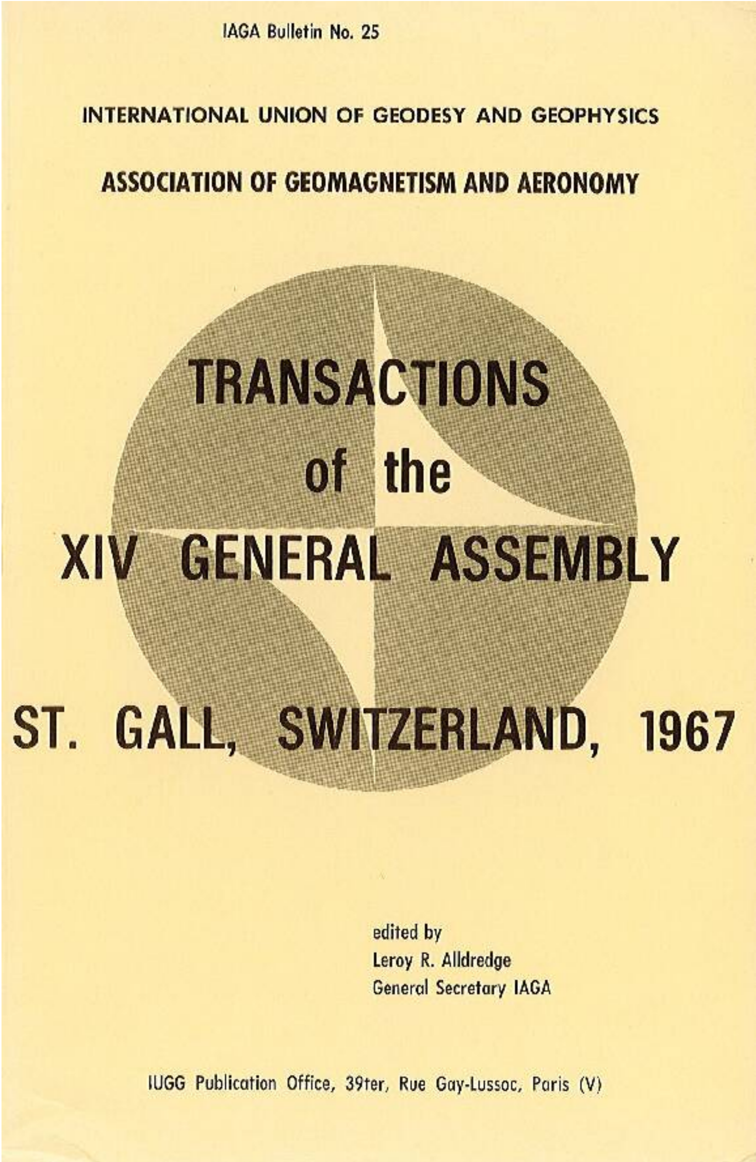

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IAGA Bulletin No. 25

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

ASSOCIATION OF GEOMAGNETISM AND AERONOMY

TRANSACTIONS of the XIV GENERAL ASSEMBLY

ST. GALL, SWITZERLAND, 1967

edited by
Leroy R. Alldredge
General Secretary IAGA

IUGG Publication Office, 39ter, Rue Gay-Lussoc, Paris (V)

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INTRODUCTION

The XIV General Assembly of IUGG was held in four cities in Switzerland from September 25 to October 7, 1967. The IAGA met in St. Gall where nearly perfect facilities were provided by the Swiss Local Committee.

Appreciation is expressed to Dr. L. Vonderschmitt, president of the St. Gall local committee, Dr. A. Semadeni, vice president of the local committee, Mr. A. Moser, secretary of the local committee, and to the secretarial and hostess staff, all of whom worked very hard to make the assembly a great success.

Three hundred and thirteen scientists registered in St. Gall. Others came for short periods from other cities. Thirty-five scientists arrived from Lucerne to attend two sessions of the Joint IAGA-IAMAP Committee on Atmospheric Electricity.

To gain a full appreciation of the XIV General Assembly, this bulletin should be read together with **IAGA Bulletin** No. 24, which contains the detailed program and abstracts for the assembly. Published before the assembly and made available to all participants, it provides a timely reference for papers presented in St. Gall. It also contains a complete listing of all IAGA officers who helped with the preliminary planning for the assembly.

This bulletin reports the business that was transacted during the assembly. It contains the results of business meetings of the Executive Committee, commissions, working groups, joint committees and boards. It reports highlights of the scientific sessions and changes in the program as shown in **IAGA Bulletin** No. 24. Abstracts published in that bulletin are not repeated here, but new abstracts that became available during the assembly are included.

It is stressed here that the new organization shown should be considered tentative as some of the scientists shown may not have been contacted by the chairmen. Commission chairmen are urged to submit nominations to the General Secretary as soon as possible to complete their working group structure, keeping in mind that a maximum of 12 scientists are allowed in any one working group and that a good geographical distribution should be obtained where possible. In some cases initials were not known for some of the scientists listed in working groups. Commission chairmen are requested to complete this information and to add addresses where needed.

