 N	.16200	.51220
Wyssokaya Doubrawa	56 44 N	61 04 E	1932	12 49.9 E	72 08.6 N	.16312	.50634
			1933	12 50.0 E	72 11.5 N	.16279	.50676
			1934	12 50.4 E	72 14.4 N	.16248	.50727
			1935	12 51.5 E	72 17.7 N	.16210	.50781
Rude Skov	55 51 N	12 27 E	1932	5 39.9 W	69 23.1 N	.16855	.44805
			1933	5 29.6 W	69 25.0 N	.16839	.44838
			1934	5 19.3 W	69 26.9 N	.16824	.44875
			1935	5 08.8 W	69 29.6 N	.16804	.44927
Saimistsche (Kasan)	55 50 N	48 51 E	1930	9 06.8 E	70 36.3 N	.16982	.48238
			1931	9 07.3 E	70 38.6 N	.16939	.48215
			1932	9 09.3 E	70 42.9 N	.16892	.48272
			1933	9 11.3 E	70 46.5 N	.16856	.48336
			1934	9 13.3 E	70 46.5 N	.16830	.48441
			1935	9 15.4 E	70 53.2 N	.16790	.48460
Nijnedevitzk	55 33 N	33 21 E	1935	5 33.6 E	67 34.7 N	.18588	.45060
Eskdalemuir	55 19 N	3 12 W	1932	14 23.7 W	69 45.0 N	.16571	.44916
			1933	14 12.1 W	69 45.2 N	.16558	.44890
			1934	14 00.6 W	69 45.9 N	.16536	.44859
Meanook	54 37 N	113 20 W	1932	26 27.2 E	77 54.6 N	.12740	.59477
			1933	26 21.9 E	77 54.0 N	.12736	.59411
Hel	54 36 N	18 48 E	1934	2 35.5 W	68 25.2 N c)	.17563	.44384 c)
Stonyhurst	53 51 N	2 38 W	1932	13 28.0 W d)	68 48.0 N c)	.17176 d)	.44284 c)
			1933	13 16.5 W d)	68 49.0 N c)	.17169 d)	.44296 c)
			1934	13 04.9 W d)	68 49.0 N c)	.17163 d)	.44279 c)
			1935	12 53.2 W d)	68 50.7 N c)	.17148 d)	.44311 c)
Wilhelmshaven	53 32 N	8 09 E	1911	12 28.2 W	67 30.7 N c)	.18110	.43747
Zouy (Irkutsk)	52 28 N	104 02 E	1929	0 20.2 E	71 19.2 N	.19038	.56310
Potsdam	52 23 N	13 04 E	1929	5 47.8 W	66 48.6 N	.18442	.43049
Seddin	52 17 N	13 01 E	1931	5 28.9 W	66 49.8 N	.18450	.43106

c) Values from absolute observations only.
d) Values for five quiet days.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity	
						Hor. (H)	Ver. (Z)
	° ′	° ′		° ′	° ′	c. g. s.	c. g. s.
Swider	52 07 N	21 15 E	1931	1 49.1 W	67 03.2 N	.18463	.43608
			1932	1 39.9 W	67 05.7 N	.18438	.43639
			1933	1 31.9 W	67 09.3 N	.18420	.43724
De Bilt	52 06 N	5 11 E	1933	8 53.1 W	67 03.0 N	.18258	.43115
			1934	8 43.0 W	67 03.7 N	.18254	.43132
			1935	8 31.9 W	67 05.4 N	.18244	.43169
Niemegk	52 04 N	12 41 E	1932	5 26.3 W	....	....	....
			1933	5 15.1 W	....	....	....
			1934	5 05.2 W	66 46.9 N	.18491	.43106
			1935	4 54.9 W	66 49.4 N	.18477	.43159
Valentia[e] (Cahirciveen)	51 56 N	10 15 W	1932	17 05.4 W	67 58.5 N	.17809	.44024
			1933	16 54.5 W	67 57.9 N	.17811	.44005
			1934	16 43.7 W	67 57.5 N	.17812	.43993
Bochum[e]	51 29 N	7 14 E	1932	8 13.7 W	....	....	....
			1933	8 02.8 W	....	....	....
			1934	7 52.4 W	....	....	....
Abinger[e]	51 11 N	0 23 W	1932	12 02.6 W	66 39.1 N	.18536	.42940
			1933	11 51.7 W	66 39.4 N	.18532	.42942
			1934	11 41.1 W	66 39.7 N	.18533	.42955
Uccle[e]	50 48 N	4 21 E	1931	9 46 W	....	....	....
			1932	9 36 W	....	....	....
			1933	9 28.9 W	....	....	....
			1934	9 18.3 W	....	....	....
Hermsdorf	50 46 N	16 14 E	1929	4 10.6 W	....	....	....
Beuthen-Mikilow	50 09 N	18 54 E	1930	2 46.7 W	....	....	....
Janów	49 54 N	23 44 E	1933	0 06.4 E[f]	64 50.9 N[g]	.20110[h]	.42830[i]
			1934	0 12.7 E	64 53.9 N	.20081	.42863
Val Joyeux	48 49 N	2 01 E	1932	10 38.0 W	64 43.7 N	.19637	.41596
			1933	10 27.4 W	64 44.2 N	.19639	.41615
			1934	10 17.5 W	64 44.3 N	.19643	.41629
Maisach[e]	48 12 N	11 15 E	1932	5 59.3 W	63 39.8 N	.20299	.41005
Auhof (Vienna)[e]	48 12 N	16 14 E	1931	3 53.3 W	63 29.0 N	.20506	.41099
			1932	3 44.5 W	63 30.8 N	.20507	.41153
			1933	3 35.1 W	63 32.7 N	.20507	.41213
			1934	3 25.8 W	63 34.4 N	.20501	.41252
Munich	48 09 N	11 37 E	1926	6 54.7 W	....	....	....
Stará Dala (O'Gyalla)	47 52 N	18 11 E	1931	3 10.3 W	....	....	....
			1932	3 00.9 W	....	....	....

e) Succeeding Greenwich.
f) Seven months, May to December.
g) Not homogeneous.
h) Four months, September to December.
i) Three months, October to December.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
	° ′	° ′		° ′	° ′	c. g. s.	c. g. s.
Stará Dala (O'Gaylla)	47 52 N	18 11 E	1933	2 51.3 W	....	....	....
			1934	2 42.5 W	....	....	....
			1935	2 32.7 W	....	....	....
Nantes j)	47 15 N	1 34 W	1932	11 43.8 W	63 44.4 N	.20244	.41035
			1933	11 33.2 W	63 44.4 N	.20250	.41045
			1934	11 22.9 W	63 43.1 N	.20245	.40995
Tyohara	46 58 N	142 45 E	1933	8 36.8 W	60 41.3 N	.25035	.44591
Otomari c)	46 39 N	142 46 E	1932	8 38.5 W	....	....	....
			1933	8 40.8 W	....	....	....
			1934	8 43.9 W	....	....	....
Odessa	46 26 N	30 46 E	1923	1 52.9 W	63 11.9 N	.21267	.42098
			1924	1 44.6 W	63 15.1 N	.21246	.42154
			1925	1 36.4 W	63 18.9 N	.21213	.42206
Agincourt	43 47 N	79 16 W	1932	7 35.8 W	74 46.9 N	.15485	.56924
			1933	7 37.7 W	74 47.4 N	.15453	.56836
Karsani	41 50 N	44 42 W	1930	4 21.7 E	58 24.9 N	.24599	.40008
			1931	4 22.5 E	58 28.5 N	.24596	.40097
			1932	4 23.9 E	58 33.0 N	.24581	.40192
			1933	4 25.4 E	58 37.1 N	.24576	.40291
			1934	4 26.5 E	58 40.9 N	.24574	.40388
Tashkent	41 20 N	69 18 E	1930	5 30.8 E	....	....	....
			1931	5 27.4 E	....	....	....
			1932	5 25.3 E	....	....	....
			1933	5 23.7 E	....	....	....
			1934	5 19.9 E	....	....	....
			1935	5 17.2 E	....	....	....
Ebro (Tortosa)	40 49 N	0 30 E	1932	10 02.0 W	57 23.6 N	.23420	.36610
			1933	9 54.3 W	57 23.0 N	.23436	.36622
			1934	9 45.5 W	57 22.7 N	.23456	.36645
Coimbra	40 12 N	8 25 W	1931	13 45.5 W	57 52.2 N	.23196	.36931
Cheltenham	38 44 N	76 50 W	1931	7 00.0 W	71 09.0 N	.18543	.54316
			1932	7 03.7 W	71 10.9 N	.18487	.54248
			1933	7 (06.2)W	71 (12.8)N	(.18432)	(.54186)
			1934	7 (06.8)W	71 (14.2)N	(.18384)	(.54116)
			1935	7 (06.4)W	....	(.18335)	....
San Miguel* (Ponta Delgada)	37 46 N	25 39 W	1932	18 18.3 W	59 37.9 N	.23334	.39822
			1933	18 12.5 W	59 35.3 N	.23374	.39822
Zinsen c k)	37 30 N	126 38 E	1926	5 57.8 W	53 09.0 N	.30001	.40030
			1927	5 59.3 W	53 07.7 N	.29971	.39959

j) Electrical disturbances, especially in Z.
k) Zinsen series extended back to 1926 due to revised observed values; Z computed from I and H.

Observatory	Latitude	Longitude	Year	Declination (*D*)	Inclination (*I*)	Intensity Hor. (*H*)	Intensity Ver. (*Z*)
	° ′	° ′		° ′	° ′	*c. g. s.*	*c. g. s.*
Zinsen[ck)]	37 30 N	126 38 E	1928	6 00.8 W	53 12.8 N	.29965	.40074
			1929	6 02.4 W	53 16.1 N	.29923	.40099
			1930	6 03.8 W	53 07.9 N	.29831	.39777
			1931	6 03.9 W	53 11.7 N	.29866	.39915
			1932	6 04.1 W	53 12.3 N	.29975	.40076
			1933	6 03.7 W	53 13.0 N	.30027	.40162
			1934	6 05.8 W	53 12.7 N	.30027	.40155
San Fernando	36 28 N	6 12 W	1932	12 18.0 W	53 24.2 N[c)]	.25129	.33840
			1933	12 08.1 W	53 21.1 N[c)]	.25148	.33802
			1934	12 01.9 W	53 15.6 N[c)]	.25190	.33746
Kakioka	36 14 N	140 11 E	1931	5 42.8 W	49 27.6 N	.29734	.34765
			1932	5 44.3 W	49 28.7 N	.29722	.34773
			1933	5 45.5 W	49 28.7 N	.29723	.34775
			1934	5 47.1 W	49 29.5 N	.29720	.34788
Tsingtao	36 04 N	120 19 E	1932	4 32.1 W	52 05.1 N	.30892	.39662
			1933	4 34.1 W	52 05.2 N	.30901	.39675
			1934	4 34.9 W	52 05.1 N	.30919	.39697
			1935	4 36.6 W	52 05.6 N	.30923	.39714
Ksara	33 49 N	35 53 E	1934	1 40.7 E	....	....	....
Tucson	32 15 N	110 50 W	1929	13 45.7 E	59 34.6 N	.26496	.45111
			1930	13 47.6 E	59 36.2 N	.26444	.45080
			1931	13 (49.5)E	59 (37.5)N	(.26399)	(.45038)
			1932	13 (51.1)E	59 (39.2)N	(.26355)	(.45015)
			1933	13 (52.2)E	59 (39.8)N	(.26319)	(.44972)
			1934	13 (52.4)E	59 (39.8)N	(.26294)	(.44933)
			1935	13 (52.2)E	59 (40.4)N	(.26259)	(.44889)
Lukiapang[1)]	31 19 N	121 02 E	1929	3 35.8 W	45 25.5 N	.33269	.33766
			1930	3 35.8 W	45 25.3 N	.33262	.33755
			1931	3 35.3 W	45 23.2 N	.33306	.33758
			1932	3 34.9 W	45 24.4 N	.33316	.33792
			1933	3 35.4 W	45 23.7 N	.33329	.33791
Zô-sè	31 06 N	121 11 E	1934	3 24.6 W	45 30.9 N	.33254	.33858
Dehra Dun	30 19 N	78 03 E	1932	1 05.4 E	45 37.3 N	.33032	.33755
			1933	1 02.8 E	45 38.2 N	.33056	.33798
			1934	1 00.0 E	45 39.0 N	.33087	.33847
Helwan	29 52 N	31 20 E	1928	0 24.3 W	41 36.5 N	.30036	.26675
			1929	0 18.8 W	41 39.4 N	.30057	.26740
			1930	0 14.0 W	41 43.0 N	.30078	.26814
			1931	0 09.1 W	41 45.3 N	.30130	.26897
			1932	0 04.1 W	41 47.7 N	.30140	.26944
			1933	0 00.6 W	41 49.3 N	.30180	.27004
			1934[c)]	0 03.6 E	41 48.9 N	.30232	.27045

1) Succeeded by Zô-sè.

Observatory	Latitude	Longitude	Year	Declination (*D*)	Inclination (*I*)	Intensity Hor. (*H*)	Intensity Ver. (*Z*)
	° ′	° ′		° ′	° ′	*c. g. s.*	*c. g. s.*
Taihoku[c]	25 02 N	121 31 E	1930	2 09.2 W	....	....	....
			1931	2 09.6 W	....	....	....
			1932	2 09.6 W	....	....	....
			1933	2 09.9 W	....	....	....
			1934	2 09.8 W	....	....	....
Au Tau[c]	22 27 N	114 03 E	1931	0 43.3 W	30 34.4 N	.37522	.22164
			1932	0 43.3 W	30 33.1 N	.37545	.22161
			1933	0 43.0 W	30 32.4 N	.37546	.22151
			1934	0 42.3 W	30 31.5 N	.37557	.22145
Honolulu	21 19 N	158 04 W	1929	10 04.7 E	39 29.3 N	.28582	.23551
			1930	10 04.4 E	39 28.1 N	.28558	.23515
			1931	10 04.3 E	39 24.1 N	.28556	.23457
			1932	10 05.0 E	39 20.6 N	.28550	.23403
			1933	10 (06.0)E	39 (16.3)N	(.28543)	(.23339)
			1934	10 (07.7)E	39 (12.2)N	(.28544)	(.23283)
			1935	10 (09.7)E	39 (10.0)N	(.28534)	(.23244)
Teoloyucan	19 45 N	99 11 W	1932	9 30.6 E	47 02.1 N	.31102	.33394
			1933[m]	9 33.8 E	47 05.2 N	.31047	.33395
			1934	9 36.1 E	47 07.3 N	.31017	.33403
Alibag	18 38 N	72 52 E	1930	0 08.0 W	25 30.6 N	.37253	.17777
			1931	0 10.5 W	25 30.3 N	.37323	.17806
			1932	0 12.7 W	25 30.6 N	.37364	.17830
			1933	0 14.5 W	25 30.4 N	.37408	.17848
			1934	0 16.2 W	25 29.9 N	.37462	.17867
San Juan[n]	18 23 N	66 07 W	1926[o]	4 21.0 W	52 10.6 N	.27743	.35737
			1927	4 26.1 W[p]	52 14.0 N[q]	.27709[q]	.35764[q]
			1928[r]	4 35.5 W	52 20.8 N	.27645	.35828
			1929	4 41.9 W	52 24.4 N	.27558	.35793
			1930	4 50.5 W	52 (28.6)N	.27503	(.35813)
			1931	4 (58.8)W	52 (30.1)N	(.27451)	(.35777)
			1932	5 (06.5)W	52 (34.2)N	(.27397)	(.35794)
			1933	5 (13.0)W	52 (38.1)N	(.27350)	(.35817)
			1934	5 (19.7)W	52 (43.5)N	(.27322)	(.35898)
			1935	5 (25.0)W	52 (46.7)N	(.27290)	(.35926)
Antipolo	14 36 N	121 10 E	1928	0 26.6 E	15 50.4 N	.38220	.10844
			1929	0 26.2 E	15 47.6 N	.38238	.10815
			1930	0 26.7 E	15 47.0 N	.38253	.10813
			1931	0 27.5 E	15 48.2 N	.38276	.10834
			1932	0 28.4 E	15 48.8 N	.38286	.10844
			1933	0 30.1 E	15 48.6 N	.38285	.10841

m) No observations in March.
n) San Juan series extended back to 1926 due to revised observed values.
o) Values for April interpolated.
p) Mean of five months, January to May.
q) Mean of seven months, January to July.
r) Mean of eleven months, February to December.

Observatory	Latitude	Longitude	Year	Declination (*D*)	Inclination (*I*)	Intensity	
						Hor. (*H*)	Ver. (*Z*)
	° ′	° ′		° ′	° ′	*c. g. s.*	*c. g. s.*
Palau[c]	7 20 N	134 29 E	1932	2 03.6 E	....	....	....
			1933	2 05.7 E	....	....	....
			1934	2 06.1 E	....	....	....
Batavia[s] (Kuyper)	6 02 S	106 44 E	1929	0 54.0 E	32 13.6 S	.36821	.23212
			1930	0 54.7 E	32 16.7 S	.36846	.23273
			1931	0 58.2 E	32 19.4 S	.36863	.23325
			1932[s]	1 01.7 E	32 21.2 S	.36869	.23356
			1933	1 05.2 E	32 21.6 S	.36891	.23376
			1934	1 06.6 E	32 20.6 S	.37001	.23430
			1935	1 09.2 E	32 20.8 S	.37035	.23455
Huancayo[t]	12 03 S	75 20 W	1926	7 54.9 E	1 09.8 N	.29666	.00601
			1927	7 50.4 E	1 17.3 N	.29659	.00667
			1928	7 46.1 E	1 25.8 N	.29646	.00740
			1929	7 41.6 E	1 33.9 N	.29636	.00810
			1930	7 36.5 E	1 42.5 N	.29614	.00883
			1931	7 30.8 E	1 50.3 N	.29624	.00951
			1932	7 25.7 E	1 58.4 N	.29617	.01021
			1933	7 21.4 E	2 04.7 N	.29614	.01075
			1934	7 18.1 E	2 08.5 N	.29622	.01107
			1935	7 (15.2)E	2 (11.2)N	(.29612)	(.01130)
Apia	13 48 S	171 46 W	1932	10 36.5 E	30 13.6 S	.35116	−.20460
			1934	10 42.2 E	30 22.4 S	.35049	−.20541
Tananarive	18 55 S	47 33 E	1929	8 06.7 W	53 19.6 S	.21649	.29073
			1932[u]	8 22.0 W	....	.21412	.28986
			1933	8 20.0 W	....	.21386	.28934
			1934	8 24.0 W	....	.21326	.28382(?)
Mauritius	20 06 S	57 33 E	1932	12 28.4 W	52 42.3 S	.22642	.29726
			1933[v]	12 37.2 W	52 43.8 S	.22562[w]	.29649
			1934[x]	12 50.9 W	52 46.5 S	.22542	.29671
			1935	12 59.6 W	52 48.6 S	.22529	.29690
La Quiaca	22 07 S	65 35 W	1932	4 24.2 E	12 21.6 S	.26241	.05750
			1933	4 16.7 E	12 21.2 S	.26223	.05743
Vassouras	22 24 S	43 39 W	1930[y]	12 42.4 E	17 05.2 S	.24146	−.07422
			1931[z]	12 49.5 E	17 11.3 S	.24112	−.07459
			1932[aa]	12 57.1 E	17 20.6 S	.24072	−.07518

s) Kuyper values reduced to Batavia by absolute values at Batavia; values 1932 to 1935 are preliminary.
t) Huancayo values extended back to 1926 due to revised observed values.
u) Means for November and December only.
v) Eight months, January to August.
w) Discontinuity about 61γ, due to new collimator, in *H*.
x) Seven months, June to December.
y) March omitted.
z) May and June omitted.
aa) December omitted.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
	° ′	° ′		° ′	° ′	c. g. s.	c. g. s.
Watheroo[bb)]	30 19 S	115 52 E	1919	4 22.8 W	63 51.4 S	.24925	-.50780
			1920	4 22.1 W	63 54.7 S	.24889	-.50832
			1921	4 21.6 W	63 58.2 S	.24842	-.50865
			1922	4 20.9 W	64 01.0 S	.24799	-.50885
			1923	4 19.5 W	64 03.0 S	.24776	-.50914
			1924	4 18.2 W	64 05.2 S	.24750	-.50941
			1925	4 17.6 W	64 07.8 S	.24720	-.50997
			1926	4 17.2 W	64 10.8 S	.24680	-.51007
			1927	4 16.3 W	64 11.9 S	.24670	-.51030
			1928	4 15.0 W	64 13.7 S	.24656	-.51070
			1929	4 12.1 W	64 15.5 S	.24646	-.51116
			1930	4 08.0 W	64 17.7 S	.24634	-.51174
			1931	4 03.3 W	64 18.0 S	.24650	-.51218
			1932	3 58.4 W	64 19.1 S	.24651	-.51264
			1933	3 53.4 W	64 19.8 S	.24659	-.51308
			1934	3 47.8 W	64 20.1 S	.24669	-.51340
			1935	3 (42.5) W	64 (21.0) S	(.24672)	(-.51379)
Pilar	31 40 S	63 53 W	1932	6 11.4 E	25 53.6 S	.24607	-.11945
			1933	6 05.0 E	25 55.9 S	.24559	-.11942
			1934	5 59.0 E	25 59.2 S	.24516	-.11950
			1935	5 53.5 E	26 03.7 S	.24456	-.11961
Capetown	33 57 S	18 28 E	1933	24 39.9 W	....	....	....
			1934	24 36.6 W	....	....	....
Toolangi	37 32 S	145 28 E	1930	8 20.8 E	67 51.5 S	.22872	-.56208
			1931	8 24.9 E	67 50.8 S	.22884	-.56206
			1932[c)]	8 27.0 E	67 51.1 S	.22886	-.56226
			1933[c)]	8 34.3 E	67 50.1 S	.22894	-.56198
			1934[c)]	8 32.3 E	67 49.2 S	.22909	-.56193
Amberley[cc)]	43 10 S	172 44 E	1930	17 51.0 E	67 58.4 S	.22351	-.55246
			1931	17 54.4 E	67 57.7 S	.22360	-.55236
			1932	17 57.3 E	67 58.2 S	.22347	-.55227
			1933	18 00.2 E	67 58.7 S	.22339	-.55233
			1934	18 02.9 E	67 59.1 S	.22332	-.55229
			1935	18 06.3 E	67 59.7 S	.22317	-.55223

[bb)] Watheroo values extended back to 1919 due to revised observed values.
[cc)] Succeeding Christchurch.

SUR LA NATURE DES PERTURBATIONS MAGNÉTIQUES

Résultats préliminaires au sujet de quelques perturbations enregistrées pendant l'Année Polaire Internationale 1932-33

Par Mario BOSSOLASCO

Dans le but de pouvoir décéler la vraie nature des phénomènes qui composent la vaste classe des perturbations du champ magnétique terrestre il est avant tout nécessaire de connaître l'allure de ces perturbations sur la surface du globe. Sous cet aspect, le nombre relativement grand de stations magnétiques qui étaient en fonction pendant l'Année Polaire Internationale 1932-1933 rend les perturbations enregistrées dans cette période particulièrement importantes et bien méritables d'être étudiées dans les détails.

Or, parmi les perturbations qui se sont vérifiées pendant l'Année Polaire, l'orage magnétique à caractère mondial (et à début brusque) du 30 Avril 1933 est sans doute la manifestation la plus intense entre celles de ce type qui a eu lieu dans cette période. Il m'a donc paru intéressant d'entreprendre une étude détaillée sur cet orage en cherchant de rassembler, de réduire et de discuter un bon nombre des enregistrements obtenus par les stations magnétiques qui étaient en fonction à cette date. Une première partie de ce programme d'étude a déjà trouvé sa réalisation grâce à l'aimable mise à ma disposition de copies de ces enregistrements de la part des directeurs de plusieurs observatoires et auxquels je renouvelle ici mes vifs remerciements.