Many changes have been made in the organizational structure and personnel. At the outset of the assembly it was made clear that, as is the case with the elected officers, the commission officers should not expect to remain in office unless invited to stay by the Executive Committee. Most of the commission chairmen who were not continued in office had requested retirement prior to the assembly.

The General Secretary wishes to thank the commission chairmen, symposium convenors, and their reporters, who were very effective in reporting so that this bulletin could be published without delay. Most reports were in the hands of the General Secretary before he left St. Gall.

Reports were, of course, submitted in a variety of formats. The editor has taken the liberty to delete parts of the very long reports and has changed some formats, but in the interest of speed has permitted a variety of reporting methods, provided the intent was clear.

EXECUTIVE COMMITTEE MINUTES

The Executive Committee of IAGA met as follows during the assembly:

September 25,	15.00h.	Regular meeting of the Committee.
September 26,	14.00h.	Regular meeting of the Committee.
September 26,	16.00h.	Executive Committee met with commission chairmen.
September 29,	17.00h.	Executive Committee met with both new and retiring commission chairmen to discuss reorganization of commissions.
October 3,	16.00h.	Executive Committee met to discuss resolutions.
October 4,	14.00h.	Regular meeting of the Committee.
October 5,	11.45h.	New and retiring Executive Committee members met together after final plenary session.

At the outset the General Secretary had provided an annotated agenda to aid Committee members in their work. The minutes of the above sessions are combined into one report below.

President M. Nicolet greeted the Committee members, wishing them and the assembly productive, successful work during the coming two-week period. He then appointed the following committees to serve on an ad hoc basis during the assembly:

Nominations Committee — V. Laursen, chairman, N. P. Benkova, H. Friedman, T. Rikitake, and E. Selzer.

Resolutions Committee — J. O. Cardus, chairman, J. H. Nelson, E. Selzer, and V. Troitskaya.

Finance Committee — A. De Vuyst, chairman, P. N. Mayaud, and J. Veldkamp.

President Nicolet said that invitations for the 1971 IUGG General Assembly had been received from India, USSR, and France. France had indicated that if convenient for IUGG its invitation would also hold for 1975. (At its final plenary session the IUGG was unable to reach a decision on a 1971 meeting plan and the decision was left to the new bureau. The inviting governments needed to reconsider their situation in view of the number of invitations.)

President Nicolet indicated that IAGA had received a tentative invitation to meet in Spain in 1969 and that the International Association of Seismology and Physics of the Earth's Interior (IASPEI) had received a similar tentative invitation.

The General Secretary together with the Chairmen of Commissions I, II, and III were appointed as a program committee to work with representatives of IASPEI to begin planning for joint meetings in Spain on problems of common interest. It was agreed that the General Secretary, F. S. Johnson, M. Nicolet, and T. Nagata would meet in Tokyo at the time of the COSPAR meeting in May of 1968 to further the plans of the assembly in Spain. The Executive Committee will meet to complete these plans in Washington, D. C. during one of the symposia being held in September and October of 1968.

President Nicolet indicated that ten more countries had been admitted to the IUGG at the council meeting on September 24, 1967, in Zurich. These countries are:

1. Democratic Peoples Republic of Korea
2. German Democratic Republic
3. Iceland
4. Lebanon
5. Madagascar
6. Monaco
7. Republic of China
8. Sierra Leone
9. Southern Rhodesia
10. Malaysia

The IUGG Executive Committee has requested that the IAGA-WMS Board be terminated by the end of 1969. Any work remaining from the Board can be taken over by Commission II.

Father Cardus reported that he has published the booklet **Instrumentation** and distributed it without an IAGA publication number. The booklet **Resolutions of IAGA** has been published and will be distributed as soon as the General Secretary provides a bulletin number. Father Cardus indicated that the **Transactions of the Berkeley Assembly** is at the printers, but the Helsinki report is not ready yet. It was decided that just one bulletin titled **Transactions of the Helsinki and Berkeley Assemblies** would be published. It was agreed that 10 or 12 pages would be added to the Berkeley report to cover the bare essentials of the Helsinki meeting. The cost of this combined report should be approximately $4,000.

Several commission chairmen had asked to be relieved of their responsibilities because of retirement at home, which generally deprived them of a base of operation. It was pointed out that all officers in IAGA are elected or appointed for single periods so that the Executive Committee should reappoint or appoint new commission chairmen and working group reporters. The following scientists were appointed as chairmen of commissions:

Commission I, Observatories and Instruments
Chairman, A. P. De Vuyst (Belgium)
Commission II, Representation of Main Magnetic Fields
Chairman, B. R. Leaton (England)
Commission III, Magnetism of the Earth's Interior
Chairman, T. Rikitake (Japan)
Commission IV, Magnetic Variations and Disturbances
Chairman, J. A. Jacobs (Canada)
Commission V, Solar-Magnetosphere Relations
Chairman, J. G. Roederer (USA)
Commission VI, Aurora
Chairman, A. Omholt (Norway)
Commission VII, Airglow
Chairman, G. M. Weill (France)
Commissoin VIII, Upper Atmospheres
Chairman, A. Dessler (USA)
Commission IX, History
Chairman, N. V. Pushkov (USSR)

The commission chairmen for the past 4-year period were invited to join with the Executive Committee in discussing the structure of the commissions. The new commission chairmen were also invited to join the group, which agreed upon the commission structure and personnel shown in the section "New IAGA Organization" in this bulletin. The membership of the two joint committees that involve the International Association of Meteorology and Atmospheric Physics (IAMAP) were agreed to by both associations.

The General Secretary was given the authority to approve working group membership in consultation with commission chairmen.

Note was taken of the request from the Joint IAGA-IAMAP Committee on Atmospheric Electricity for a budget for the 4-year period of $500 for secretarial services. This item was not specifically approved, but the General Secretary was authorized to provide reasonable funds to the commissions and joint committees for their secretarial needs.

Dr. Veldkamp reported that he received $2,000 for the Permanent Service of Geomagnetic Indices for FAGS this year, and that a similar amount is budgeted for each of the next 4 years. A question was raised about channeling sales of **IAGA Bulletin** No. 12 back to the Permanent Service. It was agreed that it was best to leave the publication sales with IAGA and that IAGA pay directly for deficits that the Permanent Service may show.

Dr. Veldkamp requested retirement as Director of the Permanent Service of Geomagnetic Indices, a position he has filled with distinction for 20 years. His resignation was accepted, with appreciation expressed for his great service. Dr. S. Van Sabben was appointed as the new director.

Future IAGA symposia were discussed as follows:

1. An IAGA Symposium on Laboratory Measurements of Aeronomic Interest will be held in Toronto, Canada, September 3-5, 1968. The General Secretary was instructed to write to Dr. H. I. Schiff, the Chairman, suggesting better international representation in the program.
2. The Fourth International Conference on the Universal Aspects of Atmospheric Electricity will be sponsored by the IAGA-IAMAP Joint Committee on Atmospheric Electricity in Tokyo, Japan, May 12-18, 1968. Dr. C. Coroniti is the convenor.
3. A Symposium on Solar Flares will be cosponsored by IUGG (IAGA), IAU, URSI, and COSPAR in Tokyo, Japan, May 9-16, 1968. Dr. Z. Svestka is Chairman of the Program Committee. Drs. T. Nagata and J. C. Roederer represent IAGA on the committee.
4. An International Symposium on Physics of the Magnetosphere, will be cosponsored by COSPAR, IAU, IUGG (IAGA), IUPAP, and URSI in Washington, D. C., USA, September 3-13, 1968. The meeting is being arranged by the U.S. National Academy of Sciences and the NASA Goddard Space Flight Center. IAGA is represented by J. C. Roederer, T. Okayashi, and W. N. Hess on the program committee.
5. An IAGA Symposium on Description of the Earth's Magnetic Field will be held in Washington, D. C., USA, October 22-25, 1968, at the U.S. National Academy of Sciences. Mr. J. H. Nelson is Chairman of the Local Arrangements Committee. Drs. V. Laursen and E. H. Vestine are cochairmen for the scientific program.
6. It was decided that the Symposium on Secular Change and the Symposium on Chemical Aeronomy listed on page 8 of **IAGA News** No. 4 as occurring in 1969 would be made a part of the General Scientific Assembly to be held in Spain in 1969.
7. There was much discussion about the Interunion Symposium on Solar Terrestrial Physics originally scheduled for 1970. Some felt that it should be held at the time of the 1971 General Assembly. Others thought it should be held earlier, as originally scheduled, and that it was better not to hold it at an assembly because the assemblies dilute the science with too much administration. Because of the uncertainty regarding the plan of the 1971 General Assembly this question could not be resolved; Dr. J. G. Roederer will act as Chairman of an IAGA Program Committee for this symposium. The Committee will consist of the Chairmen of Commissions V, VI, VII, and VIII.
8. After much discussion it was decided not to hold the Symposium on Geocorona and Magnetosphere originally suggested for 1970 because of conflicts with other meetings.
9. It was decided that in the future the following rules will apply to IAGA symposia:

   (a) If it is a cosponsored symposium, IAGA should have one or two voices in the organizing committee.

(b) IAGA-sponsored or cosponsored symposia must have the approval of the Executive Committee.

(c) Names of the Organizing Committee should be presented to the Executive Committee for approval.