L'élaboration du matériel ainsi rassemblé sur cet orage magnétique du 30 Avril, quoique pas encore achevée, a déjà permis de déduire quelques conclusions intéressantes à propos desquelles je désire donner ici un très court exposé, en me réservant de développer ensuite cette étude lorsqu'il me sera possible de traiter dans une manière complète les différentes questions qui se posent en analysant un orage magnétique.

Les sujets considérés ici sont essentiellement deux: l'un regarde le vecteur qui définit l'*impetus* initial d'un orage magnétique, tandis que l'autre se rapporte aux perturbations spéciales dites »Bay-Störungen«.

1. Etant donné le nombre relativement restreint des enregistrements à marche rapide l'étude du vecteur *impetus* de l'orage du 30 Avril 1933 a été faite en utilisant toujours, dans l'intérêt d'uniformité, les diagrammes obtenus avec des enregistreurs à marche normale. Ainsi, en remarquant que l'orage magnétique en question a eu son début à peu près vers $16^{h}27^{m}.5$ T.M.G lorsque le soleil se trouvait au zénith le long du méridien de

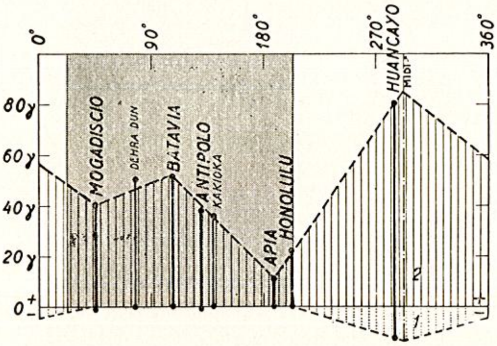


Fig. 1. — Intensité de la composante horizontale (ΔH) de l'*impetus* de l'orage magnétique de 30 Avril 1933 dans les stations équatoriales.

1 mm = 4γ

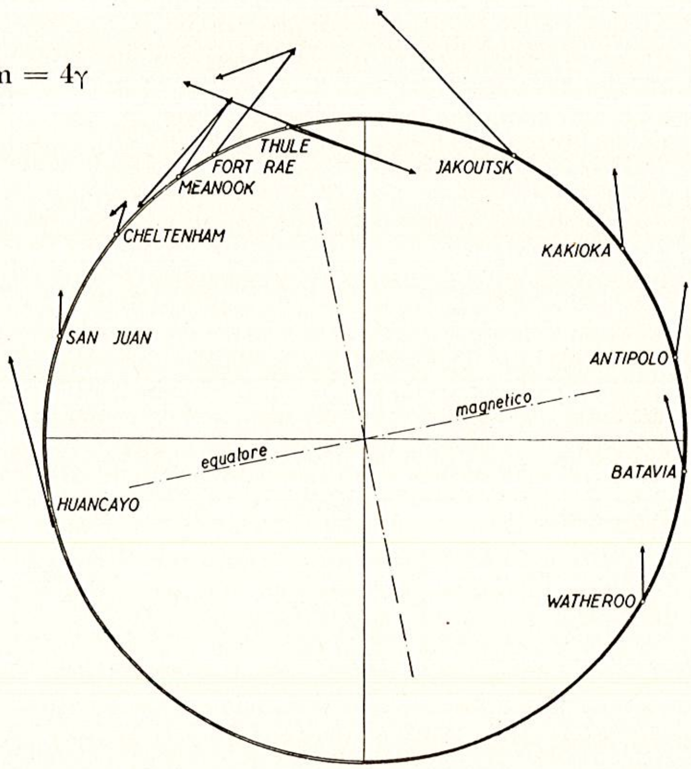


Fig. 2. — Allure de l'*impetus* de l'orage magnétique du 30 Avril 1933 dans les stations situées près du méridien qui passait par le soleil à l'instant du début de l'orage.

67°W de Greenwich et à la latitude de 15°N env., on a cherché l'allure du vecteur *impetus* sur le globe en tenant compte de cette position du soleil. Dans ce but on a représenté dans la figure 1 la variation du vecteur *impetus* avec la longitude telle qu'elle s'est vérifiée dans les stations équatoriales, ce que l'on a fait simplement au moyen des valeurs de ΔH; d'ailleurs, la figure 2 montre la distribution de l'*impetus* le long du cercle maximum de la terre contenant le méridien susdit de 67°W de Gr. déduite des diagrammes des stations situées dans la proximité de ce cercle et qui heureusement sont suffisamment bien distribuées.

Ces figures exigent quelques remarques. Avant tout, l'*impetus* d'un orage magnétique étant un vecteur variable avec le temps, on a été amené à le représenter seulement au moyen de ses valeurs extrêmes ou avec ses positions de changement de direction bien marquées; cela a toujours été limité aux premières dix minutes depuis le début de l'orage, parce que la variation rapide initiale du champ magnétique qui définit l'*impetus* en toute son intensité n'a jamais dépassé cette durée. De plus, en ce qui concerne la figure 2 les vecteurs représentés sont toujours l'image de l'*impetus* en vraie grandeur et non pas leurs projections sur le plan du méridien considéré, qui d'ailleurs ne diffèrent pas sensiblement l'un de l'autre, car les valeurs de la déclinaison et de la déviation latérale provoquée par la perturbation sont en général petites (la station de Thule exceptée).

Examinant l'allure de la variation de l'intensité de l'*impetus* sur le globe on voit que, pour l'orage magnétique en question, lorsqu'on exclut les régions polaires, le maximum de cette intensité se présente à la station de Huancayo, qui est en même temps la station la plus proche du méridien du soleil au zénith à l'instant du début de l'orage et qui est à peu près située sur l'équateur magnétique. En outre la figure 1, avec le maximum nocturne bien marqué pour ΔH, démontre que l'action du soleil, comme donnant origine aux perturbations par émissions de corpuscules électrisés, — en ce qui concerne l'*impetus* d'un orage — est influencée aussi directement par le champ magnétique permanent de la terre et s'exerce non seulement par propagation dans les couches ionisées qui enveloppent le globe. Sans discuter cette interprétation, on déduit encore de la fig. 2 que l'*impetus* tel qu'il s'est présenté vers la minuit locale se compose d'un vecteur dirigé dans une direction presque constante (pour chaque station), tandis que dans les environs du méridien qui passait par le soleil l'*impetus* se compose en général de deux vecteurs ayant des directions bien différentes ou presque opposées.

D'ailleurs, une exception à ce propos est fournie par la station de San Juan qui avait le soleil presque au zénith à l'instant du début de l'orage; cela est à rapporter à la circonstance que l'intensité de l'*impetus* a présenté sa plus petite valeur dans la région avoisinante et particulièrement au Nord, comme le prouvent les diagrammes des stations de Cheltenham et Agincourt. Quant à la station de San Juan il est aussi à remarquer que l'*impetus* s'est manifesté ici selon une direction azimutale qui diffère de 20° env. des directions des autres stations tropicales, tandis que ces dernières sont entre elles à peu près parallèles. L'explication de ces faits est à rechercher dans le caractère du système des courants électriques qui dominaient sur cette région lors du début de l'orage en rapport avec la charge des corpuscules émis par le soleil.

Enfin, l'analyse faite sur la durée de l'*impetus* a montré que dans les hautes latitudes le développement de l'*impetus* est sensiblement plus rapide que dans les régions équatoriales; naturellement il n'est pas toujours simple de définir avec précision et dans une manière uniforme la fin de l'*impetus*, tandis que d'un autre côté il paraît que l'inertie des aimants employés pour les enregistrements, qui sont encore de type trop différent entre eux, doit jouer un rôle non favorable pour ces comparaisons.

2. Dans la recherche entreprise sur l'orage en question on a étudié en détail l'allure des variations du champ magnétique relatives à toute la période entre le 28 Avril et le 5 Mai 1933. En conséquence, on a été amené à examiner aussi les trois «Bay-Störungen» (B.-S.) qui se sont présentées pendant les jours de: 30 Avril (entre 20^h et 22^h T.M.G. env.), 3 et 4 Mai 1933 (entre 18^h et 20^h T.M.G. env. tous les deux jours).

L'analyse de ces perturbations spéciales a conduit aux résultats suivants, valables vraisemblablement pour toute sorte de B.-S.

Le caractère essentiel d'une B.-S., tel qu'il est défini par le comportement du vecteur perturbateur, reste le même, soit pendant un orage magnétique (30 Avril 1933), soit dans les jours calmes ou presque calmes (3 et 4 Mai 1933); la seule différence est que dans le premier cas l'ampleur ou l'intensité de la B.-S. est nettement plus forte que dans les autres. En effet, l'étude de la variation du vecteur qui définit une B.-S. a montré que ce vecteur a en tout cas la tendence à décrire un plan (tandis que l'extrêmité du même vecteur décrit en général une courbe fermée sur ce plan). Dans une même station l'orientation de ce plan paraît être tout-à-fait indépendante des conditions orageuses du champ magnétique de la terre, tandis que l'inclinaison du plan de la B.-S. est variable avec le temps. Il s'ensuit que les actions qui provoquent une B.-S. doivent être de nature originairement différente et indépendante de celles qui donnent naissance aux orages magnétiques, tandis que ces dernières exercent seulement un effet de grossissement sur les premières. Enfin, contrairement à ce que l'on a affirmé récemment*) la propagation d'une B.-S. sur le globe doit se regarder comme tout-à-fait indépendante de la longitude, parceque on a clairement constaté que pendant une B.-S. les valeurs maxima du vecteur perturbateur se présentent dans toutes les stations dans le même instant (à une minute près, en raison des difficultés qu'il y a pour définir toujours avec la même exactitude ce maximum lorsqu'on utilise simplement les diagrammes ordinaires obtenus avec des enregistreurs à marche normale).

OBSERVATIONS OF HORIZONTAL FORCE WITH THE UNIFILAR MAGNETOMETER: THE P & Q COEFFICIENTS

By A. H. R. GOLDIE

Reference is made to the "P and Q Coefficients" in the report of the British National Committee [pp. 91-94 (a) and (b)]. The mean values of the P's and Q's at Eskdalemuir and Lerwick vary a good deal from year to year in a way that used to seem to be casual, but when the results for a series of years are considered it is seen that the courses pursued by the coefficients at the two observatories have a certain parallelism. The P's for Eskdalemuir and Lerwick are plotted in Fig. 1. Roughly the Q variation is opposite to the P variation in each case, so that we need consider only the P variation. If it were not that the Eskdalemuir and Lerwick curves move in opposite directions between 1928 and 1929 the parallelism is very nearly perfect. In fact the six years 1923 to 1928 show a linear relation. According to the observation books the Eskdalemuir collimator magnet received a "slight knock" in June 1928, and this, though it left the moment of the magnet unaffected, may conceivably have caused some real change in the distribution of magnetization. The Eskdalemuir value for 1929 was markedly displaced from the previously existing linear relationship with

*) *E. Wiechert:* Untersuchungen an Baystörungen unter besonderer Berücksichtigung der Störmerschen Theorie (Mitteil. der Geophysik. Warte Gr. Raum der Albertus-Universität Königsberg/Pr. Nr. 22, 1934, S. 9).

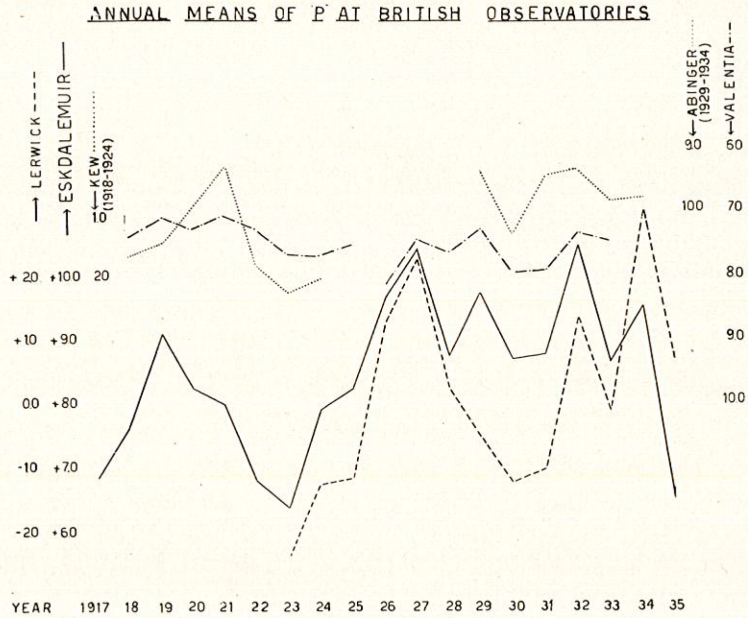


Fig. 1.

the Lerwick values; 1930, 1931 and 1932 showed some return and 1933 almost a complete return; 1934 and 1935 showed divergencies in the opposite sense. It has however to be remarked that since the middle of 1931 the number of three-distance deflection observations by the unifilar magnetometer has been reduced at both observatories to quite a small fraction of the number made in earlier years; on this account an increased scatter in the results would be not unlikely to arise.

The parallelism of the curves shows that an important part of the variations in the annual means of the distribution coefficients is due to a cause which is common to Eskdalemuir and Lerwick. Obviously it would be interesting to see whether other observatories show any similar effects. Valentia, Kew and Abinger have published values of the P coefficients but unfortunately no one of these observatories has a homogeneous series covering the whole period from 1917. Valentia has been in operation throughout the period, but prior to 1926 the method of calculation of the P coefficient was by overlapping seven-monthly means, so that without a fairly exhaustive recalculation it is only possible to get a somewhat smoothed curve for the period 1918-25; for the period from 1926 it is however possible to get data closely comparable with the Eskdalemuir data. These values, together with those of Kew for 1918-24 and Abinger for 1929-34, have been plotted also in

Fig. 1. It was obvious that these three observatories also showed a certain general parallelism in their data, but that the course of the P's at the southern observatories was practically opposite to that at Eskdalemuir and Lerwick. The data for the southern observatories have therefore been plotted with P increasing downwards as compared with the Eskdalemuir and Lerwick values. Though there are a few anomalies the many points of similarity in the curves of the five observatories in Fig. 1 cannot be dismissed as casual. There is relatively close correspondence between the curves for Valentia and Eskdalemuir from 1926, as close for example as we should find if we plotted annual means of wind speed for the two observatories. The movement of P at Eskdalemuir between 1928 and 1929, noted above as being at variance with that at Lerwick at the same time and as being possibly connected with an accident to the magnet, happens to be in harmony with the movement at Valentia. Curiously enough the Abinger magnet is noted as having been subjected to repolishing in August 1928 to remove rust; (and the mean values of P for 1928 and earlier years are not published) so that unfortunately there is no means of inquiring further into the 1928–29 changes.

Coming now to possible causes, the first cause likely to be common to the area of the British Isles is something connected with magnetic disturbance which, as is well enough known, adds to the uncertainties of absolute observations, particularly at the more northerly observatories. It is obvious that the extent to which H varies in the course of an observation is liable to affect the final determinations. At the same time none of the ordinarily employed measures of magnetic activity, or even, say the inequality ranges of quiet days, pursues for the different years a course exactly parallel to any one or to the mean of the curves in Fig. 1. This is the case even if we consider the absolute ranges only on the days on which absolute observations were actually made at Eskdalemuir. Further, the times and even the dates of observations at Eskdalemuir have differed from those at Lerwick and at the other observatories and it is scarcely to be expected that there should be a parallelism between five activity curves based on different short periods of time at five observatories. Other possible causes of spurious or non-magnetic effects, e. g. air temperature as affecting observations, have been examined, but without positive result.

SUR L'ÉTUDE DES PÉRIODES DES PHÉNOMÈNES MAGNÉTIQUES

Par H. LABROUSTE

I. — Madame Labrouste et moi avons continué l'étude des variations périodiques en magnétisme terrestre et notre attention a surtout porté sur les composantes diurne et semi-diurne de la déclinaison dont les variations de phase et d'amplitude ont été examinées dans le cas des jours calmes et dans le cas de tous les jours.

En particulier, les variations undécennales de ces grandeurs ont été comparées à la courbe undécennale de l'activité solaire Des différences marquées ont été mises en évidence entre les courbes correspondant à ces deux cas. Par exemple, si l'on considère la composante diurne, on constate dans le cas de tous les jours que la variation undécennale de sa phase est décalée par rapport à la courbe undécennale de l'activité solaire, tandis que les 2 courbes coïncident dans le cas des jours calmes.

Ces résultats ont été publiés et la bibliographie se trouve dans le rapport national français (p. 85).

II. — D'autre part, nous avons aussi ajouté quelques résultats théoriques relatifs à la méthode d'analyse par combinaisons linéaires des ordonnées publiée dans le *Terrestrial Magnetism*. Depuis la parution de ce Mémoire en mars et juin 1936, nous avons précisé quelques points nouveaux qui permettent d'énoncer les propriétés suivantes:

Si l'on considère une suite d'ordonnées équidistantes y d'un graphique, les combinaisons successives généralement utilisées sont équivalentes à une transformation sélective dans laquelle chaque ordonnée, désignée par y est remplacée par une somme de la forme:

$$\sum_{\mu=-m}^{\mu=+m} K_\mu y_\mu$$

On trouve que les meilleures conditions de sélectivité sont obtenues lorsque la courbe des coefficients K_μ, définie dans l'intervalle $-m$ à $+m$, représente un groupe (au sens où ce mot est employé dans la théorie de la dispersion) et quand la pseudo-période du groupe est égale à la période de la composante à isoler. On montre enfin que la sélectivité varie sensiblement comme la longueur du groupe.

SUR L'ÉTUDE DES RELATIONS ENTRE LES PERTURBATIONS DE LA RADIO ET LES PERTURBATIONS MAGNÉTIQUES

Par M. JOUAUST

Le comité français de radiotélégraphie scientifique a ouvert une enquête sur les phénomènes d'évanouissement (fading) qui ont été très nombreux en 1935-36. Ces évanouissements consistent en un arrêt complet des transmissions par ondes courtes, arrêt qui dure de quelques minutes à quelques heures. Ces évanouissements se produisent brusquement. On peut citer comme évanouissement typique celui qui s'est produit en 1936, le jour de l'éclipse solaire. De 16h à 18h (T. M. G.) les postes français ont dû écouler leur trafic sur ondes longues, pendant que les postes américains devaient envoyer leurs télégrammes pour l'Angleterre à Buenos Ayres qui les retransmettait à Londres. L'enquête a consisté à interroger les observatoires s'occupant d'astronomie solaire et ceux s'occupant de magnétisme terrestre sur les phénomènes qu'ils avaient pu constater dans les journées précédant ou suivant l'évanouissement.

A plusieurs reprises, des éruptions chronosphériques ont été constatées quelques heures avant l'évanouissement. Mais en général tous les évanouissements n'ont pas été accompagnés d'éruption et toutes les éruptions n'ont pas donné lieu à évanouissement.

Par contre tous les évanouissements se sont produits en période d'activité magnétique importante. Il y a donc peut-être dans l'étude des évanouissements un procédé permettant de discerner le rôle que joue la haute atmosphère dans la production des perturbations magnétiques. L'interprétation de ces phénomènes ne peut évidement être faite que par les physiciens spécialisés dans l'étude du magnétisme terrestre. C'est pourquoi, au nom du Comité français de radiotélégraphie scientifique, M. Jouaust propose à toutes les personnes que la question peut intéresser de leur communiquer les documents déjà rassemblés et ceux qui le seront dans l'avenir.

En terminant, M. Jouaust remercie M. le Directeur la Cour de tous les renseignements qu'il a bien voulu lui communiquer au cours de son enquête.

B. Ionosphere. Cosmic Radiation.

AUTOMATIC MULTIFREQUENCY TECHNIQUE FOR IONOSPHERIC MEASUREMENTS

By L. V. BERKNER, H. W. WELLS, and S. L. SEATON

Abstract: Advances in ionospheric research have necessitated the development of an automatic multifrequency equipment capable of continuous operation to obtain more complete data concerning the upper atmosphere. Such an equipment, as developed by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, is described. The problem involves recording of an essentially three-dimensional figure where virtual heights of all values of ion-densities change with time through the extent of the ionosphere. This figure is established by obtaining a series of cross-sections at regular intervals. Such sections are obtained from a record of the time-retardations of the reflections of a radio transmission as the frequency is swept through the requisite range. The frequency-range is 16.0 to 0.516 mc/sec. A sweep through this range is completed every 15 minutes. The receiver and transmitter operate from the same oscillator and on the same antenna. Tuning, accomplished by selected cams, is described. An antenna-coupling network to give reasonably constant output has been developed. Special attention has been given to the character of the emission so that the transmission has been proven to be entirely non-interfering. Sample records of the type obtained by this equipment are shown.

(I) *Introduction.*

Complete information regarding the state of ionization in the upper atmosphere is essential to an interpretation of many effects in the field of geophysics. The ionized regions of the upper atmosphere are involved in long-distance radio-wave propagation, in the short-period variations of the Earth's magnetic field, and in a large number of closely related geophysical and meteorological branches of science. There is some reason to believe that such a knowledge will yield the most effective information which can be obtained concerning changes in solar radiation. Furthermore, the ionosphere yields to the field of physics a fertile field for the investigation of the propagation of electromagnetic waves in a doubly refracting inhomogeneous medium. At normal incidence radio waves of different frequencies penetrate to levels of different ion-density. To obtain the distribution of ion-density with respect to height, the frequency of the exploring radio-transmission must be varied, continuously, through a wide range depending upon the limiting constants of the ionosphere. The ionization of the upper atmosphere undergoes rapid and irregular changes. Previous methods of ionospheric research have not provided the continuity and completeness of detail necessary to a most thorough understanding of these phenomena [see 1 of "References" at end of paper]. Such methods provide only for measurements or records on a single frequency, on a series of single frequencies by a cumbersome manual technique, or continuously over a restricted band of frequencies. An automatic, continuously recording, multifrequency equipment developed by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, has overcome most of these difficulties. Complete data are obtained with only the nominal supervision of an operator.

Such an equipment involves transmission through most of the useful radio spectrum and must possess the following characteristics: (1) Ability to record successfully without interference to or from existing radio services; (2) relatively uniform vertical radiation throughout the frequency-range; (3) automatic interlocking of transmitter- and receiver-tuning; (4) mechanical simplicity; (5) uniform limits of precision and resolution. Each of these factors inherently involves certain features of the others; a successful equipment must depend upon a series of compromises. The design of the equipment requires an understanding of these factors, and the utilization of methods and devices which permit the most satisfactory compromise.

(II) *General description.*

The equipment consists of a radio transmitter and receiver located together, both utilizing the same antenna-system and tuned circuits, together with a suitable recorder. The method is fundamentally that of Breit and Tuve [2] wherein a radio-frequency pulse of short duration is transmitted and the time-retardation of the reflections is recorded. The transmission-frequency is changed continuously so that a complete sweep through a frequency-range from 16.0 to 0.516 mc/sec is repeated every few minutes, providing a continual record of the constants of all regions of the ionosphere.

The general arrangement of the equipment is shown in Figure 1, which is a block-diagram showing the connections of the various units. This arrangement is necessary in

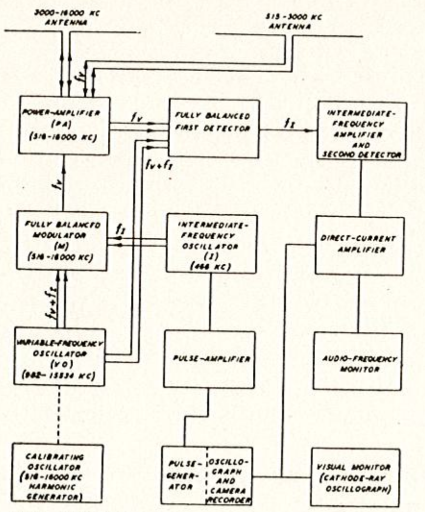


FIG. 1—BLOCK-DIAGRAM SHOWING CONNECTIONS OF UNITS OF AUTOMATIC MULTIFREQUENCY IONOSPHERIC EQUIPMENT (C.I.W., D.T.M. MODEL 3)

order that the transmitter and receiver be locked precisely in tune at all frequencies. A single variable oscillator serves for both the transmitter and the receiver, as suggested by Gilliland [3].

In describing the operation, let f_I be the frequency to which the intermediate-frequency amplifier is tuned and let f_V be the variable frequency radiated and received at the antenna. Then the variable-frequency oscillator (VO) will operate at a frequency

$$f_{VO} = f_v + f_I \qquad \text{or} \qquad f_{VO} = f_v - f_I \tag{1}$$

This oscillator excites the suppressor grids of the fully balanced, Class-B modulator (M). The control-grids of this modulator are excited by the intermediate-frequency oscillator (I), which has a fixed tuning, and operates at a frequency f_I which is identical to the frequency to which the intermediate amplifier is tuned. The output of the fully balanced modulator contains only the two side-band frequencies which are

$$f_{VO} + f_I \qquad \text{and} \qquad f_{VO} - f_I \tag{2}$$

The frequencies f_{VO} and f_I are completely suppressed by the fully balanced modulator.

The frequencies in the output-circuit of the modulator will then be, from equations (1) and (2)

$$f_{M1} = f_{VO} + f_I = f_v + f_I + f_I = f_v + 2f_I \tag{3}$$

$$f_{M2} = f_{VO} - f_I = f_v + f_I - f_I = f_v$$

These two side-bands f_{M1} and f_{M2} are therefore separated by an amount $2f_I$. The intermediate frequency f_I is approximately 500 kc so that the separation of the two side-bands is about 1000 kc. The side-band f_{MI} is readily suppressed in the tuned tank-circuit of the modulator which has a variable tuning and is adjusted to pass only frequency $f_{M2} = f_v$ to the power-amplifier.

The first detector, which is also a fully balanced modulator, is arranged so that it will pass no energy when the power-amplifier is excited, recovering in about 10^{-4} second after the excitation is stopped. These are tubes of the transmitter-type with the requisite grid-insulation and construction to withstand transmitter-voltages. The power-amplifier tank is tuned to frequency f_V and forms a tuned circuit for both the transmitter-output and the receiver-input.

The received signal is also of frequency identically f_v and is applied to the control-grids of the first detector. The second grids of these tubes are excited from the variable-frequency oscillator (VO) which also excites the modulator. Its output will therefore contain the frequency

$$f_{VO} - f_V = f_V + f_I - f_V = f_I \quad (4)$$

This is the intermediate frequency which is amplified in the usual manner by the intermediate-frequency amplifier. Inasmuch as all of the reflections which are recorded are received within 12 milliseconds after the transmitted pulse, the detuning effect in this time due to the changing frequency of oscillator (VO) is not serious. This factor does, however, limit the rate of sweep of frequency over the band, as is shown later.

To maintain the receiver and transmitter in tune, the only condition imposed is that the fixed-frequency oscillator f_I be tuned to the intermediate-frequency amplifier, a condition easy to fulfill.

The intermediate-frequency oscillator is "pulsed" through a keying amplifier by means of an electromagnetic device generating a sinusoidal pulse. This is generated by rotating a thin segment of "hypernik" through an unsaturated laminated "hypernik" core so that the flux in the core is changed for a short period as the segment is rotated through the core, in the manner of an ordinary electrical generator. A pulse is induced into a coil wound around this core. The intermediate-frequency oscillator operates only during the instant that the pulse is transmitted.

A fast automatic volume-control is incorporated in the intermediate-frequency amplifier which has a time-constant of about 10^{-4} second to prevent oscillations of excessive amplitude in the amplifier. In addition, a slow automatic volume-control, which integrates over 2×10^{-2} second, adjusts the sensitivity of the amplifier in accordance with the noise-level encountered, so that the records are not destroyed during periods of excessive noise. The equipment will record with a minimum input-signal of about 2×10^{-6} volt. A diode rectifier operates a fully balanced direct-current amplifier which in turn operates the oscillograph.

The general arrangement of the photographic recorder, shown in Figure 2, is similar to that described by Gilliland [4]. A permanent magnet, Dudell type oscillograph-element is used, although a cathode-ray tube could be used with equal facility. The galvanometer is normally operated with a bias such that the deflection is negative. The pulse merely reverses this bias so that the restoring force of the galvanometer assists in its initial acceleration, giving somewhat faster operation than with conventional operation, to provide for the short pulse-lengths used.

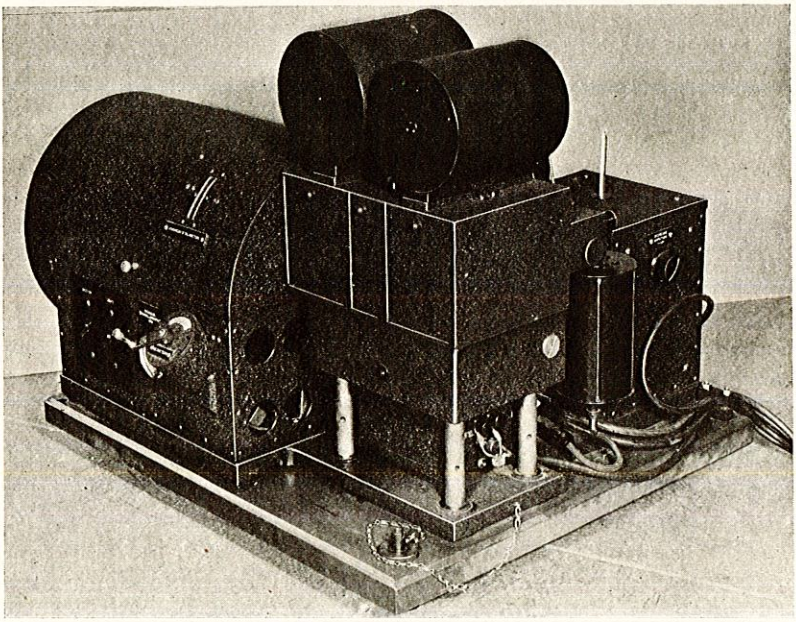


Fig. 2.— Photographic recorder for automatic multifrequency equipment.

The camera is driven by a synchronous motor and has an adjustable speed through a reduction-gear. Recording is done on photo-sensitized paper having a width of 12 cm so that scalings may be made without magnification of the trace. A vertical resolution of about 0.66 cm/100 km is ordinarily used. A speed giving about 60 cm of record per hour is found most useful. A spherical lens is included in the optical system which is focused on the recording slit of the camera. This lens is so placed that the oscillograph must deflect to about two-thirds normal amplitude before the beam falls on the lens; the last one-third of the deflection is focused on the recording paper. A resistance-capacity filter is placed between the output of the intermediate-frequency amplifier and the recorder, so that steady signals cannot deflect the element more than one-half normal amplitude. In this way much unwanted interference is avoided as it does not reach the spherical lens.

Successful recording is accomplished because reflection-patterns are not random and form a coherent trace on the paper; noise and modulated interference, which pass the filter, are random and therefore incoherent on the record, merely causing some fogging. Recording is possible at all times even though the received low-level pulses may be entirely inaudible through the noise, such as experienced during local thunder-storms.

(III) *Factors of design.*

Before discussing the automatic features, certain factors controlling the design must be considered. A pulse-duration of about 100 to 200 microseconds is used. This is necessarily a compromise; the maximum length is limited by the resolution required between reflections arriving at nearly the same time as is often the result of double refraction (vertical resolution); the minimum length is limited by the band-pass restrictions on the intermediate-frequency amplifier determined by the limitations of incoming interference, by the required fidelity of reproduction of reflection, by the necessity for restricting the frequency-spread of transmitted side-band energy to prevent interference to other services, and by the requisite resolution of critical-frequency phenomena which become indistinct when the radiation embraces too wide a band of frequencies (horizontal resolution).

The minimum time of sweep through the band is controlled by the pulse-frequency, the width of the band, the allowable frequency-change between pulses, and the allowable detuning of the receiver from the transmitted frequency between pulses. To sweep the required frequency-range in time, T, the frequency must be changed by an amount, Δf, between pulses. If N pulses are transmitted per second, the time between the commencement of successive pulses is given by $\Delta t = 1/N$. Suppose the frequency, f, at any time during the sweep to be defined by a function

$$f = F(t) \qquad (5)$$

Then

$$\Delta f = \int_0^{\Delta t} dF(t) \qquad (6)$$

The most general expression for F(t) must involve the determination of three constants depending upon the limits of the frequency-range to be swept and the permissible time-rate of change of frequency. Two of the necessary equations are formed by substituting in equation (5) the value f_{max}, the highest frequency, and f_{min}, the lowest frequency of the range. The assignment of values to Δf_{max}, and Δt_{min} yields a third equation

$$(df/dt)_{max} = \Delta f_{max}/\Delta t_{min} \qquad (7)$$

The minimum time required for a sweep therefore depends upon the values assigned to f_{max}, f_{min}, Δf_{max}, and Δt_{min} for any form of F(t).

The upper limit of the frequency-range must be a frequency above which it is improbable that reflections will be returned at vertical incidence. Reflections have been observed at frequencies up to about 14 mc/sec on unusual occasions. At night, reflections can be observed on indefinitely low frequencies, although the reflections are observed usually from the 100-km level on a frequency of about 0.5 mc/sec. Because of the location of the international distress-band on this latter frequency, the frequency-band of 0.516 to 16.0 mc/sec has been selected.

For a given band, equation (7) must be maximized for the most rapid sweep. The value of Δt is limited, however, by consideration of interference to existing services. Pulse-frequencies over 20 per second constitute a coherent sound, and, as a consequence, N must be limited to about ten pulses per second.

While the maximum value of Δf_{max} must be kept low to prevent progressive detuning of receiver, this is not ordinarily a limiting factor. To properly define the complex pattern of a critical frequency at low frequencies, such as frequently observed in a band of 50 kc, about 100 discrete pulses are required. This requires that Δf be about 0.5 kc/sec/pulse at low frequencies. This requirement is not so severe at the higher frequencies, because of the broader character of the critical frequencies. Here a value of about 3.0 kc/sec/pulse is acceptable.

The rate of frequency-change must allow the production of a trace which is satisfactory for scaling. If the percentage accuracy of the scaling is to be constant, the frequency must be changed along a record moving at a uniform velocity by

$$q \log f = l \qquad (8)$$

where q is a constant and l is the distance along the recording paper. Let p be the percentage accuracy of the frequency which should correspond to an uncertainty of l′ as scaled on the record. Then

$$\log (1 + p)f - \log f = (1/q)\ l' .$$

from which

$$q = l'/\log (1 + p) = l'/(1 + p), \text{ where p is small} \qquad (9)$$

Then

$$l = [l'/(1 + p)] \log f_{max}/f_{min} \qquad (10)$$

This expression gives the length of record such that the uncertainty of frequency corresponds to the uncertainty of scaling. Assuming that the frequency-stability of a well-designed oscillator is 0.2 per cent when operated over long periods of time, and that the record can be measured to 0.1 mm, length of record of about 15 cm is necessary from the above expression to provide the necessary accuracy in scaling a single sweep of the frequency-band. When the light-beam is sufficiently narrow to delineate complex patterns, not less than 300 pulses/cm are necessary to completely expose the recording paper. The minimum time for the entire sweep for proper film-exposure, horizontal resolution, and accuracy of scaling is therefore limited to about 7.5 minutes for N = 10. The maximum value of Δf must be consistent with this minimum time.

It is not practical to use the ideal law for frequency-change given by equation (8). Not only must the absolute value of frequency be measured, but also the difference-frequencies, as is the case in measuring the separation of critical frequencies due to double refraction. Because of the tendency of an oscillator to drift off frequency in the same direction throughout the band due to some single cause, the relative separation of two adjacent frequencies is known to a much greater accuracy than the precision of the absolute frequency. It is desirable that frequency-separations be measured with approximately the same accuracy over the whole scale. For this purpose, a linear frequency-scale would be most suitable. Such a scale would have the following disadvantages: (1) Non-uniform absolute accuracy; (2) crowding of frequency-scale below 2000 kc where reflections are observed at practically all times, while expanding the high-frequency scale where reflections are observed only during exceptional conditions, leaving much unused film under ordinary circumstances; (3) requires too much time per sweep if necessary accuracy of scaling is to be obtained at low frequencies; (4) increases difficulty of the problem of design as made clear in subsequent discussion.

A square-law scale is a logical compromise between the two extremes. Such a scale leaves the higher frequency-scale sufficiently open to observe unusual conditions with some accuracy, and at the same time yields the requisite accuracy at the lower frequencies where reflections are always observed. The frequency-sweep is made to travel from high to low frequencies to eliminate certain mechanical difficulties in the equipment attendant on tuning of antenna and is expressed by

$$f = k[(T - t) + c]^2 \qquad (11)$$

With the values of f_{max} = 16.000 kc/sec, f_{min} = 516 kc/sec, N = 10 pulses per second, and $\Delta f_{max} = 3.0704$ kc/sec, the constants evaluated from equations (6) and (7) are

$$
\begin{aligned}
kc^2 &= 516 \\
k(T + c)^2 &= 16.000 \\
2k(T + c) &= 30.704
\end{aligned}
\qquad (12)
$$

for which the solution is T = 855 seconds, k = 0.014731 kc/sec, and c = 187.18 seconds.

The entire frequency-range from 516 to 16,000 kc is divided into six bands, each requiring 142.5 seconds to traverse, with 7.5 seconds between bands for switching. Thus one sweep requires just 15 minutes for completion. During the switching period, no pulses are emitted. These bands, as determined from equation (11), are given in Table 1.

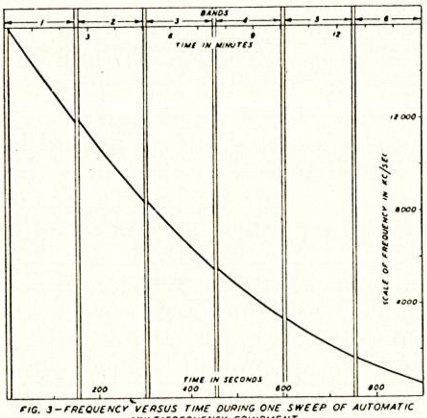


FIG. 3—FREQUENCY VERSUS TIME DURING ONE SWEEP OF AUTOMATIC MULTIFREQUENCY EQUIPMENT
(NOTE: A 7.5-SECOND INTERVAL FOR SWITCHING OCCURS BETWEEN EACH BAND)

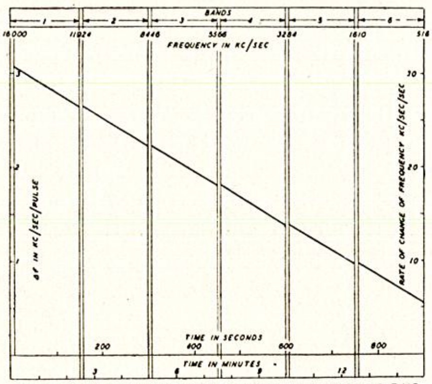


FIG. 4—RATE OF CHANGE OF FREQUENCY VERSUS FREQUENCY AND TIME AND VALUES OF Δf FOR 10 PULSES PER SECOND

Table 1 — Frequency-bands

Band	Frequency-range in kc
1	16000 to 11924
2	11924 to 8446
3	8446 to 5566
4	5566 to 3284
5	3284 to 1610
6	1610 to 516

Figure 3 shows the value of frequency at any time during the frequency-sweep. Figure 4 shows the rate of change of frequency with respect to frequency or time, and the change in frequency in kilocycles per pulse at any frequency in the range. Selection of these bands is based upon the engineering requirements of condenser-tuned circuits. Ordinarily, the frequency-range of such a circuit is limited to about 3 to 1. If the output is to be maintained reasonably uniform, the squared-frequency scale lends itself to the most economical selection of bands.

(IV) *Mechanical control.*

Figure 5 shows that only four variable tuning-controls are required for both the transmitter and receiver. These are variable capacitors in each case. Associated with each variable tuning-control is a selector-switch which introduces the proper values of L and C into the circuit for each band.

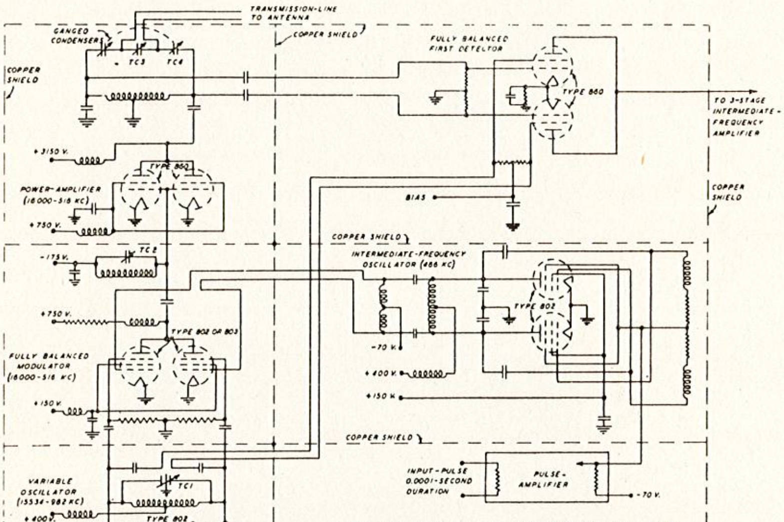


FIG. 5—SIMPLIFIED SCHEMATIC DIAGRAM OF ESSENTIAL DETAILS, RADIO-FREQUENCY POWER-CIRCUITS OF AUTOMATIC MULTI-FREQUENCY IONOSPHERIC MEASURING-EQUIPMENT (C.I.W. D.T.M. MODEL 3)

NOTES: MULTIPLE TANK-CIRCUITS AND BAND- AND ANTENNA-SWITCHES NOT INDICATED
VARIABLE TUNING-CONTROLS INDICATED BY TC

A selector-panel, shown in Figure 6, is located at the bottom of a relay-rack and provides the entire mechanical control for the equipment. The units which have the variable tuning are mounted above the selector. The main cam-shaft of the selector-panel is driven continuously at 0.4 revolution per minute by a 1/75 horse-power synchronous motor through a reduction-gear. This shaft rotates 24 cams in four groups of six, each group corresponding to one variable tuning-control. Twenty-four short cam-followers, one following each cam, have vertical motions which are determined by the shapes of the cams. Above each group of six cam-followers is a rotary cam-selector having an arm as shown in Figure 7. This arm is capable of both intermittent rotary and vertical motion. It has six positions, 60° apart; each position corresponds to the selection of one of the six cam-followers in its group. The vertical motion of a selected cam-follower causes the cam-follower selector to rise with a motion determined by the shape of the cam. This rotates the variable capacitor, providing the proper tuning. At the end of the frequency-band, the cam-followers drop and the four cam-follower selectors rotate, selecting a new set of four cam-followers. In this way a new set of cams is selected for each band.

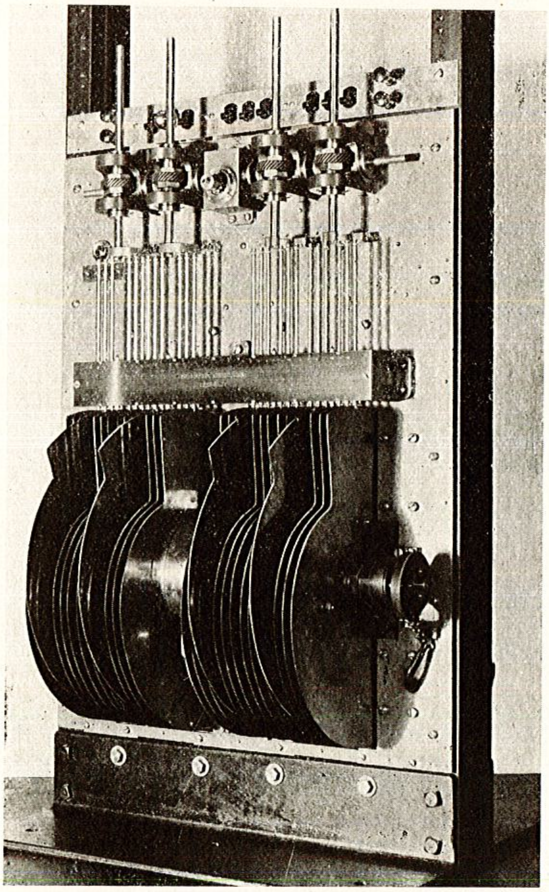


Fig. 6. — Automatic tuning-unit for multifrequency equipment (covers removed).

The cam-follower selector is motor-driven and operated through a switching device of special design. Any band-sequence can be set up by merely operating any combination of a series of six switches. Slight changes in positions of the selector-arm, due to change in frictional force, are not cumulative. The selector-arm drive-shaft also operates the selector-switches in the four tuning-units by means of a direct chaindrive to each unit. The entire assembly of an experimental multifrequency equipment is shown in Figure 8. The units are arranged as shown in Figure 1 with the receiving equipment and power-units on the right.

The design of a radio-frequency band-switch is shown in Figure 9. The switch has six positions corresponding to the six bands and the switch-cams can be readily cut into any desirable shape to provide for practically any combination of contacts in

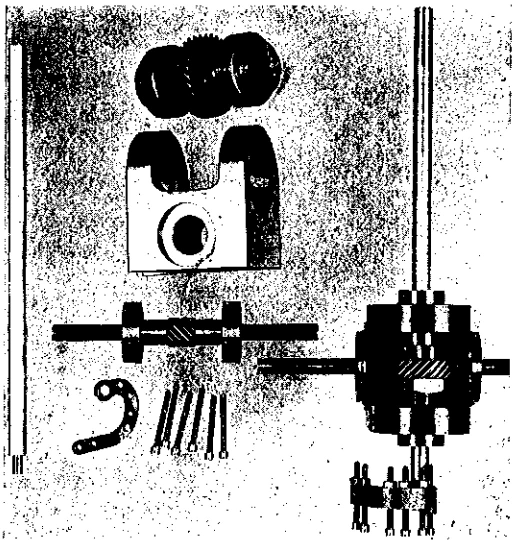


Fig. 7. — Details of selector-arms.

each position. In addition, each switch is equipped with back-contacts so that unused inductors are grounded. The design of these switches is an important feature in successful operation of the equipment. The variable capacitors are sectionalized so that the total capacitance available is changed for different bands, providing for rotation through the full 180° in each band, which is necessary if requisite frequency-calibration is to be maintained.

(V) *Antenna-arrangement.*

The details of the antenna-tuning network are shown in Figures 5 and 10. Table 2 shows schedule of contact-closure for switches 1 to 3 in these Figures. As shown capacitor-sections may be put either in series or in parallel so that the total condenser-reactance corresponds to the required values in any part of the frequency-range. It can be seen that resonance of the

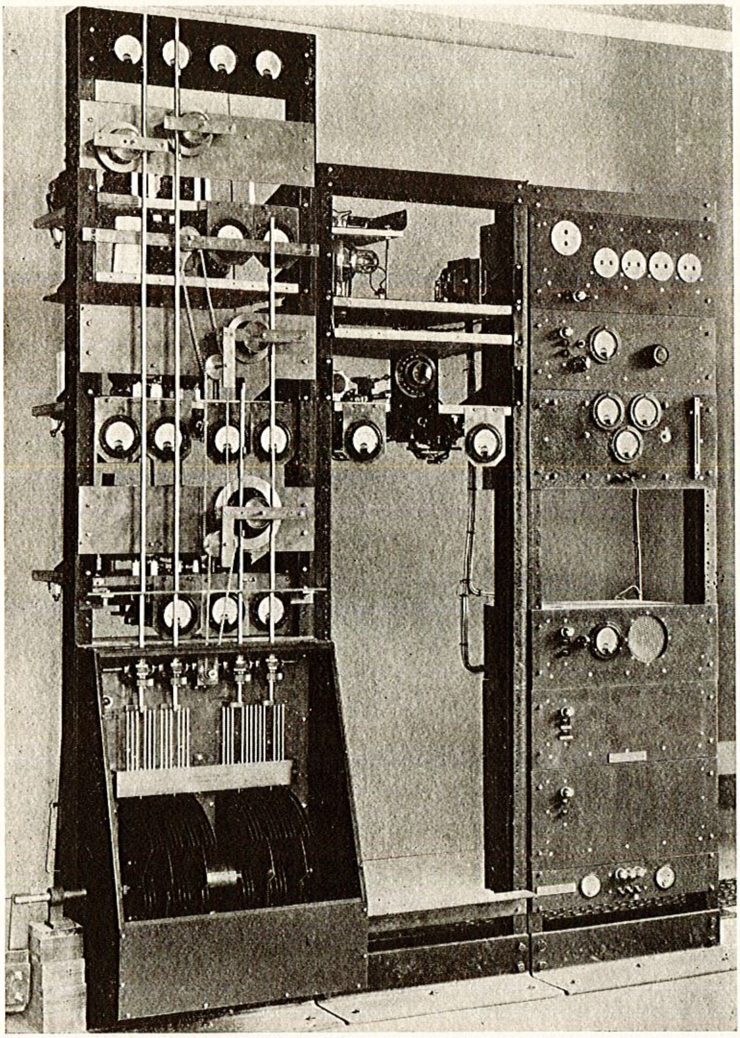


Fig. 8. — Assembly of experimental automatic multifrequency equipment showing mechanical linkage.