A very frank discussion was carried on regarding the relations between the IAGA and the new Inter-Union Commission on Solar-Terrestrial Physics (IUCSTP). Dr. H. Friedman is the Chairman of the IUCSTP as well as a member of the IAGA Executive Committee. The IUCSTP appears to necessarily deprive IAGA and URSI and IAU of freedom to act alone in the STP area since all have overlapping functions in this area.

It was recognized by the Executive Committee that only ICSU has the power to make sweeping changes that might rectify the overlap. The Executive Committee did, however, resolve to cooperate with the program of the IUCSTP regarding a program for the International Active Sun Years (IASY). (See IUGG Resolution No. 14 in a later section of this bulletin.)

The Executive Committee expressed a desire to have greater representation on the IUCSTP dicipline working group. If an expanded representation is allowed the following scientists would be nominated: A. Omholt and G. M. Weill for the working group on aeronomy (including aurora and airglow); D. Williams for particles and fields; and N. Fukushima for external geomagnetic fields.

The Executive Committee approved the following note submitted by Dr. A. Omholt, new Chairman of Commission VI, and Dr. C. G. Weill, new Chairman of Commission VII, regarding the establishment of an Auroral and Airglow Program Committee for the Active Sun Year Project:

"Commissions VI and VII are concerned with aurora and airglow and their interplay; this interplay will be of particular interest and importance during the sunspot maximum.

"The Commissions propose to establish, therefore, an Auroral and Airglow Program Committee for the Active Sun Year Project. This committee will consider, advise on, or aid special projects in the area of optical studies of upper atmospheric phenomena.

"The incoming Chairmen of Commissions VI and VII suggest the following names to the Executive Committee of IAGA for appointment to this Auroral and Airglow Program Committee: A. Omholt and G. Weill, Cochairmen; M. H. Rees, Reporter; K. D. Cole; S. I. Akasofu; B. Hultqvist; M. Huruhata; G. Lange-Hesse; J. Paton; N. N. Shefov; and Yu. L. Truttse."

All the resolutions given later in this bulletin were first approved by the Executive Committee and then by the delegates in the final plenary session.

The Executive Committee considered and accepted the finance report for the 4-year period, January 1, 1963-December 31, 1966, and the budget for the 4-year period, January 1, 1967-December 31, 1970, as submitted by the General Secretary. These two reports are reproduced here.

INTERNATIONAL ASSOCIATION OF GEOMAGNETISM AND AERONOMY

Financial Account for the Period 1 Jan. 1963 to 31 Dec. 1966

RECEIPTS		IUGG
IUGG ALLOCATION		$24,350.00
UNESCO GRANTS		—
CLOSING DANISH ACCOUNT		299.37
CONTRACTS WITH UNESCO, etc.		3,500.00
SALES OF PUBLICATIONS		752.41
MISCELLANEOUS (Interest)		777.41
TOTAL RECEIPTS		$29,679.19
CASH ON HAND AND IN BANKS 1 January 1963		
SPANISH ACCOUNT	$ 5,951.28	
U.S. ACCOUNT	5,078.22	$11,029.50
TOTAL		$40,708.69

EXPENDITURES		IUGG
ADMINISTRATIVE		$ 2,399.72
PUBLICATIONS		6,474.72
ASSEMBLIES		1,555.67
TRAVEL		11,612.04
SCIENTIFIC MEETINGS		—
GRANTS (Permanent Services, etc.)		1,000.00
CONTRACTS WITH UNESCO, etc.		500.00
MISCELLANEOUS		93.00
TOTAL EXPENDITURES		$23,634.79
CASH ON HAND AND IN BANKS 31 December 1966		
SPANISH ACCOUNT	$ 5,641.59	
U.S. ACCOUNT	11,432.31	$17,073.90
TOTAL		$40,708.69

The above financial account is for the combined Spanish and U.S. subaccounts. The individual Spanish and U.S. subaccounts have been separately audited and properly certified.

INTERNATIONAL ASSOCIATION OF GEOMAGNETISM AND AERONOMY

Estimate of Income and Expenses During the Period 1967-1970 (4 Years)

RECEIPTS	IUGG	GRANTS AND CONTRACTS
IUGG ALLOCATION	$34,000 (1)	X
UNESCO GRANTS	X	X
OTHER GRANTS	X	X
CONTRACTS WITH UNESCO, etc.	X	5,000 (2)
SALES OF PUBLICATIONS	3,000	X
MISCELLANEOUS	X	X
TOTAL RECEIPTS	$37,000	$5,000
CASH ON HAND AND IN BANKS January 1, 1967	17,000	
TOTAL RECEIPTS	$54,000	$5,000

EXPENDITURES	IUGG	GRANTS AND CONTRACTS
ADMINISTRATION	$ 3,000	X
PUBLICATIONS	20,000 (3)	3,000
ASSEMBLIES	8,000 (4)	X
SYMPOSIA	6,000 (5)	X
SCIENTIFIC MEETINGS	X	2,000
GRANTS (Permanent Service, etc.)	6,000	X
CONTRACTS WITH UNESCO, etc.	X	X
MISCELLANEOUS	1,000	X
TOTAL EXPENDITURES	44,000	$5,000
ESTIMATED CASH ON HAND AND IN BANKS December 31, 1970	10,000	
TOTAL EXPENDITURES	$54,000	$5,000

(1) This corresponds to $8,500/Yr. recommended by Finance Committee at XIV General Assembly.