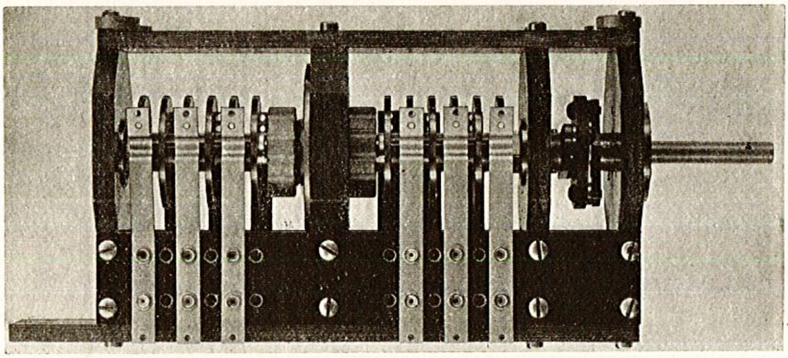
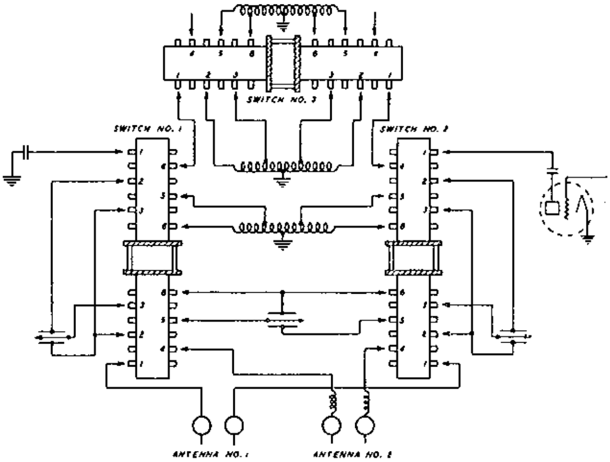


Fig. 9. — Design of band-switch



(NOTE: DETAILS OF BAND-SWITCHES SHOWN IN FIGURE 9—COILS GROUNDED WHEN NOT IN USE)

FIG 10—DETAILS OF ANTENNA-TUNING NETWORK

output-tank can be obtained for an infinite number of settings of the tank condensers. Therefore, the ratio of these capacitances can be adjusted by the cam-motion so that the impedance at the sending end of the transmission-line is matched to the output-tank both as to scalar magnitude and phase-angle at all frequencies.

Table 2 — Schedule of switch-contacts for antenna-network

(X indicates contact closed in position so marked; G indicates contact grounded through back-contact; — indicates contact open)

Switch-band	Nos. 1 and 2 (front)						Nos. 1 and 2 (back)						No. 3					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Contact 1	X	X	X	X	—	—	X	X	X	X	X	X	—	—	X	X	X	X
2	X	—	—	—	—	—	X	X	X	X	X	X	G	G	X	X	G	G
3	—	X	X	X	X	X	—	—	—	X	X	X	—	—	X	—	—	—
4	—	—	—	—	X	X	—	—	X	X	X	X	—	—	—	—	—	—
5	Given below						X	—	—	—	—	—	G	G	G	G	X	X
6	Given below						X	X	G	G	G	G	—	—	—	—	X	—
	No. 1 (front)						No. 2 (front)											
5	X	X	—	—	—	—	X	X	X	X	X	X						
6	—	· ·	X	X	X	X	—	—	—	—	X	X						

Two antennas are used to maintain high-angle radiation throughout the range. Antenna 1 is used for bands 1 to 4 (16,000 to 3284 kc), inclusive, and is 30 meters in length. Antenna 2 is used in bands 5 and 6 (3284 to 516 kc) and is 125 meters in length. Both antennas are in the form of horizontal doublets with 550-ohm transmission-lines connected to the centers. Matching between the transmission-lines and the antennas is evidently impracticable, in so far as scalar values of the impedance are concerned, while the reactance is taken up in the antenna-tuning network at the transmitter. To reduce the anti-resonant impedance of the antenna, each arm of the doublet is of the form of a cage of diameter about two meters. The anti-resonant resistance of such a doublet at the center is given approximately by the expression

$$R = Z_0^2 / R_L \qquad (13)$$

where R_L is the radiation-resistance and Z_0 is the surge-impedance of the doublet. If, for example, a No. 10 Brown and Sharpe gage doublet-antenna is compared to the 2-meter cage doublet-antenna, the anti-resonant impedance of the cage is about 3000 ohms as compared to about 30,000 ohms for the No. 10 wire, with some variation depending upon the other dimensions of the antennas. The mismatch between the transmission-line and the antenna is not serious in this case, never exceeding about 5:1 either way. Similarly, it is practicable to match the anti-resonant resistance of 3000 ohms into the power-amplifier tank efficiently. Likewise the reactance is correspondingly reduced so that the tuning-matching arrangement is feasible.

(VI) *Calibration.*

To obtain proper calibration, the maximum cam-rise is 100 mm which, when coupled to a disc having a periphery of 200 mm, provides for capacitor-rotation of 180°. It is possible to grind the cams to 0.1 mm providing for a mechanical calibration-accuracy of one part in 1000. The oscillator is designed to operate within these limits. Frequencies are repeated for given cam-positions on successive runs to well within one part in 10,000. The calibration on the automatic tuning-unit provides for cam-settings of one part in 1000. To obtain the proper shape of cam, the calibrated readings of the dials on the four tuning-units are obtained directly from a dial reading 0 to 1000. This calibration corresponds exactly to the rise of cam in tenths of millimeters.

(VII) *Non-interference of emission.*

It is essential that for successful operation there must exist no interference to radio service whatsoever. That this is the case is apparent from a review of the following details of design:

(1) The emission is a short pulse of 1/10,000-second duration. One such pulse is emitted each one-tenth second. On an average, the frequency sweeps at the rate of about 900 kc or more per minute so that the frequency advances an average of 1.5 kc between each pulse (see curve of Figure 2 for exact data). On an average, about five pulses occur in any channel.

(2) One complete sweep of frequency is made in about 15 minutes. Therefore, the pulses are repeated in any channel only at intervals of about 15 minutes.

(3) The antenna is a high-angle radiator with practically no low-angle radiation. Therefore, to even a nearby receiver located just outside the induction-field of the antenna the ground-wave is inappreciable. Such a receiver is thus at an equivalent distance of not less than 200 km from the equipment (the lowest layer is about 100-km height).

(4) The average radiated power of the equipment is 0.64 watt, and the peak-power of any pulse is less than 800 watts. Therefore, the power involved is much less than that of most existing services. Only sufficient power is used to discriminate against atmospheric noise. The level of the received pulse is often down into the atmospheric noise-level.

(5) The pulse is of very short duration and as nearly sinusoidal form as possible so that the side-band energy occupies a restricted band. The side-band frequency of the pulse is greatly attenuated by all but receivers especially designed to receive it.

(6) The pulse-frequency (10 pulses per second) is so low that it does not constitute a "sound" as defined in audio-frequency parlance. This pulse-rate has been made the minimum consistent with the rate of frequency-change, any lower rate materially affecting the completeness of the record.

(7) The emission can only be received continuously on a special receiver whose frequency is changed with the frequency of the transmitter. The pulses and their side-bands will be actually emitted in any channel for a total time of only 0.0003 to 0.0005 second during the period of less than one-half second that the equipment-frequency is passing through the channel. This will be repeated once each 15 minutes. Thus the emission, to a receiver adjusted to the threshold of maximum sensitivity, will sound about like a watch ticking in any channel for less than one second in each 15 minutes.

The equipment has been subjected to exhaustive tests and inspections by the engineering staffs of the United States Federal

Communications Commission to determine whether interference to existing radio services might possibly result. It has been found after extensive listening tests that interference does not occur. License has been granted for operation at Kensington, Maryland, which, being within a few miles of governmental, commercial, and broadcast activities, demonstrates most aptly the non-interfering character of the emission.

(VIII) *Nature of results.*

Typical records are shown in Figure 11 for the afternoon of December 27, 1935, and the night of January 28, 1936. These

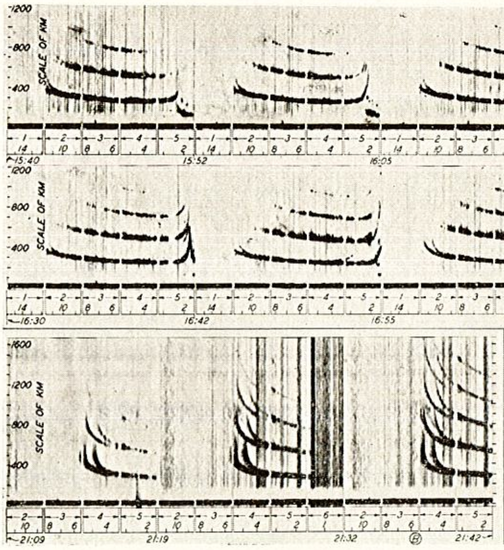


FIG. 11—PHOTOGRAPHIC RECORDS OF AUTOMATIC MULTIFREQUENCY EQUIPMENT, KENSINGTON, MARYLAND—DECEMBER 27, 1935 (A); JANUARY 28, 1936 (B)

LEGEND

HORIZONTAL INDICATIONS ARE:-
FIRST LINE: BAND NUMBERS
SECOND LINE: SCALE OF FREQUENCY IN MC/SEC
THIRD LINE: 75° WEST MERIDIAN TIME IN HOURS AND MINUTES

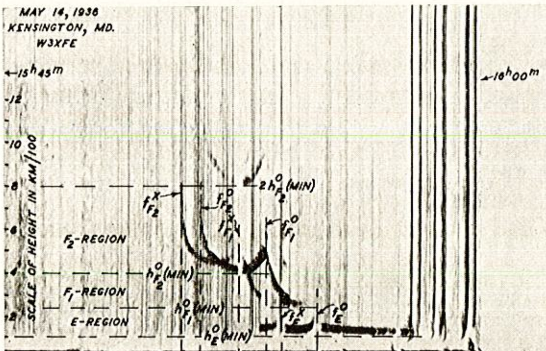


FIG. 12—PHOTOGRAPHIC RECORD OF AUTOMATIC MULTIFREQUENCY EQUIPMENT SHOWING TYPICAL IONOSPHERIC CONDITION DURING SUMMER AFTERNOON AT WASHINGTON, D.C.

records were made over a frequency-range of 16,000 kc to 1610 kc, or bands 1 to 5. Figure 12 shows a record for May 14, 1936, and illustrates by contrast the change which has taken place in the ionosphere during this period. Many details, which are impossible to obtain by manual methods, are immediately apparent in these records. Such records lend themselves to rapid scaling using a glass calibrated in frequency and height. The band-switching intervals act as calibration-points. It is expected that equipments of this type will be located at Huancayo in Peru, at Watheroo in Western Australia, and perhaps at College in Alaska. These stations operating continuously, together with a somewhat similar equipment of the National Bureau of Standards at Washington, should provide a much more complete survey of the upper atmosphere than has been heretofore possible.

References

[1] L. V. Berkner, C. R. Assemblée Lisbonne, 1933; Union Géod. Géophys. Internat., Ass. Mag. Electr. Terr., Bull. No. 9, pp. 201-206, 1934.
[2] G. Breit and M. A. Tuve, Phys. Rev., v. 28, pp. 554-575, 1926.
[3] T. R. Gilliland, Nature, v. 134, p. 379, 1934.
[4] T. R. Gilliland and G. W. Kenrick, Proc. Inst. Radio Eng., v. 20, pp. 540-547, 1932.

Dep. Terr. Magn., C.I.W., July 31, 1936.

STUDIES OF THE E-REGION OF THE IONOSPHERE AT LOW LATITUDES

By L. V. BERKNER and H. W. WELLS

Abstract: The widespread interest in sudden and irregular ionization of the upper atmosphere, frequently observed at a height of about 100 km in the Northern Hemisphere, has led to conjecture as to the possible origin of such effects in the high electric fields of thunder-storms. This paper reports observation of this effect at Huancayo, Peru (12° south, 75° west) on the geomagnetic equator, and at Watheroo, Western Australia (30° south, 116° east). Abnormal ionization of this region is practically non-existent at Huancayo, although the frequency of thunderstorms is high. At Watheroo, the effect is about 70 times as pronounced as at Huancayo, appearing similar to the observed effects in the north temperate zone. Thunder-storm conditions are much less frequent at Watheroo than at Huancayo. The results indicate that generation of this abnormal ionization by thunder-storm fields is improbable. The absence of the effect at Huancayo and its great prevalence in the polar regions suggest that the phenomenon may depend upon geomagnetic latitude. There is some evidence that the abnormal ionization may be related to magnetic bays and aurorae which have a similar distribution with latitude and probably originate in the same atmospheric region.

Investigations of ionization of the upper atmosphere during recent years by radio methods have provided a new field of investigation in physics involving the propagation of electromagnetic waves in a doubly-refracting medium of non-uniform density and the production of ions in gas of low density. The dependence of terrestrial-magnetic variations and long-distance radio transmission upon the character of this ionization has insured the rapid progress of investigation which has taken place. With the introduction and improvement of suitable methods of investigation, the conception of the ionized upper atmosphere has progressed from the original rather vague idea to a more comprehensive picture of several major regions, each of which, while merging into adjacent regions, has certain specific characteristics. These characteristics change with location over the surface of the Earth, and it has been necessary to carry on the work at a number of stations which are strategically located. In recent publications by Appleton [see 1 under "References" at end of paper] and Mitra [2], the progress of these investigations has been comprehensively reviewed in an interesting and effective manner. We are concerned here only with a particular property of the ionized region found at about 100 km which is generally designated as the E-region. The data reported herewith from two stations in the Southern Hemisphere adds information which must effectively change the background upon which the rather extensive discussion of the phenomenon has been based.

Investigation of this region in the Northern Hemisphere has disclosed the existence of occasional abnormally high values of ion-density at heights of 100 to 110 km. These are important because of their predominant effect during periods of occurrence. Normally, the ion-density of this E-region undergoes relatively smooth diurnal and seasonal variations [3, 4]. It has been demonstrated that this normal ionization is caused principally by electromagnetic radiation [5, 6] from the Sun. It is probably the result of ionization of atomic oxygen by ultraviolet light. This normal maximum of ion-density reaches a value of about 1.8×10^5, expressed in equivalent numbers of electrons per cc, when the Sun is directly overhead [7]. A wave of radio frequency 3.8 mc/sec will just penetrate a region of this ion-density at normal incidence.

Occasionally, reflections of great magnitude are observed from the E-region when frequencies much higher than the normal critical penetration-frequency for the E-region are used [3, 4, 8, 9, 10, 11]. Reflections from the upper regions, otherwise apparent on these frequencies, may be entirely obscured. It is therefore supposed that an abnormal or "sporadic" ionization must have occurred in the E-region. Such events may occur at any hour and last for a few minutes or even several hours. Ion-density during such periods often exceeds 10^6 equivalent electrons per cc, as deduced from the penetration-frequency.

Ionosphere-observation at the Huancayo Magnetic Observatory, Peru, in latitude 12° south and longitude 75° west [12, 13, 14], and at the Watheroo Magnetic Observatory, Western Australia, in latitude 30° south and longitude 116° east [15], by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, permits a further investigation of this effect. It is especially significant that Huancayo Magnetic Observatory is at the geomagnetic equator and that both stations are in the Southern Hemisphere.

The results at these observatories, upon which this paper is based, cover the period July 1, 1935 to May 15, 1936. The frequency of 4.8 mc/sec, used in the study, ordinarily penetrates the E-region, but is reflected from this region when the ion-density increases about 50 per cent over the normal maximum. Records at Huancayo are practically continuous for about 7680

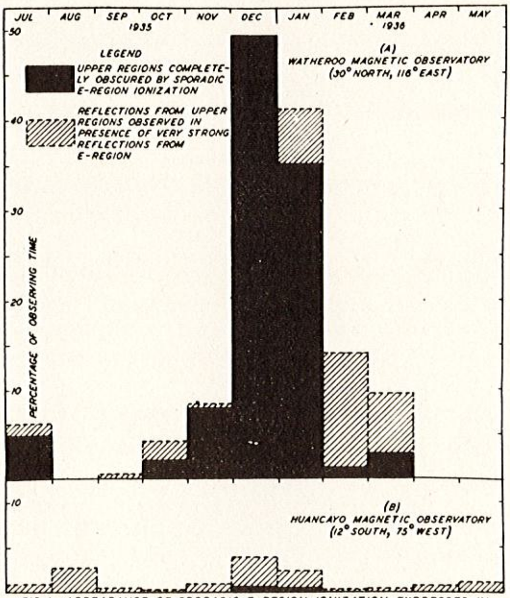


FIG. 1—APPEARANCE OF SPORADIC E-REGION IONIZATION EXPRESSED IN PER CENT OF OBSERVING TIME (OBSERVING FREQUENCY 4.8 MC/SEC)

hours during the period. Data at Watheroo were taken manually three days a week during such times that the entire 24 hours were canvassed regularly. These observations covered about 1090 hours — one-seventh of the entire period.

Two phenomena, somewhat similar but nevertheless distinct, were observed. The first, represented by the black blocks of

Figure 1, was the appearance of strong reflections from the E-region, accompanied by one or more multiple reflections, characterized by complete cessation of reflections from higher regions on the observing frequency. The second, shown by the hatched blocks of Figure 1, was similar except that reflections from the upper regions were observed. This latter effect probably arises from partial reflection from a relatively sharp boundary; it may indicate a change of ion-distribution or ion-gradient [16] but not an increase of equivalent electron-density to 2.8×10^5.

Two factors of particular significance are recognized in Figure 1. While sporadic ionization is not infrequent at Watheroo, it is rarely observed at Huancayo. Furthermore, its occurrence seems definitely related to the December solstice.

Sporadic ionization of the E-region at Huancayo was observed only during 6.3 hours of almost a year of continuous observation, while at Watheroo, in only one-seventh of the total observing time (1090 hours), it appeared during about 60 hours. The effect was therefore about 70 times as apparent at Watheroo.

The effect at Huancayo was confined to four days in December and January which corresponds to its most frequent appearance at Watheroo. The Sun is overhead at Huancayo during October and February; therefore, the effect seems associated with the Sun's declination.

The association of the effect with local summer months caused much conjecture concerning a possible local terrestrial origin. Two mechanisms proposed by C. T. R. Wilson [17] involving the effect of the high electric fields of thunder-clouds have been invoked [3, 9]. The first involves the electrical breakdown of the high atmosphere above thunder-clouds. Sporadic ionization of the E-region from this cause should appear in the vicinity of the thunder-storm area, unless high conductivity of the ionized region disposes of the charge as rapidly as formed. The frequency of thunder-storms is very much greater at Huancayo than at Watheroo. When the relative absence of abnormal ionization at Huancayo is considered, this explanation for the effect seems improbable, in agreement with the conclusion of Healey [18], based on theoretical considerations.

The second involves ionization by beta particles, or "runaway electrons," accelerated in high thunder-storm fields. The electron, accelerated upward in the high electric field and at Huancayo across the Earth's magnetic field, would move eastward. It might be argued that sporadic E-region ionization at Huancayo does not occur because the necessary thunder-storm field must be westward and therefore over the Pacific Ocean where thunder-storm conditions are infrequent. It could be further adduced that, while Watheroo is similarly located near a western coast, the high inclination of the Earth's magnetic field there would not prevent a sporadic ionization from local thunder-storms. Infrequency of thunder-storm fields near Watheroo minimizes this possibility.

The prevalence of sporadic E-region ionization in polar regions has been mentioned by Appleton [9] and Fleming [10]. The effect is in evidence in such latitudes even during the winter night. It is difficult to reconcile this fact with the suggested origin of sporadic ionization in thunder-storm fields, in view of the absence of such ionization at Huancayo.

The relative absence of sporadic ionization of the E-region at Huancayo is particularly significant. Prevalence of such effects north and south of Huancayo suggests that the phenomenon may depend on latitude or, more probably, on geomagnetic latitude, as well as on solar declination. Other geophysical phenomena such as aurorae, and certain types of magnetic disturbance such as bays, are similarly distributed with respect to latitude, have a seasonal distribution of occurrence, and probably originate in the same atmospheric region. No relation between the sporadic E-region ionizations and magnetic disturbances of wide-spread character is apparent so far at Huancayo and Watheroo. However, magnetic conditions have been relatively undisturbed during this period. It is probable that these effects are related more closely to the relatively frequent and local magnetic disturbances observed only in large magnitude near the polar regions as shown by Harang [19].

References

[1] E. V. Appleton, Phys. Soc., Reports on Progress in Physics, v. 2, pp. 129-165, 1936.
[2] S. K. Mitra, Proc. Nation. Inst. Sci. India, v. 1, pp. 131-215, 1935.
[3] E. V. Appleton and R. Naismith, Proc. Phys. Soc., v. 45, pp. 389-398, 1933.
[4] S. S. Kirby, L. V. Berkner, and D. M. Stuart, Proc. Inst. Radio Eng., v. 22, pp. 481-521, 1934; also Bur. Stan. J. Res., v. 12, pp. 15-51, 1934.
[5] J. T. Henderson, Canad. J. Res., v. 8, pp. 1-4, 1933.
[6] S. S. Kirby, L. V. Berkner, T. R. Gilliland, and K. A. Norton, Bur. Stan. J. Res., v. 11, pp. 829-845, 1933; also Proc. Inst. Radio Eng., v. 22, pp. 247-264, 1934.
[7] H. W. Wells, Terr. Mag., v. 39, pp. 209-214, 1934.
[8] J. P. Schafer and W. M. Goodall, Proc. Inst. Radio Eng., v. 20, pp. 1131-1148, 1932.
[9] J. A. Ratcliffe and E. L. C. White, Proc. Phys. Soc.; v. 45, pp. 399-413, 1933, and v. 46, pp. 107-115, 1934.
[10] J. A. Fleming, Terr. Mag., v. 39, pp. 305-313, 1934.
[11] E. V. Appleton, R. Naismith, and G. Builder, Nature, v. 132, pp. 340-341, 1933.
[12] L. V. Berkner and H. W. Wells, Proc. Inst. Radio Eng., v. 22, pp. 1102-1123, 1934.

[13] L. V. Berkner and H. W. Wells, Terr. Mag., v. 39, pp. 215-230, 1934.
[14] H. W. Wells and L. V. Berkner, Terr. Mag., v. 41, pp. 75-82, 1936.
[15] L. V. Berkner, H. W. Wells, and S. L. Seaton, Terr. Mag., v. 41, pp. 173-184, 1936.
[16] T. R. Gilliland, G. W. Kenrick, and K. A. Norton, Proc. Inst. Radio Eng., v. 20, pp. 286-309, 1932.
[17] C. T. R. Wilson, Proc. Phys. Soc., v. 37, pp. 32D-37D, 1925.
[18] R. H. Healey, Phil. Mag., v. 21, pp. 187-198, 1936.
[19] L. Harang, Terr. Mag., v. 41, pp. 143-160, 1936.

Dep. Terr. Magn., C. I. W., July 31, 1936.