(2) Expect this from UNESCO in support of WMS Analysis.

(3) Includes:

(a) Publication of transactions for Helsinki and Berkeley	$4,000
(b) Publication of proceedings of symposia	8,000
(c) Publication of XIV General Assembly and Special IAGA General Assembly	6,000
(d) Publication of four **IAGA News**	2,000
TOTAL	$20,000

(4) Includes preparation for two assemblies.

(5) Two IAGA symposia at $3,000 = $6,000

PLENARY SESSIONS

The first IAGA plenary session of the XIV General Assembly was held at 17.00h on Monday, September 25, 1967. President M. Nicolet called the meeting to order and introduced Professor L. Vonderschmitt, President of the Local Organizing Committee, whose comments are presented below.

COMMENTS BY PROFESSOR L. VONDERSCHMITT

"Ladies and Gentlemen,

"The Local Committee of St. Gall trusted me to give you a hearty welcome.

"You travelled from all corners of the world to this town, not only to present papers on your investigations, but also — as you have heard already this morning in Zurich — to discuss and clarify the aims and possibilities of your science and the wisest distribution of new research assignments.

"St. Gall is proud to house the Association of Geomagnetism and Aeronomy, which is not only one of the biggest associations of the IUGG, but also — I believe — the one with the most ambitious scope. You start right in the core of our earth, where — as we believe at present — originates the force for the geomagnetic field. You pass through the mantle and the crust high up through the atmosphere, as some say more than 500 km, but I am sure you will not stop there, but carry on higher and higher at least to the border of our magnetic field. In one of the abstracts of 1967, one author reaches already several times the radius of the earth.

"If a small country like ours has to carry the organization of a congress like this one, it soon becomes aware of several handicaps.

"There is first the finance, but this is — in my opinion — not grave as long as we find the support of a community with a wide open mind towards science — as is the case for example with St. Gall.

"Then comes the question of rooms. There also we are lucky since the authorities of the High School generously helped out.

"The biggest hindrance, however, for a small country is the scarceness of scientifically trained persons for the widespread aims of your union. This leaves the burden of the scientific preparations entirely on the associations themselves — and what this means you will realize if you go through or only glance at the **Program and Abstracts** for this meeting, edited so ably by Dr. Alldredge.

"I doubt that we would have been able to do it and I do not think that I could have found colleagues in Switzerland willing to dive down to the core of the earth — of course I mean in their scientific imagination — and fly then right away to the outmost borders of the geomagnetic field.

"With these remarks I do not wish to derogate or belittle the achievements of my dear colleagues in Switzerland. They all strive hard to serve science with our reduced means. Some leave for foreign countries where they find better research facilities, but many of them return and bring us the profits of their experience and at the same time help us to convince our authorities that the money spent on science is an investment and not a loss.

"This leads us to today's writings and talkings about the limits between pure science and applied science. For the scientist himself this seems to be of little concern. The impact of science on technique and vice versa is necessary and natural.

"There is also much talk of brain-drain from one country to another. But does not this merely concern the economist? We know it — and this association is a very token for it — science is worldwide! Whether you work at the North Pole or on the equator is less important than that you make your achievements known worldwide, to the benefit of everybody — and for this we are here together.

"Ladies and Gentlemen, the local committee wishes you all the good for the coming days. We hope for and are convinced that the congress will be a success and I sincerely hope that it will help to further your science in our country and arouse so much interest in our youth that the best of them will soon join the IUGG."

REMARKS BY THE PRESIDENT

President M. Nicolet introduced Professor Heinz Weinhold, Professor for Business Management of the Graduate School of Economics, Business and Public Administration. Professor Weinhold, speaking for the director of the Hochschule, extended a welcome to the IAGA and told a little about the operation of the Hochschule where the IAGA Assembly is being held.

President Nicolet called for a moment of silence in memory of IAGA members who had died since the last assembly. Deceased members include: Professor J. Bartels, Dr. L. V. Berkner, Professor A. I. Lebedinsky, and Dr. D. Barbier.

He introduced the Vice-Presidents, Professor T. Nagata, and Father J. D. Cardus; the General Secretary, Dr. L. R. Alldredge; members of the Executive Committee, Dr. V. Laursen (past President and Chairman of WMS Board), Dr. S. E. Isaev, Professor J. C. Roederer, Professor E. Thellier, and Dr. J. Veldkamp.

President Nicolet and General Secretary L. R. Alldredge described the results of the IUGG Extraordinary General Assembly held in Zurich on Saturday, September 23, 1967, and the effects the actions taken there may have on the IAGA. At the Extraordinary Assembly, the IUGG Statutes and Bylaws were changed almost exactly as had been recommended by the Committee of Fourteen. The main changes are:

1. The Bureau of the Union will have only one vice-president instead of two and three elected members instead of two.
2. For council voting purposes a quorum was defined as (1) total number voting (yes, no, and abstention) must be at least half the membership of the Union and (2) the number of yes and no votes is not less than one-third of the membership. Simple or two-thirds majorities are determined by yes/yes and no.
3. The Union changed the name of the International Association of Volcanology to International Association of Volcanology and Chemistry of the Earth's Interior.
4. General assemblies shall normally be held every 4 years, instead of every 3 years.
5. The association shall hold business meetings at the general assemblies of the Union. At the general assembly, scientific meetings should be confined to joint sessions of two or more associations on topics of interdisciplinary character decided 1 year in advance by the Union Executive Committee. Associations may arrange assemblies of their own between Union general assemblies.
6. The president of the Union is elected for one period and cannot be immediately reelected. The vice-president and three elected members are to be elected for one period and may be reelected for not more than one consecutive period in the same position.
7. The Union Nominations Committee shall recommend only one nomination for each office.

President Nicolet referred to the relationship between IAGA and COSPAR and suggested that IAGA members should be active in COSPAR working groups. (A statement by President Nicolet is given in the final section, "Relations with COSPAR," in this bulletin.)

It was pointed out that all IAGA officers, both elected and appointed, serve for only one period (4 years) unless reelected or reappointed. All working group memberships will be reconsidered after the Executive Committee has appointed commission chairmen and working group reporters.

Countries submitting national reports were recognized. The following countries are known to have submitted national reports that were made available to all delegates:

Hungary	West Germany
India	Germany DR
Iran	Rumania
Italy	South Africa
Japan	Spain
Mexico	Switzerland
Canada	Turkey
Czechoslovakia	USSR
France	United Kingdom

REPORT BY THE GENERAL SECRETARY

The General Secretary, Leroy R. Alldredge, presented the following report:

ORGANIZATION

During the past 4-year period the Secretariat published **IAGA News** numbers 1 through 5 as follows: **IAGA News** No. 1 — December 1963; No. 2 — July 1964; No. 3 — February 1965; No. 4 — November 1965; No. 5 — November 1966.

Since these publications include most of the activities of IAGA during this period they can be considered as part of the General Secretary's report, permitting this report to be very short. Only the highlights will be reiterated here. Material for each **IAGA News** was solicited from all IAGA officials. Copies were mailed to nearly 800 people, including national committees, IAGA officials, and others who have expressed an interest to the General Secretary. Additional copies of the **IAGA News** Nos. 1-5 are available at the Secretariat's office for those who do not have copies. Persons wishing to have their names added to the distribution list should notify the General Secretary.

IAGA was completely reorganized at the XIII General Assembly from 11 committees into IX commissions containing 57 working groups. Because of this, much time was required during the first 6 months to consolidate the new organization and to establish needed communication lines.

During the 4-year period the following changes in personnel were made in the commission chairmen and working group reporters by action of the Executive Committee:

Commission II, Working Group Reporter for Cartography from Dr. H. F. Finch (Eng.) to Dr. B. R. Leaton (Eng.).

Commission IV, Chairman from Professor J. Bartels (Ger.) to Professor A. T. Price (Eng.).

Commission VII, Chairman from Dr. D. Barbier (Fr.) to Dr. F. E. Roach (U.S.) and Working Group Reporter for Photometry from Dr. D. Barbier (Fr.) to Dr. M. Huruhata (Japan).

A few changes were made in the working groups themselves. Quite a few of the working groups were not heard from at all during the 4-year period. It is suggested that at the XIV General Assembly these be carefully scrutinized to see if they are performing any useful function. If they are not, they should be eliminated. It is evident that some major reorganization should take place in the commission structure, and some definite proposals have already been received. These will be carefully considered by the Executive Committee before they are presented to the general assembly.

FINANCE AND BUDGET

A brief summary of the income and expenses of IAGA for the period January 1, 1963, to December 31, 1966, was given (see Executive Committee minutes). The books have been audited by William D. Walters, Systems Accountant for the U.S. Department of Commerce, Environmental Science Services Administration, who has verified that the money was spent as indicated. A certified statement to this effect is available for the Finance Committee.

A proposed budget through 1970 was discussed. In this budget, more money was allocated for IAGA symposia than in the past. This was done in anticipation that IUGG would be reorganized at the Extraordinary General Assembly preceding the XIV General Assembly along lines that would put greater emphasis on symposia. To meet the needs of the proposed budget, allocations approximately 66 percent greater than in the past would be required from IUGG.