NEW FACTORS IN THE INVESTIGATION OF THE HIGH REGION OF THE UPPER ATMOSPHERE

By L. V. BERKNER and H. W. WELLS

Abstract: Recent data from the Southern Hemisphere indicate that the maximum ion-density of the upper or F_2-region of the ionosphere does not undergo the simple seasonal change originally thought. That the variation seems to be of the same form in both hemispheres leads to a strong presumption that the effect is an annual one. Separation of the F-region into the F_1- and F_2-regions is considered. The fact that this separation exists, indicates some basic difference in the manner in which the F_1- and F_2-regions become ionized. The resultant effect of one region on the other because of overlapping is considered. Apparently anomalous results during eclipses appear consistent when this effect is taken into account, and differences in average ion-densities in different locations of apparently seasonal nature seem to be satisfactorily explained. During local winter when the regions are merged, the two modes of ionization would act in the same region to give the resultant F-region ionization.

Location of stations for observation of the ionosphere in a number of geographically very different locations over the surface of the Earth has made available much more extensive data for use in upper atmospheric studies. Earlier observations in the Northern Hemisphere alone had led to the establishment of certain characteristics of the several ionospheric regions. Maximum ion-densities of these regions were found to be functions of the Sun's altitude, in some cases quite complicated. For the two lower regions, the E and the F_1, the maximum ion-density was found to increase with increasing altitude of the Sun, indicating relatively simple ordinary diurnal and seasonal variations; for the upper or F_2-region a more complicated form of variation was apparent. While a diurnal characteristic was observed, it changed with the time of year. Further, the maximum ion-density was lower during the June than during the December solstice, and the diurnal and day-to-day variations were extremely irregular as contrasted to the lower regions.

The attempt to explain these phenomena also as seasonal effects was natural in the absence of further data. Various explanations were offered; one advanced the possibility of limitation by absorption due to redistribution of ionization during the summer [see 1 of "References" at end of paper], while another postulated an expansion of the upper atmosphere under the more direct rays of the Sun [2, 3].

Regular observations were begun in the Southern Hemisphere in 1933 by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, at its Magnetic Observatory near Huancayo, Peru, located on the geomagnetic equator [4, 5]. Similar observations at its Watheroo Magnetic Observatory in Western Australia were undertaken in 1935 [6]. Regular measurements of the ionosphere are conducted at both stations on three days each week by manual multifrequency methods. At Huancayo, continuous automatic records of the ionosphere are obtained on a frequency of 4.8 mc/sec in addition to these triweekly runs.

Data from these stations in the Southern Hemisphere require some revision of ideas concerning the upper region of the ionosphere, while extending and confirming the concepts of the lower regions. It is found that the seasonal characteristics of the E- and F_1-regions exist as originally conceived, with values of maximum ion-density in close correspondence to those calculated from latitude and solar declination on the basis of observations in the Northern Hemisphere. That the values are slightly higher is to be expected from the slight ellipticity of the Earth's orbit and the resultant change in received radiation in a given location.

Curves for maximum ion-density of the upper or F_2-region reveal a result perhaps unexpected but nevertheless of particular significance. These curves are shown in Figure 1 where they are compared with the data published by the National Bureau of Standards for Washington, D. C. Over a period of three years, the average maximum ion-densities at Huancayo and at Washington have varied in a similar manner notwithstanding the fact that they are in different hemispheres. Likewise, at Watheroo, the maximum ion-densities also exhibit their lowest values during the months of June to August. These data require a revision of the idea that the effect is a simple seasonal one, and lead to a strong presumption that instead it is an annual effect, though probably complicated by secondary factors of seasonal nature peculiar to the particular locations.

These facts render untenable the simple hypotheses of absorption or thermal expansion based upon the assumption that the effect was a seasonal one.

An examination of the minimum virtual heights of the F_2-region indicates a variation of seasonal nature. Curves of Figure 2 for Watheroo and Washington appear quite definitely

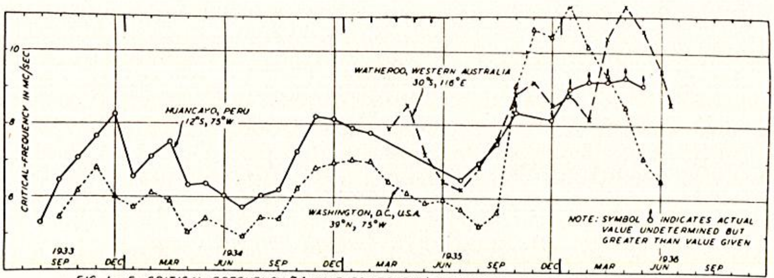


FIG. 1—F_2 CRITICAL-FREQUENCY ("O" WAVE-COMPONENT), COMPARISON MONTHLY AVERAGES NOON VALUES, HUANCAYO, WATHEROO, AND WASHINGTON

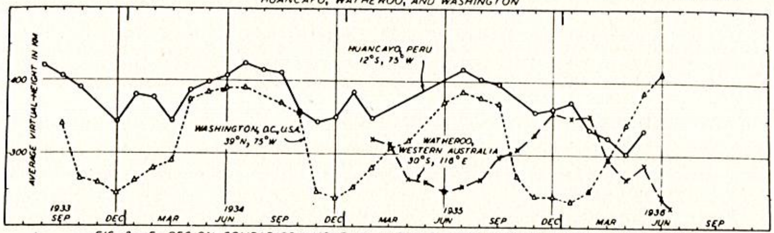


FIG. 2—F_2-REGION, COMPARISON MONTHLY AVERAGES NOON VALUES MINIMUM VIRTUAL-HEIGHT, HUANCAYO, WATHEROO, AND WASHINGTON

of opposite phase. At Huancayo the effect, while exhibiting a seasonal characteristic, is more complicated. There the minimum virtual height follows a function of solar zenith-angle which is roughly the reverse of that observed in the temperate zones.

As previously mentioned, the maximum ion-density at a particular station, while exhibiting what appears to be an annual characteristic, must be complicated by secondary seasonal effects which change the resultant maximum in different locations. That the F-region separates into the F_1- and F_2-regions under small zenith-angles of the Sun is well established. For example, at a station located centrally in a temperate zone, this separation is usually well defined during the summer, becoming indistinct or non-existent during the winter. This is illustrated graphically in Figure 3 which shows two automatic records of the ionosphere taken during the afternoons of December 27, 1935, and May 14, 1936, at the Kensington Experimental Station of the Department of Terrestrial Magnetism near Washington, D. C.

The fact that two separate F-regions exist at all [1, 4, 5] indicates some basic difference in the principal manner of ionization of each, either with respect to the ionizing agent or the physical nature of the particles ionized. If this difference is assumed, then the ionization due to one mode must contribute to some extent to the ion-density of the other region because of overlapping. During local winter this effect must be great, for when the separation of the regions is not distinguishable, it follows that the maximum ion-density must be the result of

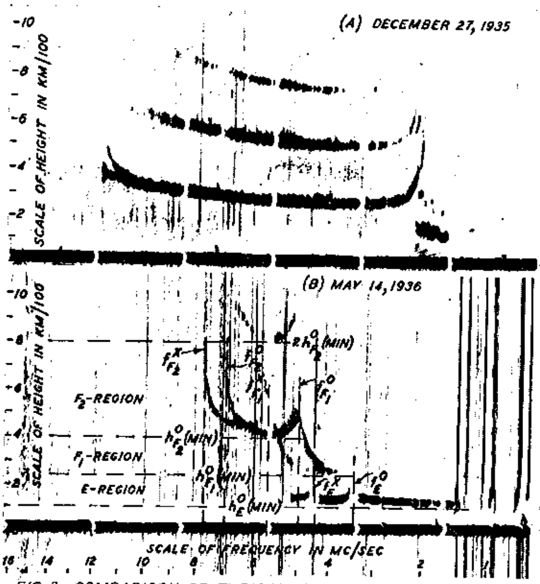


FIG. 3—COMPARISON OF TYPICAL IONOSPHERIC RECORDS FOR SUMMER AND WINTER AFTERNOONS (15^h45^m TO 16^h00^m), KENSINGTON, MARYLAND

these two ionizing modes acting separately and simultaneously in the same region. Conversely, during summer, when the separation of the regions is great and their two maxima exist separately, the ionization due to one mode can contribute but little to the ion-density of the other region, and they can be recognized separately.

From November to January, when the maximum ion-density of the F_2-region is greatest, this effect will act to increase the ion-density at Washington without a corresponding increase at Watheroo, while from May to August, when the maximum ion-density is low, the reverse is true. Thus the range of maximum ion-densities should be greater in the northern than in corresponding southern latitudes because this effect is added to the annual one. Figure 1 shows that these relative maximum ion-densities have been maintained at Washington and Watheroo during the past year.

More critical study of the data indicates that the peak of ion-density at Washington around December was accompanied by almost, if not complete, cessation of distinction between the F_1- and F_2-regions, while at Watheroo the separation was marked and associated with somewhat lower values of ion-density. By April, the F_1- and F_2-regions were practically merged at Watheroo, with accompanying high ion-densities, while at Washington the separation was becoming evident and was associated with rapidly falling values of maximum ion-density. Thus there is some support for the view that the F_1- and F_2-regions represent the result of two distinct modes of ionization which continue to operate even though the two regions are merged.

During the solar eclipses of August 1932 [7] and 1933 [9], in contrast with the effects observed in the lower regions, no decrease in the maximum ion-density was observed in the F_2-region which could be attributed to the optical eclipse. Subsequent observations during the eclipse of February 1935 [8, 10] indicated that a decrease took place in the upper region, though less sharp than that for the lower regions. The result during the later eclipse [11] has been accepted as more representative because of better correspondence with theoretical ideas. However, a critical point may have been overlooked. At the time of the eclipse of August 1932, the F_1- and F_2-regions were widely separated because the Sun's zenith-angle was small, while during the February 1935 observations the Sun's zenith-angle was large and the regions were nearly merged. Under the latter condition, the maxima of the two regions are only slightly separated in height, so that the contribution of upper F_1-ionization to the maximum F_2-region ion-density must be large. Therefore, although the F_2-region appeared to be eclipsed during the February eclipse, the decrease of maximum ion-density observed can be attributed to the decrease of the ionizing agent of the F_1-region rather than to a change in the primary ionizing mechanism in the F_2-region. This view makes the data during the various eclipse-observations mutually consistent, and indicates that the primary ionizing mechanism for the F_2-region is not eclipsed at the time of an optical eclipse. While such a conclusion does not agree with the frequently proposed mechanism [12] for ionization of the F_2-region involving ultra-violet light alone, it must be admitted that, with the new data, there is a sufficient conflict of fact to leave unanswered the important question of the nature of the ionizing mechanism in the F_2-region. Ionization by collision of corpuscles from an extra-terrestrial source must remain a possibility at the present time.

In reviewing the data, the pronounced increase of ion-density of all regions during the past year must be mentioned. This is apparent from Figure 1, where the average ion-density for the F_2-region shows a twofold increase. At Huancayo, critical frequencies for the F_1-region have increased by a ratio of about 4.8 to 5.3 representing an increase of ion-density of 20 per cent. This is of the same order as the seasonal variation. The E-region has undergone a similar increase. It should be remarked that, while changes in the E- and F_1-regions, when the chief ionizing agent is known to be ultra-violet light, are similar, the change in the F_2-region has been relatively enormous. This lends additional significance to the previous suggestions.

The fact that a diurnal characteristic exists for all regions shows the Sun to be the source of the ionizing agents, whether they be ultra-violet or corpuscular in nature. This reasoning leads to the conclusion that the Earth may experience relatively large changes of solar radiation of the types responsible for the ionization of the upper atmosphere, changes of a magnitude unknown in the visible spectrum. While observations are as yet limited to about a half sunspot-cycle, the annual mean values of ion-density show a correspondence to sunspot-changes. The data are, of course, too restricted to reach any final conclusion in this regard. However, the possibility that changes in the value of critical frequencies may yield a sensitive measure of changes of solar radiation in the invisible spectrum must not be overlooked. A day-to-day correspondence with observed sunspot-phenomena is not to be expected necessarily, when it is remembered that the sunspots in themselves may not be the source of the ionizing agents, but rather the manifestation of a more fundamental solar-variation which is otherwise invisible through the Earth's atmosphere. This is indicated from observed phenomena of terrestrial magnetism; the dependence of magnetic activity on solar changes [13] is a statistical rather than a one-to-one correspondence.

References

[1] S. S. Kirby, L. V. Berkner, and D. M. Stuart, Proc. Inst. Radio Eng., v. 22, pp. 1102-1123, 1934.

[2] E. V. Appleton, Nature, v. 136, pp. 52-53, 1935.

[3] E. O. Hulburt, Terr. Mag., v. 40, pp. 193-200, 1935.

[4] L. V. Berkner and H. W. Wells, Proc. Inst. Radio Eng., v. 22, pp. 1102-1123, 1934.

[5] L. V. Berkner and H. W. Wells, Terr. Mag., v. 39, pp. 215-230, 1934.

[6] L. V. Berkner, H. W. Wells, and S. L. Seaton, Terr. Mag., v. 41, pp. 173-184, 1936.

[7] S. S. Kirby, L. V. Berkner, T. R. Gilliland, and K. A. Norton, Bur. Stan. J. Res., v. 11, pp. 829-845, 1933; also Proc. Inst. Radio Eng., v. 22, pp. 247-264, 1934.

[8] J. P. Schafer and W. M. Goodall, Proc. Inst. Radio Eng., v. 23, pp. 1356-1360, 1935.

[9] S. K. Mitra and others, Nature, v. 132, pp. 442-443, 1933.

[10] S. S. Kirby, T. R. Gilliland, and E. B. Judson, Phys. Rev., v. 47, pp. 632-633, 1935; also Bur. Stan. J. Res., v. 16, pp. 213-225, 1936; also Proc. Inst. Radio Eng., v. 24, pp. 1027-1040, 1936.

[11] E. V. Appleton and S. Chapman, Proc. Inst. Radio Eng., v. 23, pp. 658-669, 1935.
[12] D. F. Martyn and O. O. Pulley, Proc. R. Soc., A, v. 154, pp. 455-486, 1936.
[13] J. Bartels, Terr. Mag., v. 37, pp. 1-52, 1932.

Dep. Terr. Magn., C. I. W., July 31, 1936.

NEW RESULTS OF COSMIC RAY RESEARCH

By V. F. HESS

Continuous registrations of the cosmic ray ionisation by Steinke's Standard Apparatus in 2300 and 600 meters altitude (Hafelekar-Observatory and Innsbruck) kept at constant temperature from 1931 to 1934 and in 1936, have brought interesting results: for instance the existence of regular, small diurnal variations according to solar time has been established*).

Recently one of my collaborators (W. Illing**) tested the existence of diurnal variations according to sidereal time as postulated by A. H. Compton's theory of the extragalactic origin of the cosmic radiation. The curve derived from 21000 hourly observations in three years showed a certain resemblance to Compton's theoretical curve which, however, disappeared when all observations were reduced to the same out-door temperature.

I. *The External Temperature-Effect.*

Several authors have shown that the cosmic ray ionisation after reduction to a constant barometric pressure still shows a certain correlation to the out-door temperature. On the Hafelekar, in 2300 meters above sea level with the apparatus screened by lead (10 cm thick) on all sides, the ionisation decreases by about -0.9 per mille when the out-door temperature rises by one degree. It seemed important to investigate this "external temperature effect" thoroughly.

It may be realised that an effect of this kind can only be due to the change of density of the air in the neighbourhood of the station, perhaps within a few hundred meters, caused by out-door temperature variations; a rise of temperature results in a diminution of scattered radiation from the vicinity of the apparatus.

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*) V. F. Hess and H. Th. Graziadei, Terr. Magn., vol. 41, pp. 9-14, 1936.
**) W. Illing, Terr. Magn., vol. 41, pp. 185-191, 1936.

Therefore it seems feasable that every change in the mass-distribution within the air — even at constant barometric pressure — should be accompanied by a slight variation of the observed cosmic ray intensity.

In order to study this "external temperature effect" more closely it was necessary to work out quantitatively the correlation between out-door temperature and barometric pressure and then — on account of this — by the method of multiple correlation (1) the correlation between cosmic ray ionisation and atmospheric pressure, and (2) the correlation between cosmic ray ionisation and out-door temperature.

This analysis of our observations of 1931-1934 has been carried out by J. A. Priebsch and W. Baldauf. The whole material was divided in 25 sections (comprising one to two months each) and the correlation- and regression-coefficients were individually calculated for each section, using daily mean values of the cosmic ray ionisation (J), temperature (T) and barometric pressure (B).

It was found that the out-door temperature effect is not constant but shows seasonal variations. On the Hafelekar (mean intensity of cosmic radiation, filtered by 10 cm. lead 2.7 J = 2700 m J) the temperature coefficient in the average of three years amounts to about −2.8 m J per degree in winter and to −1.5 m J per degree in summer.

Thus it would be incorrect to reduce the observations by using an average temperature coefficient for all seasons.

The practical use of the method of mutiple correlation was much simplified by J. A. Priebsch*) and can be applied readily without undue loss of time when daily average values of J, B and T are used. Instead of the out-door temperature T the density of the air can be introduced by a simple transformation.

The variation of the cosmic ray ionisation with the barometric pressure is usually expressed by an J/B-diagram; G. Hoffmann and E. G. Steinke were drawing these diagrams in such a way that the corresponding J/B-values of successive days were connected by straight lines. Thus a broken line-graph is obtained. Priebsch and Baldauf showed that these graphs are much more regular when the J-values are already reduced to a constant out-door temperature. It was also proved conclusively that reduction to a constant density of out-door air has the same effect as the reduction to constant temperature. In the first case, however, the correlation between cosmic ray ionisation and barometric pressure is a better one. A full account of these studies will be published in *Sitzungsberichte d. Wiener Akademie d. Wissensch.* in October 1936.

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*) J. A. Priebsch, Sitz. Ber. Wien. Akad. d. Wiss., II a, 145, pp. 101-144, 1936.

The seasonal variation of the temperature coefficient of the cosmic ray ionisation is most probably due to the different vertical mass-distribution of the air in different seasons.

II. *Cosmic Rays and Solar Activity.*

From all that we know at present it is generally considered as not very probable that even a small percentage of cosmic rays is primarily emitted by the sun. Nevertheless it seemed interesting to investigate if certain processes on the sun are accompanied by variations of the cosmic ray intensity. This analysis was carried out by H. Th. Graziadei in the Institute of the writer *(Sitzungsber. d. Akademie d. Wissensch. Wien,* II a. Bd. 145, Nr. 7/8, 1936, under press).

First the correlation with the number of flocculi was investigated. In 1931 to 1934 it was found that the intensity of the cosmic ray ionisation at the Hafelekar shows a slight decrease with increasing number of flocculi. The correlation coefficient was -0.48 ± 0.08.

Then the whole observational material was divided according to the cycles of the sun's rotation. Different periods of rotation (from 25 to 29 days) were tried out and it was found graphically that a rather regular variation of the cosmic ray intensity (expressed by the daily mean values) does result within the rotation period when this is taken as 27,2 days. The amplitude of this variation amounts to $\pm$ 7 m J. It seems therefore that according to the relative position of the surface of the sun to our planet the intensity of the cosmic radiation shows a slight but distinct variation. Now since our observations are covering as yet not much more than one third of a whole sunspot-cycle of 11 years it would be premature to draw far-reaching conclusions at present. Nevertheless a certain relation between cosmic ray ionisation and solar activity seems to be established.

III. *Irregular Fluctuations of Cosmic Ray Ionisation.*

Aside from the statistical variations the existence of irregular fluctuations of the cosmic ray ionisation (variations of the second kind, as termed by A. Corlin) was found by several authors.

Our observations show that these fluctuations of the daily mean values, sometimes amounting to as much as 2 per cent, do occur even after reduction to normal barometric pressure and to a constant out-door temperature.

The existence of these fluctuations was proved more directly and conclusively within the last few months by independent registrations of the cosmic ray intensity at two distant stations and also by simultaneous registration of counter coincidences. The two stations were 5 kilometers apart, at the Hafelekar (2300 m above sea level) and in Innsbruck (under the roof of the University Building, 600 m above sea level). The ionisation was registered by two Steinke apparatus, surrounded by lead screens, 10 cm thick on all sides (plus 7 cm iron at the Hafelekar). A double coincidence counting set was also placed at the Hafelekar with the tubes parallel and with their axes vertically above each other. The daily mean values of the ionisation and of the number of coincidences were reduced to normal pressure and then plotted with the time as abscissa. This graph shows beautifully that the variations of ionisations and of the number of coincidences occur simultaneously in both stations and therefore cannot be due to instrumental deficiencies. The graph shows a general decrease of intensity from May 27th to June 2nd and a very sharp increase beginning on the 20th of June, reaching a maximum on the 25th of June. This increase amounts to +50 m J on the Hafelekar, and +34 m J in Innsbruck, i. e. 2 per cent of the total intensity, and the counting tubes showed at the same time an increase of the number of double coincidences of +8 per cent (vertical radiation). A triple coincidence counting set, registering the number of showers (tubes in triangle arrangement) also showed a similar increase. From all this we must conclude that between the 20th and 25th of June a real increase of the cosmic radiation was registered by our instruments. The appearance of a new star (Nova Cephei), visually discovered in the night of June 18th to 19th might be a mere coincidence; it will be remembered that no effect of the last Nova (Nova Herculis) on the cosmic ray ionisation could be detected with certainty. It will nevertheless be very interesting to compare our results with the observations in other countries.

Innsbruck, July 30, 1936.

REPORT ON CONSPICUOUS INTENSITY VARIATIONS WITHIN THE AURORAL SPECTRUM DUE TO SUNLIGHT AND OTHER CAUSES

By L. VEGARD

As it appears from previous publications (1, 2, 3, 4) the auroral spectrum has been extensively explored from infrared to the limit in ultraviolet and is found to be dominated by nitrogen band systems. It is therefore very remarkable that the green line 5577 and sometimes the red one 6300 (or rather triplet) are the only strong atomic lines in the auroral spectrum. In papers published some years ago (cfr. No. 2) this fact was explained by assuming these lines to be excited indirectly by the action of activated nitrogen upon oxygen molecules.

The intensity distribution within the auroral spectrum call for great interest. The distribution of intensity of vibrational bands gives us information with regard to the excitation process, but can give us no means of temperature determinations. The intensity distribution within the rotational bands, however, gives us a very reliable method for determining the temperature of the upper atmosphere (1, 7).

The most conspicuous variations within the auroral spectrum and which are responsible for colour changes are those corresponding to changes in the relative frequency with which the electronic transitions take place, and we have here first of all to consider the transitions corresponding to the negative and the 1st and 2nd positive groups of nitrogen and the ($^1S_0$ - $^1D_2$) and the ($^1D_2$ - $^3P_{0,1,2}$) transitions of the oxygen atom, the latter two giving the green and red lines respectively.

Extensive investigations carried out since 1923 and during the last years in collaboration with Mr. E. Tönsberg led to the discovery of a considerable number of conspicuous spectral changes of which the following are the most important.

(1) Enhancement of the negative bands relative to the green line with increasing altitude, showing, that nitrogen is the dominating component up to the extreme limit of the atmosphere (cfr. paper 1).

(2) Enhancement of the bands of the 1st positive group, the negative bands and the red line 6300 from diffuse areas. (Cfr. 2, and results to be published).

(3) The intensity of bands of the 2nd positive group relative to those of the negative diminishes with increasing altitude, and is different for various auroral types. For high altitudes and for certain diffuse forms a considerable number of bands or lines appear in the region 4700-4000. The dispersion by which they are obtained is too small to allow all of them to be measured and identified. (Cfr. publ. 1, 2 and paper to be published).

(4) Enhancement of the 1st positive group producing the red-coloured aurorae of type B (red colour restricted to lower limit) (2, 8).

(5) An enormous enhancement of the red line 6300 producing the red aurorae of type A (red colour along the whole streamer) (9, 2).

(6) A most conspicuous enhancement of the red line 6300 and usually bands of the 1st positive and perhaps the negative

group of nitrogen from aurorae appearing in a sunlit atmosphere (10).

(7) A comparison between the auroral spectrum and that of the night sky luminescence showed very marked differences, which were explained when the aurorae are supposed to be mainly due to direct excitation with electric rays and the night sky luminescence to a process of recombination from excited states produced during the day (5, 6).

The enhancement of the red line 6300, responsible for the red aurorae of type A, and found for sunlit aurorae is most likely due to an excitation process which brings the oxygen atom into the $^1D_2$-state, but not to the $^1S_0$-state. In previous papers it was suggested that activated nitrogen molecules in the metastable A state acting on ozon, might give an excitation process of this kind (2, 5, 6).

A diminution of pressure might increase the probability for the ($^1D_2 - {}^3P_{0,1,2}$) transition and thus enhance the red line (6300), but this cannot explain red aurorae of type A, because we should then expect all auroral rays to be red at the top where the pressure is small.

Previous publications:

1. L. Vegard: Results of investigations of the auroral spectrum during the years 1921-1926. Geofys. Publ., v. IX, No. 11, 1932.
2. L. Vegard: Investigations of the auroral spectrum based on observations from the Auroral Observatory, Tromsø. Geofys. Publ., v. X, No. 4, 1933.
3. L. Vegard and L. Harang: The auroral spectrum in the region of long waves. Geofys. Publ., v. X, No. 5, 1933.
4. L. Vegard and L. Harang: The wave-length of the green auroral line determined by an interferometer-method. Geofys. Publ., v. XI, No. 1, 1934.
5. L. Vegard and E. Tönsberg: Die spektrale Intensitätsverteilung im Nachthimmellicht und Nordlicht. Zs. Physik, v. 88, pp. 709-726, 1934.
6. L. Vegard and E. Tönsberg: Nachthimmellicht und Nordlicht im langwelligen Spektralgebiet. Zs. Physik, v. 94, pp. 413-433, 1935.
7. L. Vegard and E. Tönsberg: Continued investigations on the temperature of the upper atmosphere determined by means of bands appearing in the auroral spectrum. Geofys. Publ., v. XI, No. 2, 1935.
8. L. Vegard: The aurorae and night sky spectra and the upper atmosphere. Trans. of American Geophys. Union, p. 38, 1935.
9. L. Vegard: On the origin of the red colour of the aurorae of Jan. 26, 1926. Nature, 117, 356, 1926.
10. L. Vegard: Enhancement of red lines and bands in the auroral spectrum from a sunlit atmosphere. Nature, v. 137, p. 778, 1936.

Physical Institute,
University, Oslo.

REPORT REGARDING PROPOSED SUB-COMMITTEE ON IONOSPHERIC RESEARCH

I. *Organization.*

It is recommended

1. that an ionospheric sub-committee of the Committee on the study of the relationship between solar activity and terrestrial magnetism of this Association be formed.
2. that this sub-committee be instructed to work in conjunction with the ionospheric sub-committee of the International Scientific Radio Union (U.R.S.I.) and with an appropriate committee of the International Meteorological Organization, Commission on Terrestrial Magnetism.
3. that this Association communicate immediately with the above mentioned bodies inviting their co-operation.
4. that the Executive Committee consider the following names to constitute the proposed sub-committee:

Appleton, *Chairman*
Berkner, *Secretary*
Chapman
Martyn
Mitra
Jouaust

II. *Purposes and functions.*

1. To maintain a current list of all stations conducting ionospheric investigations.
2. To consider the most strategic distribution of a world-wide network of stations for ionospheric investigations and to take steps toward the recommendation of additional suitable sites to the appropriate local authorities.
3. To encourage and facilitate the fullest interchange of constructional data in order that the work in different parts of the world may proceed with the minimum duplication of effort.
4. To consider and recommend the details of types of measurements by which the ionospheric characteristics may be most readily determined and to communicate these recommendations to all adhering organizations.
5. To encourage and arrange for the prompt interchange of data between organizations conducting such measure-

ments, and to consider and recommend methods of such interchange of information.

6. To report to the full commission prior to the next general session of the Union.

E. V. APPLETON. L. V. BERKNER.

C. Atmospheric and Terrestrial Electricity.

SUR LES CARACTÉRISTIQUES DE L'APPAREIL DE GERDIEN ET LEUR VARIATION SAISONNIÈRE

Par W. SMOSARSKI

On peut déterminer la conductibilité électrique de l'air atmosphérique à condition que la tension qu'on emploie dans l'appareil soit assez faible, de sorte que l'afflux d'électricité dû aux ions reste proportionnel au champ du condensateur. Mais les déterminations anciennes de conductibilité étaient faites fréquemment avec des tensions trop fortes qui ne répondaient pas à la condition indiquée. Il me semblait donc utile d'examiner plus en détail les variations du courant ionique dans l'appareil de Gerdien en fonction de la tension du condensateur de la même manière qu'on le fait pour les appareils plus perfectionnés, comme les compteurs d'ions, et de construire en particulier les courbes caractéristiques correspondant aux différentes saisons de l'année.

L'appareil employé à Poznan est composé de trois cylindres. Le cylindre extérieur muni d'un ajutage divergent reste relié au sol, le cylindre intermédiaire (13.9 · 41.5 cm) est isolé et porté à un potentiel choisi; l'électrode intérieure (1.5 · 25.4 cm) reliée à l'électromètre bifilaire de Wulf est d'abord mise au sol, puis isolée et se charge des ions captés pendant l'expérience. La capacité électrostatique du système électrode-électromètre (déterminée à l'aide du condensateur de Wulf) est 12.1 cm, la capacité de l'électromètre avec une tige de diamètre et de longueur convenable, atteignant l'ouverture de la paroi du cylindre intermédiaire, est 4.0 cm; la capacité de l'électrode seule et de la partie de leur tige surmontant la paroi du cylindre est donc 8 cm environ. L'électromètre est muni d'une pile de charge de 50 volts, ce qui assure la constance de la sensibilité. Pour les prises de potentiel, de bonnes batteries des piles sèches de radiophonie ont été employées. L'électromètre et les piles étaient étalonnés à l'aide d'une batterie étalon de piles de Krueger. Le ventilateur est mû à main et l'uniformité de la rotation est vérifiée à l'aide d'une montre à secondes. La vitesse du courant était 140 cm/sec. Pour déterminer la fuite de l'électromètre par le défaut de l'isolement, deux expériences étaient faites successivement avec l'appareil clos; le cylindre intermédiaire étant relié au sol on observait d'abord la chute a du potentiel de l'électromètre chargé préalablement; puis la prise du potentiel correspondant était portée au cylindre intermédiaire et on notait le potentiel b acquis par l'électrode intérieure par l'afflux des ions dans le même intervalle de temps. La différence $a - b$, qui pouvait atteindre 70 % de la perte totale a, représente à peu près la fuite de l'électromètre par le défaut d'isolement. La correction qui en résultait se montrant négligeable dans les conditions des observations, je n'en tenais pas compte. L'appareil était nettoyé soigneusement chaque fois.

Le cylindre intermédiaire était porté successivement aux potentiels négatifs proches des valeurs suivantes: 10, 20, 30, 40, 60, 100, 150, 200 et 250 volts. Chaque expérience durait 5 minutes ou la moitié de cet intervalle de temps, si les déviations de l'électromètre devenaient assez grandes. Les expériences étaient répétées en chaque série dans l'ordre inverse des degrés du potentiel, pour réduire l'influence de la variation diurne de la teneur en ions de l'air atmosphérique et de causes de perturbation accidentelles. Les expériences étaient faites entre 10 et 12 heures. Le nombre des courbes caractéristiques trouvées depuis l'été de 1935 jusqu'au mois de juillet de 1936 est de 38. En rapportant le potentiel mesuré v de l'armature intérieure dû aux ions captés, à la tension moyenne du condensateur entre V au commencement et $V—v$ à la fin de chaque observation partielle, j'ai déterminé par interpolation les valeurs du courant ionique correspondant aux valeurs arrondies indiquées de la tension du condensateur et j'en ai calculé les valeurs moyennes pour chaque saison de l'année. Les résultats moyens sont représentés dans le tableau suivant.

On en peut tirer les remarques suivantes:

(1) Le rapport v/V va en diminuant, commençant même par les valeurs les plus faibles du potentiel employées. On ne peut donc, suivant les observations présentées, établir une limite du potentiel, au-dessous de laquelle l'afflux des ions soit rigoureusement proportionnel au champ du condensateur. Cependant, si l'on calcule la conductibilité pour les diverses prises du

Tension moyenne du condensateur en volts

	—10	—20	—30	—40	—50	—100	—150	—200	—250
	Charge négative de l'armature intérieure due aux ions, en volts par minute								
Eté	.62	1.22	1.77	2.27	2.70	4.45	5.37	5.16	5.16
Automne	.45	.87	1.25	1.62	2.00	2.86	3.73	3.66	3.64
Hiver	.26	.48	.71	.94	1.12	1.81	2.27	2.31	2.34
Printemps	.45	.83	1.19	1.55	1.96	3.15	3.85	4.04	3.98

potentiel jusqu'à 40 volts par la formule, au cas actuel $\lambda = 0.12/t \cdot \log \text{nat} (V+v/2) : (V-v/2)$, on reçoit des valeurs concordantes à la 4ième décimale près.

(2) Si l'on désigne la valeur de l'expression $\log (V+v/2) : (V-v/2)$ pour la prise du potentiel 20 volts par 100 % et exprime conformément les valeurs pour les potentiels 50, 100 et 150 volts, on reçoit le tableau suivant:

Tension	Eté	Automne	Hiver	Printemps	Année
	Valeurs relatives du logarithme				
20 volts	100 %	100 %	100 %	100 %	100 %
50	89	92	94	85	90
100	73	67	75	76	73
150	59	57	63	62	60

On peut s'en rendre compte de l'erreur qu'on commettrait en calculant la conductibilité, si la tension du condensateur était trop forte, par exemple 100 ou 150 volts. Cependant, les pourcentages présentant une marche annuelle qui n'est pas très prononcée ni régulière, on aurait bien raison de considérer les valeurs calculées comme des valeurs relatives de la conductibilité qui se prêtent assez bien à représenter la variation annuelle de la conductibilité, à condition qu'on portait le condensateur toujours au même potentiel initial et employait la même vitesse du courant d'air.

(3) L'afflux des ions va en croissant jusqu'à la tension du condensateur, de 150 volts, mais à 200 volts il se montrait le plus souvent affaibli. Suivant les recherches de *Yo Itiwara* (Phys. Zt., 1931, p. 97) on doit attribuer ce phénomène à l'action du champ du condensateur qui empêche que les petits ions ne pénètrent dans l'appareil.

Les remarques que je viens d'exposer concernent les ions négatifs. Les circonstances pour les ions positifs semblent différentes. Ainsi des comparaisons faites pendant plusieurs jours ont montré que les valeurs calculées pour la conductibilité des ions positifs à la tension du condensateur 42 volts étaient de 10 % au-dessous de celles à la tension de 21 volts, tandis que les valeurs pour les ions négatifs étaient concordantes en moyenne dans les mêmes limites de la tension. De plus, en variant la vitesse du courant d'air aspiré dans l'appareil, j'ai constaté que l'augmentation de la vitesse pouvait produire un afflux croissant des ions positifs, bien que les variations de vitesse semblables laissaient l'afflux des ions négatifs invariable. Cette observation s'accorde bien avec l'opinion que les ions positifs ont une mobilité plus faible que celle des ions négatifs.

Institut de Météorologie de l'Université de Poznan.

NEW ASPECTS OF EARTH-CURRENT CIRCULATIONS REVEALED BY POLAR-YEAR DATA

By O. H. GISH and W. J. ROONEY

A study made during the past year has shown that the earth-current data recorded at College, Alaska, and at Chesterfield Inlet, Canada, during the Second International Polar Year

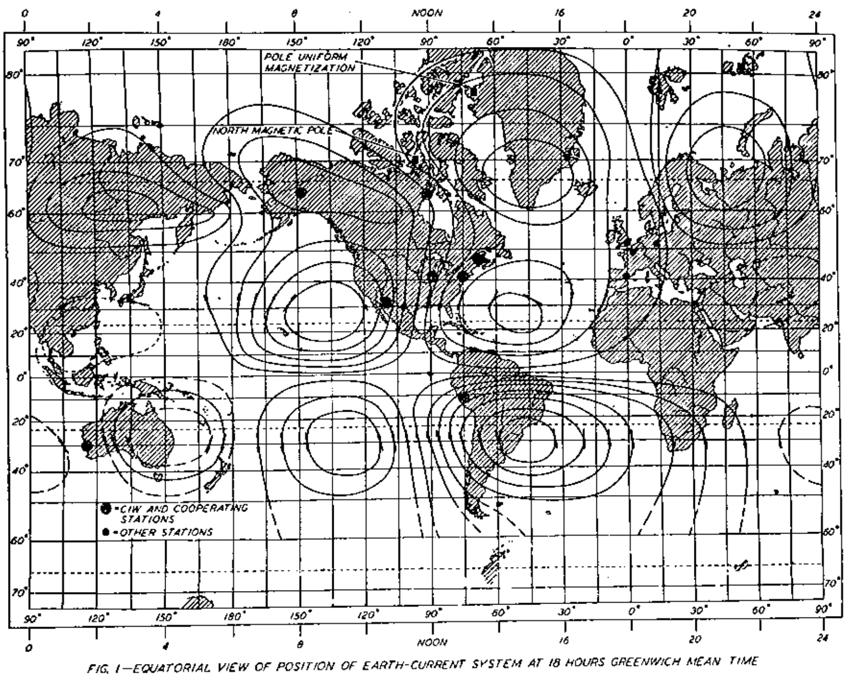


FIG. 1—EQUATORIAL VIEW OF POSITION OF EARTH-CURRENT SYSTEM AT 18 HOURS GREENWICH MEAN TIME

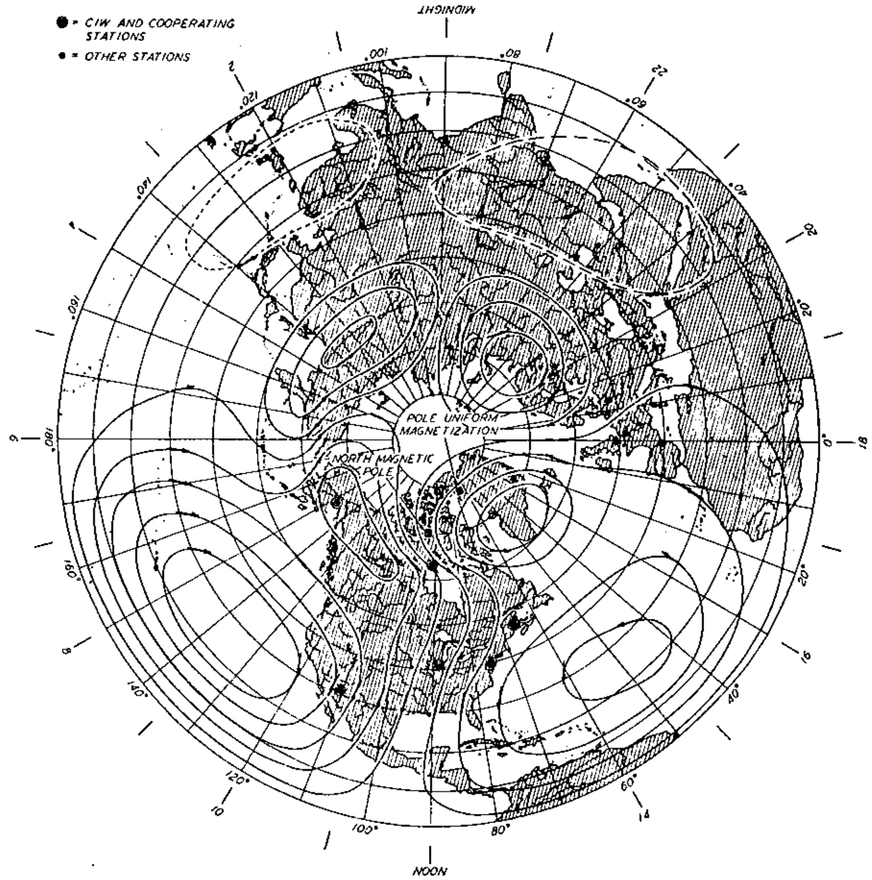


FIG. 2—POLAR VIEW OF POSITION OF EARTH-CURRENT SYSTEM AT 18 HOURS GREENWICH MEAN TIME

contain convincing evidence of the existence of a polar system of electric circulation in the Earth's crust. That such a system exists in lower latitudes has been apparent for some time, but no satisfactory delineation of this has been published.

In that study, upon which this brief report is based, an attempt was made to construct on a world map the boundaries of tubes of flow in such a way as to be consistent with the mean diurnal-variation in the observed earth-current intensities on quiet days. The type of chart obtained is shown in Figures 1 and 2. Although all the principal series of available earth-current data have been examined in a similar manner, yet the charts exhibited here are based, in so far as concerns their quantitative aspects, wholly upon data from three stations, namely: Watheroo, Western Australia; Tucson, Arizona, United States; Chesterfield Inlet, Canada. A selection was necessary because no satisfactory means has been found for constructing a chart in such a way that it would constitute the "best fit" for all the available data. However, the other data, especially that for Huancayo, Peru, did serve as a guide in the construction of some parts of the charts. No special merit is claimed for this particular selection except that the use of the data from Chesterfield Inlet along with those for Tucson may represent the relation between the polar- and the lower-latitude circulations better than do the data from College because Chesterfield Inlet and Tucson are in nearly the same geomagnetic longitude.

The curves on the charts of the electric circulations are constructed in such a way that two adjacent curves represent the boundaries of a tube of flow. Those tubes which are bounded by solid lines contain the same amount of current, except the innermost ones which in some cases are not full tubes. In order to show some of the weaker eddies, it was necessary to subdivide certain tubes into halves and sometimes into quarters. These are outlined by broken lines with long segments for the halves and short segments for the quarters. The direction of flow is indicated by arrows. The interpretation of these charts is briefly as follows.

Electric currents in the Earth's crust circulate in a number of extensive eddies. Eight of these are located in the middle and low latitudes. Four in the Northern Hemisphere and four in the Southern Hemisphere form a symmetrical arrangement about the equator. The centers of these eddies are about equally spaced in longitude and lie near the tropics of Cancer and Capricorn, respectively.

Four other eddies also appear in high northerly latitudes with their centers near the arctic circle. These also are about equally spaced in longitude. A corresponding set of eddies presumably exists in high southerly latitudes, but data to establish the fact are not available.

All these eddies follow the Sun in such a way that eight of them are always on the sunlit side of the Earth and eight on the dark side. The current in the daylight eddies of middle latitudes is considerably greater than that in the corresponding night-time eddies. However, a contrast of this character is not a common feature of the circulations constructed from data obtained at high latitudes. The centers of the forenoon eddies in middle latitudes lie near the meridian for which the time of day is 9 a.m., while the afternoon eddies center on the meridian for which the time is about 3 p.m. This feature varies between stations by as much as two hours. The current circulation is clockwise in the forenoon eddy of the Northern Hemisphere and in the afternoon eddy of the Southern Hemisphere. The sense of the circulation in the other middle-latitude eddies may be ascertained by applying the rule that the sense of circulation is opposite in any two adjacent eddies of corresponding latitude. Thus the circulations in the eight eddies of the middle-latitude belt are related in the same way as are the rotations in a series of interlocking gears when oriented in a manner similar to that of these eddies.

The rule just stated applies to the circulations in the four eddies of a high-latitude belt but it does not seem to describe the relationship between a high-latitude eddy and the adjacent eddy of the lower-latitude belt, for here the sense of circulation is the same in each eddy of such a pair. As a result, there is an area between these eddies in which the currents (or impelling forces) of the two eddies are in conflict. The recognition of this circumstance helps to reconcile some earth-current data which heretofore seemed to be inconsistent with the majority of observations.

The entire system of eddies moves with the Sun in its apparent daily motion so that a given place on the Earth will at different times of day occupy different positions in the system of eddies. It is in this way that the intensity and direction of the electric currents in the Earth at a given place vary on a daily schedule, and that this schedule in turn varies with the latitude of the place.

Because of the great contrasts in electrical conductivity presented by different constituents of the Earth's crust, especially that between sea-water and land, and because of the irregular distribution of these, considerable tolerance must be allowed in the simple picture which is presented by the charts.

This picture will better represent the observed facts if the eddies are regarded as very flexible, easily deformable, so that their content may vary, their shape be distorted, and their progress around the Earth may be halting and devious, all to an extent and in such manner as to be in conformity with the distribution of the electrical properties of the Earth, especially of that portion which constitutes the more immediate environment of a given eddy. It also seems likely that the development and orientation of the eddies is complicated by the fact that the magnetic axis of the Earth does not coincide with its geographic axis.

If due allowance is made for these modifying factors, which cannot yet be taken into account in a quantitative way, then this interpretation will, it is believed, be found in accord with the observed facts.

This interpretation, in addition to unifying observed quiet-day earth-current phenomena, may well serve as a guide when consideration is being given to the location of new stations for the registration of earth-currents. Thus, for example, it would seem desirable to obtain registrations at stations located in magnetic latitude 15° to 20° north or south and also in about magnetic latitude 80° north in order to better locate the centers of the low-latitude and the high-latitude eddies, respectively. It would also seem advisable to avoid locations within the belt of confusion which lies between the high-latitude and the low-latitude circulations.

The improved perspective in which it now seems possible to view earth-current phenomena may be regarded as an achievement of the Second International Polar Year and should accordingly be a source of satisfaction to the Association of Terrestrial Magnetism and Electricity and to the International Polar Year Commission whose members by their tireless and effective efforts made the realization of that project possible.

Dep. Terr. Magn., C. I. W., July 31, 1936.

INFORMATION TO BE OBTAINED FROM SOME ATMOSPHERIC-ELECTRIC MEASUREMENTS IN THE STRATOSPHERE

By O. H. GISH and K. L. SHERMAN

On the stratosphere flight, sponsored by the National Geographic Society and the United States Army Air Corps, which was made on November 11, 1935, in the balloon *Explorer II* commanded by Major Albert W. Stevens and piloted by Captain Orvil A. Anderson, one of the scientific projects was to obtain a continuous registration of the electrical conductivity of air. This was satisfactorily accomplished with apparatus designed and constructed at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The results and some of the conclusions which have been derived from the record contain points of interest, which it seems appropriate to present before the Association of Terrestrial Magnetism and Electricity of the International Union of Geodesy and Geophysics, especially since a report of some features, which suggest projects and programs for the future, may further the objectives of the Association. It shall, therefore, be our purpose in this report to stress features which indicate wherein further direct measurements of the atmospheric-electric elements in the high atmosphere may aid, not alone in the study of atmospheric electricity, but also in the solution of other problems of the atmosphere.

The apparatus used for registering air-conductivity on this flight consisted of a conventional Gerdien condenser mounted in a vertical position outside the gondola, with its mid-point about 16 inches (41 cm) away from the gondola and lying in its equatorial plane. The condenser was supported by a cylindrical neck through which passed a fine wire that connected the central element of the condenser with the recorder inside the gondola. Air was circulated through the condenser at a velocity af 880 feet per minute (when the balloon was stationary) by an electric fan. A device, termed an electrostatic pilot, governed the recharging of the central element of the Gerdien condenser. As soon as a definite predetermined quantity of electricity had been dissipated the pilot first provided a preliminary recharge. The charging pulse, through capacitative coupling with a vacuum-tube amplifier, was made to actuate a pen, which marked the event by an instantaneous departure from the spiral which it normally traced on a rotating disc of paper. The amplified pulse acting through a relay also operated an electromagnetic contactor which supplied the final charge to the central system. The potential of this contactor could be readily controlled so that at the start of an interval of measurement the central system was at a potential either greater or less than that previously applied directly by the pilot. In this way the quantity to be dissipated between charges could be readily altered, thus providing a means of changing the sensitivity of the recorder. The change of sensitivity accomplished in this way, together with that which could be effected by changing the field across the Gerdien condenser, permitted the selection of a wide range of sensitivity. In operation, one of five available sensitivities could be selected as required by turning a dial to the appropriate position. The sensitivities provided for were related roughly as the terms of a geometrical progression with a common ratio of about 3, the highest sensitivity being 38.5 times the lowest. With this range of sensitivities, and the normal range at a given sensitivity, satisfactory records could be obtained if the conductivity varied more or less steadily with altitude from the usual value at the surface up to 1000 times that value. A switch was provided for selecting the sign of the polar conductivity which it was desired to record. It was planned to record positive and negative conductivity alternately for intervals of five minutes, but this required more attention from the balloonists than it was possible for them to give to this aspect of the crowded program which they had to carry through. The electric fan in the end of the Gerdien condenser was operated by a 12-volt storage-battery, which was also used for other equipment. Exclusive of this storage-battery, the entire weight of the equipment for recording conductivity was 50 pounds (23 kg).