WORLD MAGNETIC SURVEY BOARD

The Board has held five meetings during the 4-year period, as follows:

1. Berkeley, California, August 1963
2. Florence, Italy, May 1964
3. Pittsburgh, Pennsylvania, November 1964
4. Madrid, Spain, April 1965
5. Royal Greenwich Observatory, Herstmonceux Castle, England, October 1966

The WMS Board has published **WMS Notes** No. 1, January 1964, **WMS Notes** No. 2, October 1964, and **WMS Notes** No. 3, January 1966. The **Instruction Manual on World Magnetic Survey** No. 1 was published as Monograph No. 11 in August 1961. The draft of **Instruction Manual on World Magnetic Survey** No. 2 was turned over to UNESCO July 17, 1967.

The WMS Board together with Commissions II and III will sponsor a Symposium on the Description of the Earth's Magnetic Field, in Washington, D. C., October 22-25, 1968.

Under the direction of the WMS Board and with the financial help of UNESCO, Dr. K. A. Wienert, in 1964, visited observatories in Africa to assist in observatory standardization and technique improvement. A similiar trip was made to South America almost a year later by Dr. J. M. Stagg. Both trips were very helpful to the areas visited. UNESCO paid $5,500 for both trips. UNESCO also provided $500 for an anomaly study by Dr. A. Hahn.

EXECUTIVE COMMITTEE

The Executive Committee met on the following occasions: Florence, Italy, May 1964; Copenhagen, Denmark, September 1965; and Belgrade, Yugoslavia, August 1966.

SYMPOSIA

IAGA sponsored or cosponsored the following symposia:

Cosponsored: Symposium on Ultra Low Frequency Electromagnetic Fields, August 17-20, 1964, Boulder, Colorado, with the Institute of Telecommunication Sciences and Aeronomy, ESSA; AGU; and Office of Naval Research Laboratories.

Sponsored: Symposium on Magnetism of the Earth's Interior, November 16-20, 1964, Pittsburgh, Pennsylvania.

Cosponsored: The Second International Symposium on Equatorial Aeronomy, September 6-17, 1965, Sao Paulo, Brazil, with the International Scientific Radio Union; Commissão Nacional de Atividades Espaciais; U.S. Air Force Cambridge Research Laboratories; U.S. National Bureau of Standards; Consejo Latino Americano de Fisica Espacial, and Voice of America.

Sponsored: Symposium on Upper Atmosphere Density and Composition, August 16-20, 1965, Cambridge, Massachusetts.

Cosponsored: Symposium on Solar-Terrestrial Physics, August 29-September 2, 1966, Belgrade, with COSPAR, IAU, and URSI.

Cosponsored: The Birkeland Symposium on Aurora and Magnetic Storms, September 18-21, 1967, Sandefjord, Norway, with the Norwegian Government, the Norwegian Geophysical Society, and the Norwegian Research Council for Science and the Humanities.

IAGA will sponsor the following symposia at the XIV General Assembly:

1. Symposium on Recent Development in Geoelectricity and Geomagnetism Instrumentation, September, 27, 1967.
2. Symposium on Conjugate Point Experiments, September 29, 1967.
3. Symposium on Special Events, October 2, 1967.
4. Symposium on Atmospheric Wind, Waves and Ionospheric Drift, October 3-4, 1967.

PUBLICATIONS

IAGA symposia publications during the past 4 years are as follows:

1. **IAGA Symposium No. 2, Symposium d'Aeronomie Communications,** presented at the Berkeley Assembly, August 1963.
2. **IAGA Symposium No. 3, Proceedings of the Symposium on Magnetism of the Earth's Interior,** University of Pittsburgh, November 16-20, 1964.
3. **IAGA Symposium No. 4, Symposium d'Aeronomie,** Cambridge, Massachusetts, August 16-20, 1965.
4. **IAGA Symposium No. 5, IIème Symposium d'Aeronomie Equatoriale,** Sao Jose Dos Campos, Brazil, September 1965.

The program and abstracts for the general assembly were published as **IAGA Bulletin** No. 24.

The highlights of the IAGA General Assembly, and the meetings of the various working groups, commissions, and the Executive Committee will constitute the remainder of the proceedings of the St. Gall meeting and will be published as **IAGA Bulletin** No. 25 as soon as possible after the conclusion of the assembly.

The following IAGA Bulletins have been published:

No. 12 o 1 — **Geomagnetic Data 1960; Indices K and C.,** by J. Bartels, A. Romaña, and J. Veldkamp, 1963.

No. 12 n 2 — **Geomagnetic Data 1959; Rapid Variations,** by J. Bartels, A. Romaña, and J. Veldkamp, 1963.

No. 12 p 1 — **Geomagnetic Data 1961; Indices K and C,** by J. Bartels, A. Romaña, and J. Veldkamp, 1964.

No. 12 o 2 — **Geomagnetic Data 1960; Rapid Variations,** by J. Bartels, A. Romaña, and J. Veldkamp, 1964.