A photographic copy of the record obtained on this flight, with some auxiliary information added, is reproduced in Figure 1. The spiral is generated from the center outwards at the rate of one turn per hour. The marks or "teeth" on the spiral constitute a record of the times when the system was recharged. They are on the convex side for positive conductivity

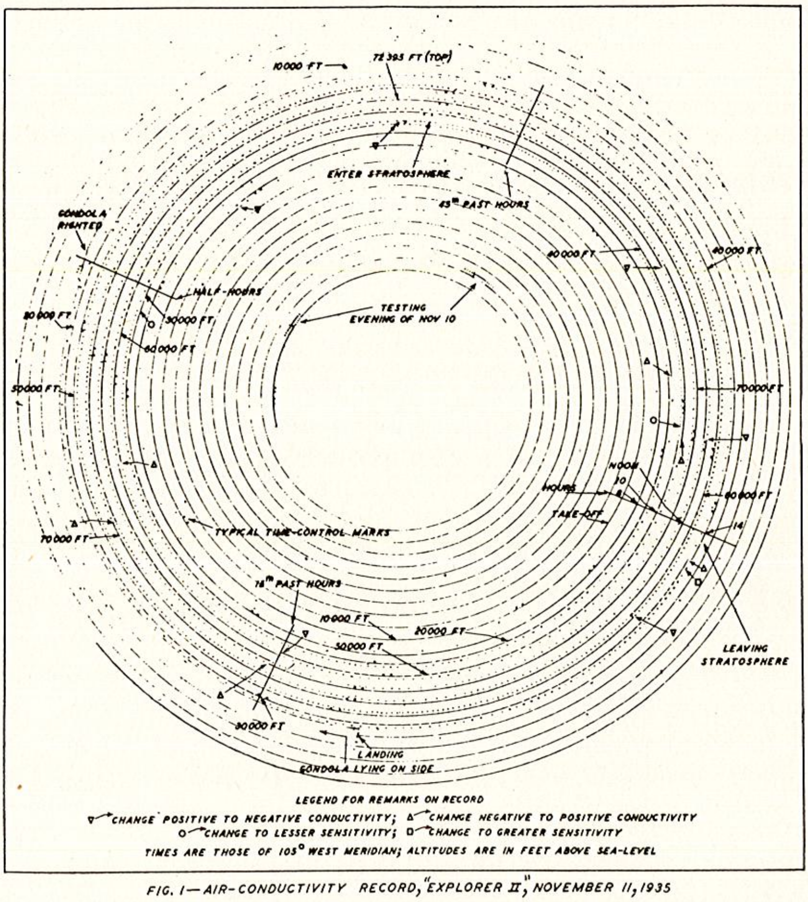


FIG. 1—AIR-CONDUCTIVITY RECORD, "EXPLORER II," NOVEMBER 11, 1935

and on the concave side for negative conductivity. When the instrument is switched from the recording of positive to the recording of negative conductivity, the spiral is abruptly displaced outward and remains thus displaced as long as that sign of conductivity is being recorded. Time-control marks, which appear in pairs 15 seconds apart at intervals of about 15 minutes, occur as displacements on the concave side of the spiral. The length of these displacements is less and their duration is greater than in the case of the charging marks and, furthermore, a charging displacement and a time displacement are additive when they occur simultaneously. These characteristics enable one to identify the charging marks when they occur simultaneously with a timemark.

It is, of course, obvious that for a given sensitivity-setting the charging marks are more closely spaced the greater the conductivity. From the spacing of the marks on this record it can be seen at once that, although there are minor irregularities, the conductivity generally increases with altitude.

The values of conductivity derived from this record by taking the average frequency of marks over altitude-intervals of about 1000 feet are shown graphically in Figure 2, where

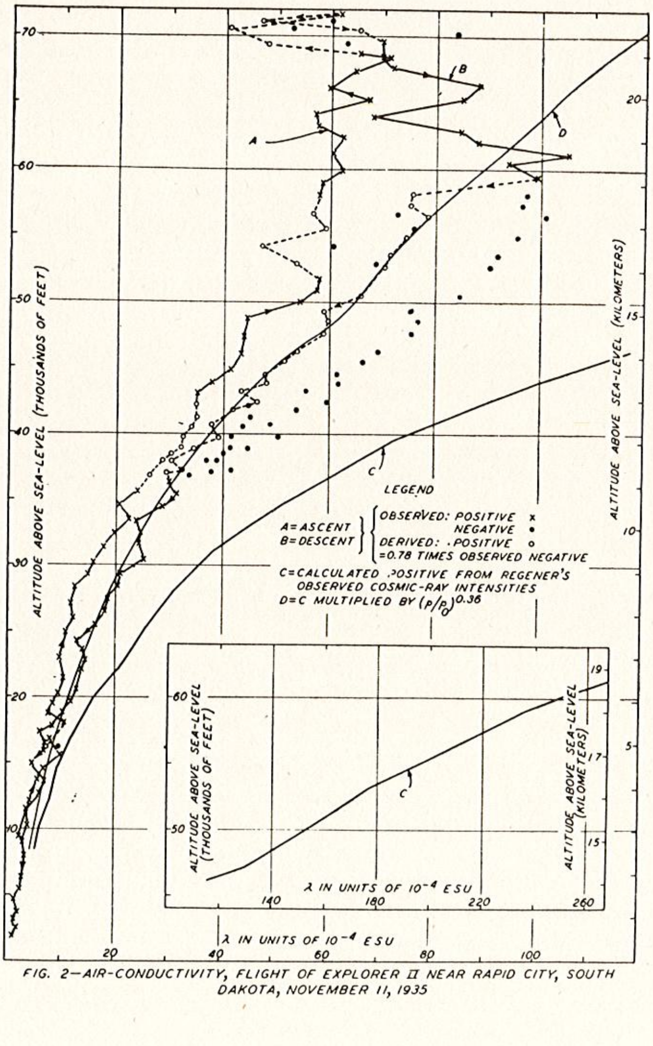


FIG. 2—AIR-CONDUCTIVITY, FLIGHT OF EXPLORER II NEAR RAPID CITY, SOUTH DAKOTA, NOVEMBER 11, 1935

the altitude above sea-level is shown as ordinate and the polar conductivity as abscissa. The record, as can be seen by inspection of Figure 1, contains many details not shown in this chart. A discussion of those shall not be undertaken here further than to say that an attempt to correlate them with activities on the craft, such as discharge of ballast, velocity of ascent or descent, etc., have shown no relationship except that the negative conductivity is, at the highest altitude, related to the velocity of ascent of the balloon. Graph A, Figure 2, represents the values of positive conductivity during the ascent and Graph B that for the descent. Aside from the increase of conductivity with altitude, one of the first features to be noted is that the values recorded on the ascent are generally less than those recorded on the descent. The only suggestion which can be offered to account for this feature is that the sample of air involved in a measurement on the ascent may have been "polluted" by its previous proximity to the large balloon, whereas on the descent the sample was taken from the uncontaminated air into which the gondola was continuously moving at an average rate of about 500 feet per minute. The values measured on the descent should, therefore, be representative of conditions prevailing in the free atmosphere. According to this observation it seems preferable when measuring air-conductivity on balloon-flights to utilize the descent for this purpose. It may be mentioned here that these data show not the slightest trace of such ion-densities as would be required to return radio waves (R. C. Colwell and A. W. Friend, *Nature,* v. 137, p. 782, 1936; R. A. Watson Watt, L. H. Bainbridge-Bell, A. F. Wilkins, and E. G. Bowen, *Nature,* v. 137, p. 866, 1936; and S. K. Mitra, *Nature,* v. 137, p. 867, 1936).

Attention is next invited to the relation between values of positive and of negative conductivity — the former marked by oblique crosses, the latter by solid circles. The negative conductivity is generally greater than the positive values recorded at the same level, the only significant exception being the group of negative values shown near the top of the chart. These values are doubtless too small because calculation, in which account is taken of the ascensional velocity of the balloon together with the pressure and other pertinent factors, indicates that for the measurements of negative conductivity at this level the conductance across the airstream in the Gerdien condenser was not of an ohmic character, at least for the higher ascensional velocities. Furthermore, the correlation of negative conductivity with the ascensional velocity of the balloon, which was sometimes rising and sometimes falling at this level, bears out the conclusion derived from the calculations. This comparison also yields a rough estimate of the mobility of the negative ions at this altitude, which is of interest in that it corroborates the conclusions regarding negative ion-mobility derived by a comparison of the values of negative and of positive conductivity measured at other levels.

Except for the group of values just mentioned, the ratio of negative to positive conductivity is approximately constant at all altitudes where comparison is possible. This is shown by the satisfactory alignment of the points which correspond to the observed values of positive conductivity — those marked by crosses — with those which are marked by open circles. The abscissae for the latter were obtained by multiplying the observed values of negative conductivity by a constant. The constant which was used (0.78) is the ratio of the mobility of the positive to that of the negative ion in air at standard temperature and pressure, the former being taken as 1.4 and the latter as 1.8 cm^2 $volt^{-1}$ sec^{-1}.

From this observation it seems necessary to conclude that the ratio of positive to negative conductivity, under the circumstances which prevail in the free atmosphere, is constant over the range of pressures from 760 to 30 mm of mercury. This unexpected result, which we have been unable to trace to an instrumental source, harbors important implications, which will now be discussed.

In order that the air-to-earth electric current may be continuous, the number of positive ions must, on the average, be nearly equal to that for negative ions at a given altitude, except very near the Earth's surface, and hence the ratio of the polar conductivities should be equal to the ratio of the mobilities. However, measurements made in the laboratory, as reported and interpreted in handbooks and treatises on the conduction of electricity in gases, would have the negative mobility increase relative to the positive, beginning slowly at about 200 mm of mercury and progressing rapidly at pressures of 100 mm and below. The results reported by Kovarik (*Phys. Rev.*, v. 30, p. 415, 1910) would lead one to expect the negative conductivity to be at least eight times the positive conductivity at the maximum altitude of this flight. The failure to realize this expectation calls for a careful examination of the following: (a) Whether the conductivity-measurements as a function of pressure may have been vitiated through faults in the measuring instruments or by obtaining samples of air which were not representative; (b) whether the results of the study of mobility made in the laboratory have been correctly interpreted; or (c) whether there exist factors in the free atmosphere which prevent the effect observed in the laboratory. Such an examination can not be reviewed here. It must suffice to say that several lines of evidence seem to exclude (a), especially during the descent. As regards (b) there seems to be ground for thinking that the usual interpretation of the results of investigations in the laboratory of the mobility versus pressure is too general. It is doubted whether enough is yet known about factors which may critically affect the negative mobility at low pressures to enable one to give much consideration to (c). Lattey *(Proc. Roy. Soc.,* v. 84, p. 415, 1910) reports that in air at low pressures, such as come into account here, the negative mobility is much less than that in dry air. Perhaps there is sufficient water-vapor in the air, even at altitudes as great as 22 km, to prevent the ratio of mobilities from increasing at the lower pressures.

The absolute value of the ratio of the mobility of negative ions to that for positive ions may also be a criterion of the presence of water-vapor for Erickson (*Phys. Rev.,* v. 34, pp. 635-643, 1929) reports that in very dry air at atmospheric pressure this ratio should be close to unity, while Griffiths and Awbery *(Phys. Soc. Proc.,* v. 44, pp. 240-247, 1929) find that the negative mobility decreases 18 per cent as the relative humidity increases from 0 to 100 per cent.

The foregoing is designed to show a type of information which may be derived from air-conductivity measurements in the high atmosphere. However, it seems obvious that in order for some aspects of this information to be definite, further studies in the laboratory pertaining to the mobility of ions in air are required. The conductivity-data would, of course, be enhanced for this purpose if both positive and negative conductivities were registered continuously or, next best, if measurements of these were made alternately and over intervals just long enough to yield satisfactory precision. A simple method of making a direct measurement of the ratio of the polar conductivities or of the mobilities of positive and negative ions would be helpful for this type of investigation.

Some other points of interest have come from a joint consideration of these air-conductivity data and measurements of the intensity of the cosmic radiation which were kindly sent us by Professor E. Regener. These were obtained on a sounding-balloon flight from Stuttgart, Germany, May 19, 1934, and are regarded by Professor Regener as the most reliable data he has thus far obtained. It should be noted that the magnetic latitude of Stuttgart is within a degree of that for Rapid City, South Dakota. The cosmic radiation is doubtless the only important ionizing agency in most of the region of the atmosphere with which we are here concerned, namely, from 1.5 to 22 km above sea-level. Hence, values of positive conductivity were calculated assuming that the air contained no condensation-nuclei and using the following relations: (a) The mobility, k, varies directly with the absolute temperature, T, and inversely with pressure, p; (b) the rate of formation of ion-pairs, q, in the open air is directly proportional to the measure of cosmic-radiation intensity, I, expressed in ions per cubic centimeter per second at standard temperature and pressure, and to the density of air; (c) the population-density of ion-pairs, n, is equal to the square root of the quantity, q, divided by the recombination-coefficient, α; (d) the recombination-coefficient varies directly as the pressure and inversely as the 7/3 power of the absolute temperature; (e) the positive conductivity is the product of the electronic charge, e, the mobility of the positive ions, k_1, and the population-density of ions, n. The following values of the constants at standard temperature and pressure were used: $(k_1)_0$: 1.31 $cm^2\,volt^{-1}\,sec^{-1}$; α_0 : 1.6×10^{-6}.

The values for positive conductivity obtained from this calculation are represented by graph C of Figure 2. It will be noted that every one of these values is greater than that observed at a corresponding altitude. A difference of this character, but decreasing with altitude, was expected for altitudes up to five or six km on account of the presence there of condensation-nuclei (see graph B, Fig. 4) to which the small ions readily become attached, thus forming large and relatively immobile ions which contribute little to electrical conduction in the air. However, it seems unlikely that the difference between the values observed and those calculated for altitudes above six km may be attributed to the presence of nuclei. It would be difficult to account for the quantity of nuclei and the character of their distribution which are required for such an explanation. For example, the distribution of nuclei should be such that in the altitude-range 6 to 18 km their effect varies quite regularly as the reciprocal of the pressure. The distribution of nuclei up to an altitude of nearly nine km observed by Wigand (*Ann. Physik,* v. 59, pp. 689-742, 1919), see graph B, Figure 4, on 14 balloon-flights indicates that their effect should vary directly as the pressure and that this should be negligible at an altitude of six km and above.

Confronted with these circumstances, a reexamination was made of the assumptions and relationships involved in the calculations. This led to the suspicion that the dependence of the recombination-coefficient upon pressure under conditions which obtain in the atmosphere may differ from that used in the calculations. Although several investigations in the laboratory indicate that this coefficient varies as the first power of the pressure, others have indicated a lower power and several have shown no dependence on pressure. In the most recent investigation, that of E. Lentz (*Zs. Physik,* v. 76, pp. 660-678, 1932), the first-power relation was found (this paper summarizes the results of others), whereas J. Schemel, a few years earlier, found no dependence. Apparently many difficulties attend the investigation of this relationship, and perhaps not all these have yet been overcome.

This surmise is strengthened by the observation that the ratio of the calculated to the observed conductivity-values varies as a simple function of the pressure throughout the range of altitudes from 6 to 18 km. This function is the 0.36 power of the pressure, expressed in atmospheres. The exponent, 0.36, was determined by applying the method of least squares to all the data obtained during the descent from the 18-km level to the 6-km level. The nature of the fit may be seen by comparing graphs B and D of Figure 2. The data for lower levels were not used because it is expected that factors, for which allowance could not be made in the calculations, are more or less active there. The reason for omitting the data for higher levels from consideration when making this adjustment will be seen from an inspection of Figure 2, namely, the anomalous character of that data. Further discussion of this will be given later.

If the adjustment of the calculated data, mentioned above, is regarded as a correction upon the relationship between the recombination-coefficient and the pressure, then one must conclude that this comparison of air-conductivity data and data of cosmic-radiation intensity indicates that, for the conditions which prevail in the free atmosphere, the recombination-coefficient for small ions in air varies as the 0.28 power of the pressure.

It is not intended to claim that the evidence presented is adequate to establish this relationship. It may be suggestive rather than definitive, in that it points toward the need for a reinvestigation of this, a relationship which is required for the consideration of various electrical phenomena of the atmosphere. In order to illustrate this, it may be mentioned that estimates which have been made of the population-density of ions maintained in the ionosphere by a given agency are two orders of magnitude greater than the estimates which are obtained when the relationship given above is used.

Information of another type is derived from a joint consideration of the air-conductivity observed on the flight and the air-earth current-density measurements made at the surface of the Earth. If the reciprocals of the values of air-conductivity, or the values of air-resistivity, are integrated from the Earth's surface up to a given altitude, the resistance of a column of air of unit cross-sectional area is obtained. The values of resistance obtained in this way may be read from the graph in Figure 3 by referring to the scale at the top of the Figure. The potential, relative to the Earth, of a point at a given altitude in the atmosphere, may be ascertained from the graph by referring to the scale at the bottom of the Figure. The asymptote of this graph is obtained by extrapolation from 18 km to "infinity", on the assumption that the population-density of ions is constant at all higher altitudes. This over-simplified assumption is not in accord with the conductivity-values measured at altitudes greater than 18 or 19 km. However, the decrease in conductivity at these higher altitudes is probably not a permanent feature, nor is it likely that it extends to altitudes far beyond that reached in this flight. The limiting values defined by the asymptote of the graph may therefore have some significance.

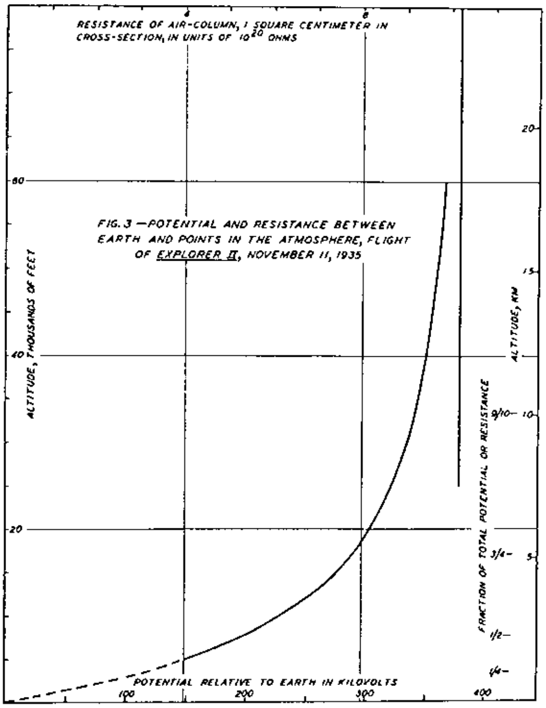
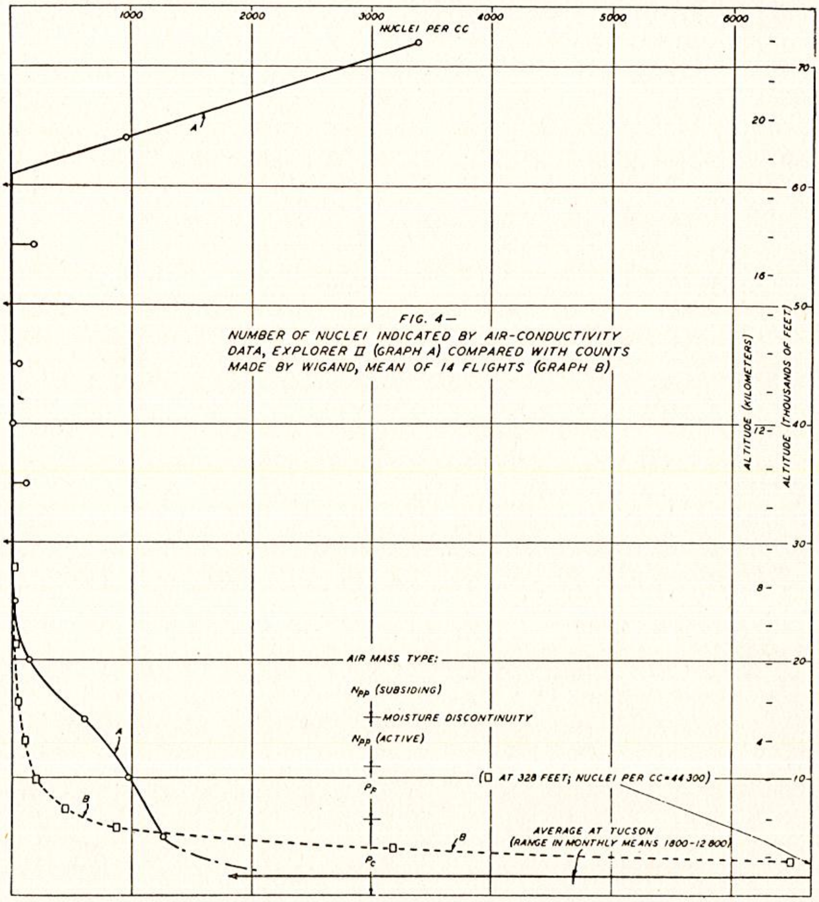


FIG. 3 —POTENTIAL AND RESISTANCE BETWEEN EARTH AND POINTS IN THE ATMOSPHERE, FLIGHT OF EXPLORER II, NOVEMBER 11, 1935

This may then indicate that the high atmosphere (say, the ionosphere) is at about 400.000 volts higher potential than the Earth. The potential and the resistance increase rapidly with altitude at the lower levels, so that nearly half the limiting value of each is found at an altitude of two km and nine-tenths at an altitude of ten km. From this it can be seen that any process which would, for example, double the electrical conductivity of the air throughout the troposphere may be expected to nearly double the electric current which normally flows from air to Earth. So far as the features illustrated by Figure 3 are alone concerned, one would expect the average air-earth current to be greater over a high plateau than over a low-lying plain.

As has already been noted, the air-conductivity values observed on the descent from altitudes between 18 to 6 km may be reconciled with the observed values of cosmic-ray



intensity provided the relationship for calculating conductivity from the cosmic-radiation data is revised. However, below six km and above 18 km the revised calculation yields values which are greater than those observed. (See graphs B and D, Fig. 2). If these differences are attributable to the presence of dust or condensation-nuclei, then the distribution of the dust and nuclei in the atmosphere up to 22 km at the time and place of this flight may be described with the aid of Figure 4. In that Figure ordinates represent altitude and abscissae represent the number of nuclei per cubic centimeter. The means of values observed by Wigand with an Aitken counter on 14 balloon-flights are also shown here by the broken curve. Although the individual values which go to make up his means fluctuate over a considerable range, especially at the lower levels, yet on the average the number of nuclei over central Europe, where his observations were made, apparently decreases with altitude in a fairly regular manner, becoming negligibly small at about 6-km altitude.

The number of nuclei per cubic centimeter as here calculated from the conductivity-data is of somewhat doubtful quantitative significance because it is not definitely known how some factors (namely, the combination-coefficients of small ions with large ions and with neutral nuclei) involved in such a calculation vary with temperature and pressure. However, it is thought that the values shown graphically in Figure 4, especially those for the lower levels, are a sufficient approximation for the present purpose, which is chiefly to illustrate another sort of information which may apparently be derived from a joint consideration of measurements of air-conductivity and of cosmic-radiation intensity.

No estimate of the distribution of nuclei at levels below 1.5 km can be made from the air-conductivity data except by extrapolation, which, however, indicates that the nuclei-content in that region was less than the average observed by Wigand. This seems reasonable because in the sparsely settled area over which the conductivity-measurements were made there are no large cities and relatively few towns such as doubtless contributed large numbers of nuclei to the atmosphere in the regions where Wigand's observations were made. The number indicated at levels between 1.5 and 6 km is greater than that reported by Wigand. This is within a body of air which appears to be of Polar-Pacific origin, but the indicated number of nuclei is somewhat greater than has been observed at sea on the *Carnegie.* It therefore seems likely that additional nuclei have been carried to these altitudes while this air was traversing land where the number of nuclei at the surface is generally much greater than at sea.

From analyses kindly supplied by the United States Weather Bureau, it appears that Polar-Pacific (P_p) air, overrunning Polar-Continental air, extended from about 2-km to more than 3-km elevation and that above this a layer of active transitional Polar-Pacific (N_{pp}) air extended to a height of over four km. The excess of nuclei, relative to the trend indicated by Wigand's data, appears to be associated chiefly with the Polar-Pacific air-masses. That there could have been sufficient mixing to carry nuclei up from the Earth while these air-masses crossed the 1000 miles of high plateaus and mountain-ranges seems not unlikely. In a study of dust-storms which occurred over the Great Plains in recent years, G. R. Parkinson *(Bull. Amer. Met. Soc.,* v. 16, p. 186, 1935) remarks that in many cases the dust was confined to transitional Polar-Pacific air. This may be taken to indicate that conditions in N_{pp} air are such as to keep nuclei in suspension for relatively long periods of time.

The greatest surprise presented by the calculations exhibited in Figure 4 is the indication of considerable quantities of nuclei at altitudes above 18 km, the number increasing from that level to the highest altitude reached (22 km). The balloon apparently entered a different air-mass at about the same level as that of the lower boundary of this apparent bank of nuclei. The air-movement here was brisk from the west-southwest, which suggests that this air may have been of tropical origin. This surmise is entertained because several observers have reported that nuclei are relatively abundant in surface-air of tropical origin.

One might speculate as to other possible sources of these nuclei, such as volcanic eruptions, the disintegration of meteors, or the more general capture of matter from cosmic space. Since the range of speculation here is not yet limited by much quantitative information, one may also be free to surmise that ozone, which becomes especially abundant in about this same region of the atmosphere, acts as an agent in the formation of nuclei. But until such speculation can be guided by a greater variety and abundance of quantitative information it is likely to be of little value.

The illustrations given in this report will, it is thought, have shown that in addition to the information about the magnitude and distribution of the electrical conductivity of air and about related electrical phenemena, which is provided by measurements of that property in the free atmosphere, other information of interest may apparently be derived from them. Thus the constant ratios found between the positive and the negative conductivities call into question a generally accepted interpretation of measurements made in the laboratory according to which this ratio should increase at pressures below 100 mm of mercury. The ratio of the conductivities may also bear on the question whether a significant amount of water-vapor exists in the stratosphere, especially in its higher reaches. A joint consideration of air-conductivity and cosmic-radiation intensity data indicates that the coefficient of recombination for small ions in the atmosphere probably decreases less rapidly, as the pressure decreases, than is generally assumed. If this point is settled, then a joint consideration of air-conductivity and cosmic-radiation data appears capable of providing information about the amount and distribution of dust, condensation-nuclei, or other substances which diminish the conductivity of air.

In order to realize the definiteness and reliability desired in information of this sort, it is not only necessary that further measurements be made of the electrical properties of the free atmosphere but also that the properties of ions in air be further investigated in the laboratory. It is hoped that the need of the latter for the investigation of geophysical problems may stimulate physicists to further research along this line.

Although it seems feasible to obtain, in the future, valuable registrations of air-conductivity with light apparatus, of design similar to that described in this report, which may be carried aloft by sounding balloons, yet the advantages for the present work which were provided by the facilities of the *Explorer II*, especially the full line of auxiliary and control data which were obtained, seemed indispensable.

Dep. Terr. Magn., C.I.W., July 31, 1936.

CHANGE FROM YEAR TO YEAR IN THE POTENTIAL GRADIENT AND THE ELECTRICAL CONDUCTIVITY OF THE ATMOSPHERE AT EBRO, WATHEROO, AND HUANCAYO

By G. R. WAIT

The universal character of the diurnal variation in atmospheric potential-gradient at stations undisturbed by local effects, as first shown by Mauchly, is now generally accepted as an established fact. The diurnal variation is believed to be due to a systematic variation through the day in the average amount of electric charge coming to the Earth's surface. It is of interest to inquire whether or not there is also a variation in the amount of charge coming to the Earth's surface, having periods longer than 24 hours. Unfortunately, practically no location over land can qualify as an undisturbed station, and there do not exist sufficient data from oceanic areas to make it possible to investigate the longer-period variations. Notwithstanding the fact that all stations on land are to some extent affected by local effects, it seems worth while to select data from a few of the more suitably located stations for possible indications of longer-period variations. Consequently data from Ebro, Watheroo, and Huancayo have been assembled, caution being exercised to exclude data known to be affected by factors such as smoke, meteorological conditions, and known accidental variations. Yearly mean values of the potential gradient from each of the three observatories are plotted in Figure 1 for the years 1924 to 1934. If the average electric charge coming to the surface of the Earth varies from year to year, the average value of the potential gradient will likewise vary, except as it may be modified through local effects, the variation at each station being similar. One may therefore examine the curves for similarities in the variations at the three stations. There is little doubt that some similarities do exist in spite of the fact that local effects must, to some extent, be present in the data

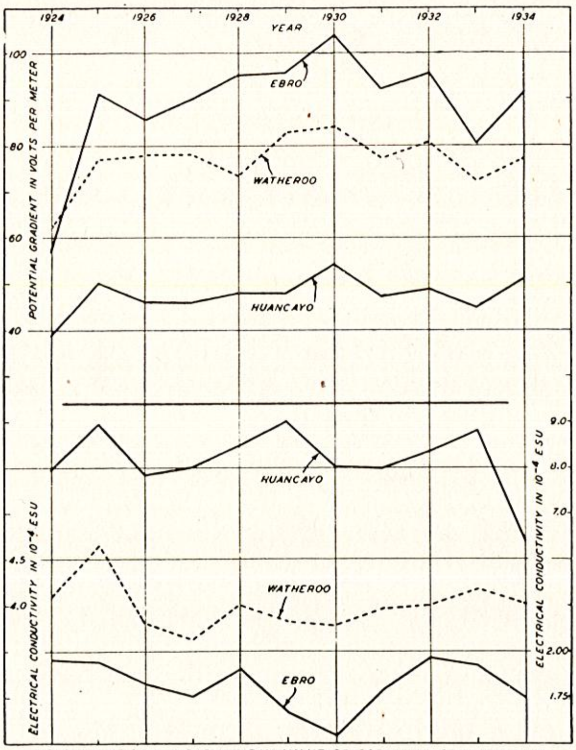


FIG. 1—VARIATION IN YEARLY MEAN VALUE OF POTENTIAL GRADIENT AND OF CONDUCTIVITY OF ATMOSPHERE AT EBRO, WATHEROO, AND HUANCAYO, 1924-1934

and that these tend to obscure any similarity that otherwise might exist.

In addition to analyzing the results for the potential gradient from the three observatories indicated above, the values for the electrical conductivity of the air have likewise been examined. Due precaution was exercised also in this case to exclude data known to be affected by local factors. Graphs of the results are shown in Figure 1 for the same years as for the potential gradient. There is less reason to expect any similarity in the curves for this element than for the potential gradient. There is no known ionizing agency that varies in a known universal manner to an extent sufficient to produce marked variations in the conductivity. The mobility of the small ions could hardly be expected to vary in any marked manner from one year to another, and the destroying agencies are supposed to be of local origin. One cannot entirely exclude the possibility of a portion of the destroying agencies acting in a somewhat universal manner having a long period, since it is known that finely divided dust has been observed to travel several times around the Earth. To that extent one is justified in looking for a universal variation in this element. The local effects are, however, likely to be so pronounced as to mask any universal effect. The curves as presented show very little tendency towards similarity in variation, certainly less than do the curves for the potential gradient.

The question of establishing additional stations for the collection of atmospheric data, especially those on the potential gradient and the conductivity of the atmosphere, arises from time to time. There is a question also as to the length of time the observatories already collecting such data should continue such work. As a result of this survey, it seems to the writer that additional data from very well-located stations (C. R. Assemblée de Stockholm, août 1930; Union Géod. Géophys. Internat., Sec. Mag. Electr. Terr., Bull. No. 8, pp. 346-347, 1931) would be of assistance in determining to what extent universality exists in the variations of both the potential gradient and the conductivity. Data from those stations that are already well located are also of value, and additional data from such stations, if carefully selected, are desirable. It is not intended to infer that all other stations, where local influences are more pronounced, should immediately cease the collection of such data. It is suggested, on the other hand, that in those localities, wherever possible, more detailed investigations be carried on to determine in what manner the local influences act and the laws underlying such action.

Dep. Terr. Magn., C. I. W., July 31, 1936.

THE VARIATION OF LIGHTNING CURRENTS

By Harald NORINDER

At the Institute of High Tension Research of the University of Upsala I have, during the last few years, studied the rapid variations in the magnetic field caused by lightning discharges. Similar measurements with improved experimental arrange-

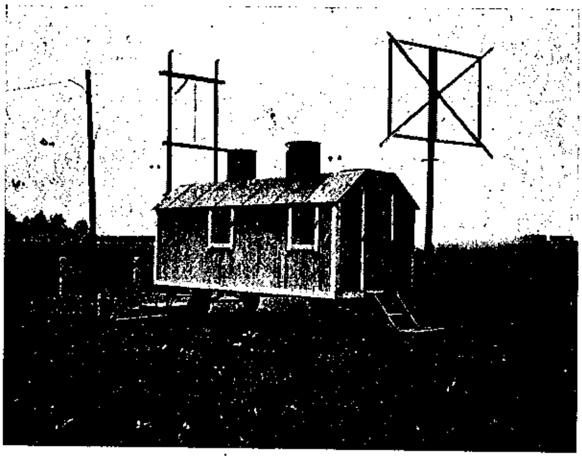


Fig. 1.

ments have also been carried out during the thunderstorm season of this year (1936). It will be the purpose of this communication to give a short account of the most important results covering the period of investigation mentioned.

The principle of methods employed

The measurements of the magnetic field variations were carried out by using the induced effect from the lightning currents on frame aerials.

The field variations proved to be so rapid, that it was necessary to work with specially constructed cathode ray oscillographs in order to record the variations. These instruments have been described in an earlier publication.*)

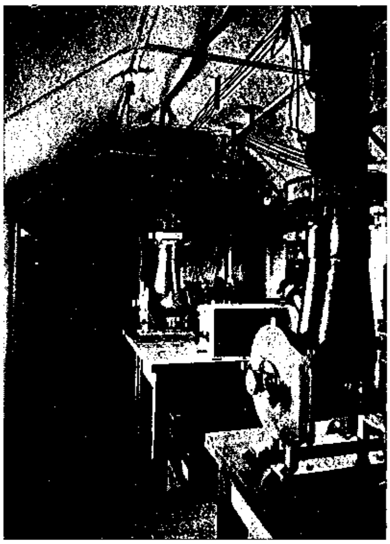


Fig. 2.

The external arrangements of the observation station with the frame aerial visible are reproduced in Fig. 1 and the equipment of cathode ray oscillographs with amplifier in Fig. 2.

If the field force is H in cgs units and if the surface of the frame aerial is A in cm^2 and its turn number is n, the induced voltage in volts between the ends of the frame will follow the well known relation

*) Harald Norinder: Ein besonderer Typus der Kathodenstrahloszillographen. Zeitschrift für Physik, 63, 9-10. Berlin 1930.

$$V = nA \frac{dH}{dt} 10^{-8} \cos \varphi \qquad (1)$$

In relation (1) φ is the angle between the field force lines and the coil axis.

In the following measurements the direction and the distance between the observation-point and the lightning paths were directly observed.

From an integration-procedure of the oscillographic curves it was possible, as is shown by relation (2), to calculate the magnetic field component H in the frame plane or:

$$H\varphi = \frac{10^8}{nA} \int V dt \qquad (2)$$

From the observed variations in the magnetic field it was further possible, with regard to vertical lightnings located within a certain distance from the observation point, to make an approximate calculation of the current variations in the lightnings. The principle of this calculation has been given in an earlier work.*)

The measurements

By the use of frames exposed in the free air in vertical planes, the observations were limited to the horizontal components of the magnetic field. In earlier investigations I used frames of such a size that the induced voltages from the frames became directly recorded in the oscillographs. The order of voltage received between the ends of the frame in such a case was about 200 volts for lightning discharges within 2 to 4 kilometers from the observation-point. The method did not allow a record of weak field-variations.

In order to complete the investigations, also with regard to weaker fields, I have improved the experimental equipment by the use of an amplifier in the circuit. This improvement worked very well and the first results where I used the improved arrangements, were obtained during the past summer.

Typical oscillograms of the observation period mentioned, where a rapid time-variation record of the order of microseconds was used, are reproduced in Fig. 3. The recording methods, as illustrated in Fig. 3, were mainly used to study the variation characteristics of individual current pulses.

In order to analyze the sequence of individual current pulses of which a lightning discharge is built up, it was, on the other

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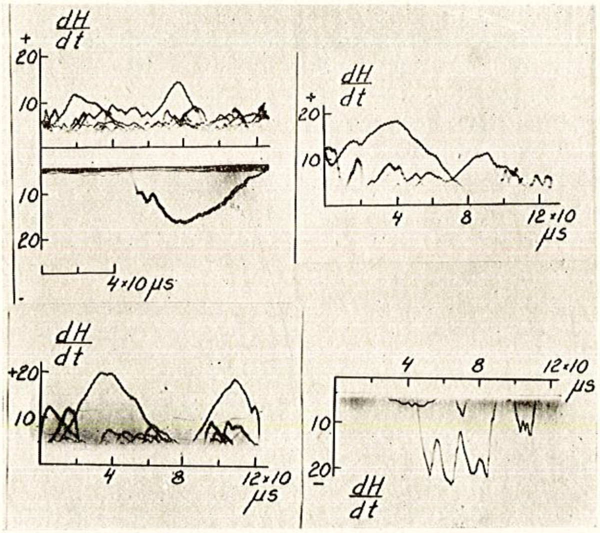
*) Harald Norinder: Lightning Currents and their Variations. Journ. of the Franklin Inst., vol. 220, No. 1, July 1935.


dH/dt
+20
10
10
20
4×10 μs
dH/dt
+20
10
4
8
12×10 μs
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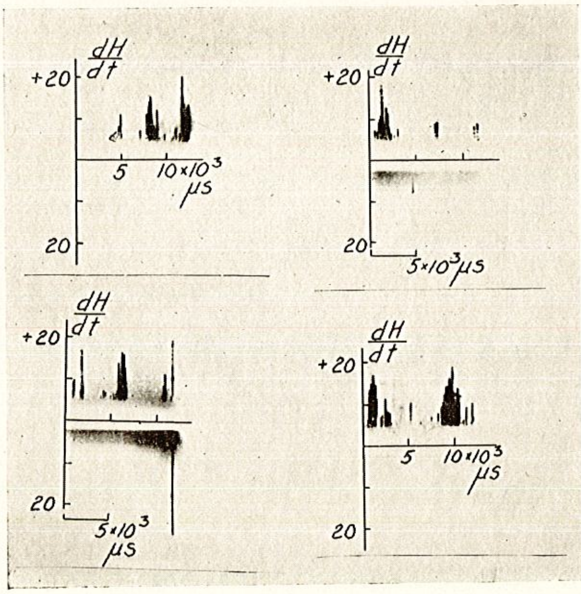
dH/dt

Fig. 3.


dH/dt
+20
5
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dH/dt
+20
5
10×10³ μs
20

Fig. 4.

hand, necessary to complete the rapid registration by a slow moving record method as exemplified by the oscillograms in Fig. 4.

The results

The observations allowed a calculation of the total duration of the current pulses in 50 lightnings. The result is reproduced in Fig. 5. The greater part of the lightnings gave results which consisted of total durations of current pulses below 5 thousand parts of a second.

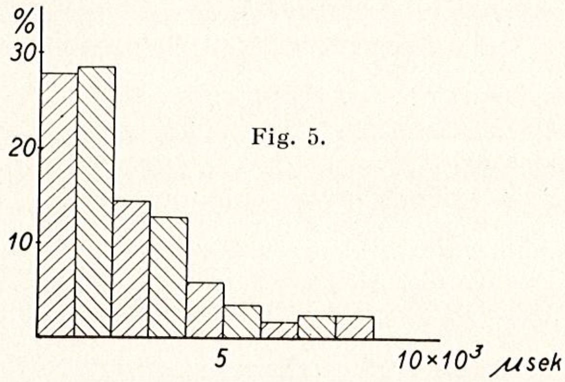

Fig. 5.

The time distance between sequent partial lightning current pulses for a number of 344 individual cases are reproduced in Fig. 6. The most usual time distance is characterized by time intervals below 1/1000 second.

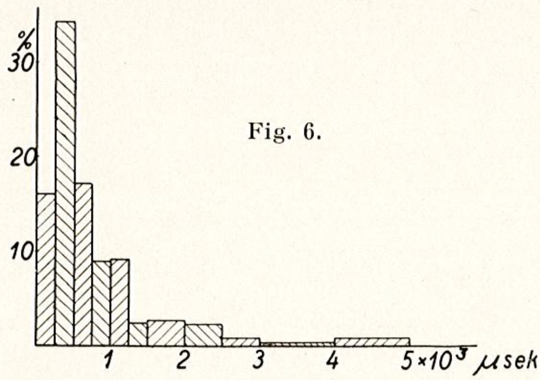

Fig. 6.

The percentage distribution of the number of current pulses in 127 lightnings is reproduced in Fig. 7, from which follows that the most usual number consisted of three separate pulses.

It is of interest to analyze the distribution of the maximal current amplitudes in sequent individual pulses. In lightnings, consisting of a number of 4 or more current pulses, I have

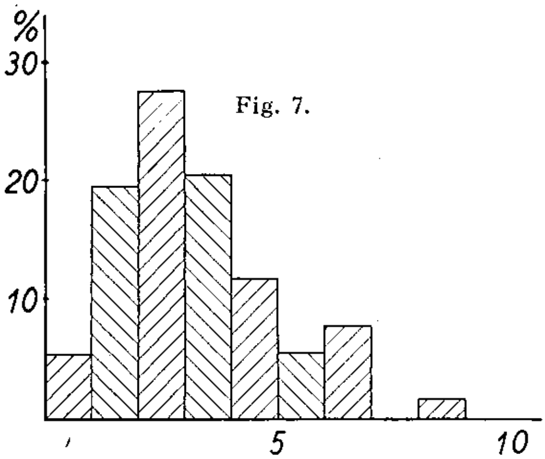

Fig. 7.

observed the maximal current amplitudes to be located in 85 per cent of the cases to the two first pulses or within the first half part of the discharge. At lightnings consisting of 3 partial discharges I have observed the maximal current to be located quite as often to the first as to the second of the three discharges.

The distribution of the observed horizontal components of the magnetic field has been calculated in cgs units in observed vertical lightnings and is reproduced in Fig. 8. The positive sign is defined when a positive charge goes to earth.

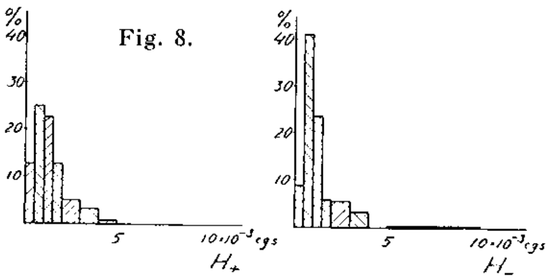

Fig. 8.

Of 88 recorded vertical lightnings 47 % were positive and 53 % negative, which is in full accordance with earlier results.

In 28 cases vertical lightnings were suitably located with regard to their distances to the observation point so as to permit a calculation of the maximal current values in the partial discharges. It was thus possible to calculate a number of 65 such partial discharges. The distribution of these calculated current values in kiloamperes is reproduced in Fig. 9.

The order of magnitudes of the maximal currents is in very good agreement with my earlier results. It is necessary to point out that a difference exists with regard to the distribution of the lower maximal current values. This difference can be fully explained by the following circumstance. In my earlier investigations as I have already mentioned, experimental arrangements were not sensitive enough to record the lower field amplitudes.

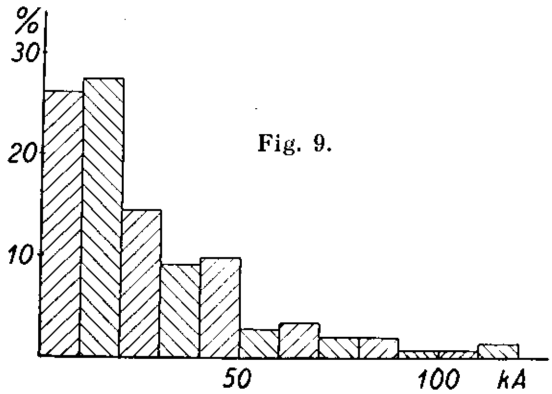

Fig. 9.

The improvement, which was adapted during the past season and which consisted in the use of an amplifier in the frame aerial circuit, allowed records also of currents characterized by relatively small amplitudes. The possibility of recording such small amplitudes explains the occurrence of lower maximal current amplitudes compared with my earlier measurements, which gave amplitudes from 20 to 40 kiloamperes as being the most common values.

THE MEAN ELECTRIC CHARACTER OF EIGHT WIDELY DISTRIBUTED STATIONS

By O. H. GISH

As a preliminary step in a study of the relative merits of several possible schemes for assigning an electric character-number to each day, it was undertaken to collect and compare such numbers as have been assigned according to the scheme employed in the British Meteorological Office. The collection is as yet incomplete, but it is thought that it may constitute a sample sufficiently representative to be of some value to others. The geographical distribution and periods corresponding to the available data may be seen from Table 1.

Table 1

Station	Longitude	Latitude	Elevation above sea-level	Epoch for which data
	°	°	meters	
College, Alaska (near Fairbanks)	147.8W	64.9N	180	October 1932 to August 1933
Lerwick, Shetland Islands	1.2W	60.1N	85	Since about 1926
Eskdalemuir, Scotland	3.2W	55.3N	240	Published since beginning of 1922
Kew Observatory, Richmond, England	0.3W	51.5N	6	Published since beginning of 1922
Washington, D. C.	77.1W	40.0N	85	February 1917 to December 1930
Tucson, Arizona	110.8W	32.2N	770	Since January 1930
Huancayo, Peru	75.3W	12.0S	3350	Since February 1924
Apia, Western Samoa	171.8W	13.8S	2	Assigned for land station since January 1926
Watheroo, Western Australia	115.9E	30.3S	244	Since January 1925
Oceans *(Carnegie)*	All 53N-40S		...	August 1928 to November 1929

An electric character-number, according to classification 0, 1, or 2, is assigned to each day at all of these stations on the basis of the registered air-potential and in accordance with the following:

"0" for days on which no negative potential was recorded
"1" for days on which negative potential was recorded for at least one short period, but for an aggregate duration of less than three hours
"2" for days on which negative potential was recorded for an aggregate duration of three hours or more

At Eskdalemuir and Lerwick some sub-classes are assigned. Those data have not yet been collected for this study.

Although the significance of the arithmetical mean of numbers, defined in this way, is vague, yet it seems worth while to attempt to determine whether such numbers may be used to advantage for studying some general aspects of electric events which occur in the atmosphere.

The annual variation in the monthly means of these character-numbers for each of seven stations on land and for the oceans covered on Cruise VII of the *Carnegie* is shown in Fig. 1. The magnitude and character of this variation, although quite regular for a given place, differ considerably from place to place. This usually reflects the rainy season at