No. 12 q 1 — **Geomagnetic Data 1962; Indices K and C,** by J. Bartels, A. Romaña, and J. Veldkamp, 1965.

No. 20 — **List of Geomagnetic Observatories,** by G. Fanselau, 1965.

No. 12 r 1 — **Geomagnetic Data 1963; Indices K and C,** by J. Bartels, A. Romaña, and J. Veldkamp, 1966.

No. 12 p 2 — **Geomagnetic Data 1961; Rapid Variations,** by J. Bartels, A. Romaña and J. Veldkamp, 1966.

No. 21 — **Atlas of Indices K,** parts I (text) and II (figures), by P. N. Mayaud, 1967.

No. 12 q 2 — **Geomagnetic Data 1962; Rapid Variations;** by J. Bartels, A. Romaña, and J. Veldkamp, 1967.

No. 12 s 1 — **Geomagnetic Data 1964; Indices K and C,** by A. T. Price, A. Romaña, and J. Veldkamp, 1967.

No. 12 r 2 — **Geomagnetic Data 1963; Rapid Variations,** by A. T. Price, A. Romaña, and J. Veldkamp, 1967.

* * *

It was noted that the U.K. had submitted five items and the USA one item for consideration at the assembly. It was agreed that these items should be sent to appropriate working groups for actions. (All of these items later appeared in the form of resolutions slightly modified in form).

Vice-President T. Nagata gave a very brief report of the very successful Birkeland Symposium, held in Sandefjord, Norway, September 18-21, just preceeding the assembly in St. Gall. He thanked Dr. G. L. Kvifte, Chairman of the Organizing Committee and the other members of the committee for their work.

AD HOC COMMITTEES

President Nicolet introduced ad hoc committee members for the assembly as follows:

Nominating Committee: Dr. Laursen (Chairman), Mme. N. P. Benkova, Dr. H. Friedman, Dr. T. Rikitake, and Dr. E. Selzer.

Resolutions Committee: Rev. J. O. Cardus (Chairman), Mme. V. Troitskaya, Mr. J. H. Nelson, and Dr. E. Selzer.

Finance Committee: Dr. A. P. De Vuyst, Rev. P. N. Mayaud, and Dr. J. Veldkamp.

The meeting closed at 18.00h.

REPORTS BY COMMISSION CHAIRMEN

The final plenary session was called to order at 09.00h, Thursday, October 5, 1967, by President Nicolet who called on each commission chairman to give a 5-minute report for their commissions of the highlights of the assembly.

Prof. E. Thellier reported for Commission I; Dr. E. H. Vestine, for Commission II; Dr. T. Nagata, for Commission III; Dr. A. T. Price, for Commission IV; Dr. J. G. Roederer, for Commission V; Dr. M. Gadsden, in the absence of Drs. Chamberlain and Omholt, read the report for Commission VI prepared by Dr. Rees, Acting Chairman, who had to leave the assembly early; Dr. M. Gadsden, Acting Chairman for Dr. Roach, reported for Commission VII; Dr. H. Friedman, for Commission VIII; Dr. N. Pushkov, for Commission IX; Dr. O. Schneider, for the Joint Commission of IAGA IAMAP Lunar Effects; and Dr. V. Laursen reported for the WMS Board.

These reports, if they were made available to the Secretary, are included under "Reports of IAGA Organizational Units" in the next section of this bulletin unless the comments are clearly covered in the body of the other reports.

The resolutions were read by the General Secretary. The President obtained approval of each one with only slight modifications. The General Secretary was instructed to take care of any minor editorial changes that might be required. The final resolutions are given in a later section of this bulletin.

REPORT BY FINANCE COMMITTEE

Dr. J. Veldkamp read the report of the Finance Committee, as follows:

"The Finance Committee, Dr. A. DeVuyst, Dr. J. Veldkamp and Dr. N. Mayaud, held a meeting during the General Assembly of the IAGA on Monday, October 2, 1967, and examined the finance account for the period January 1, 1963, to December 31, 1966. All the documents received from the General Secretary, Dr. Leroy R. Alldredge, were very clear and had already been checked by official accountants.

"At the beginning of the period the cash on hand and in banks amounted to \$11,029.50 and at the end of the period to \$17,073.90, which means an increase of about \$6,000. A discussion with the General Secretary revealed, however, that this increase would be spent during the year 1967 to cover the cost of:

1. Transactions of the last two assemblies.
2. Special expenditures connected with the IAGA General Assembly in St. Gall.
3. Symposiums held during this meeting.

"The Finance Committee proposes to discharge the General Secretary from his financial responsibility for the period January 1, 1963, to December 31, 1966 and to express the thanks of the IAGA to the General Secretary for his excellent management of all financial problems of the IAGA."

The report was approved and Dr. J. Veldkamp thanked the General Secretary for the very clear and complete financial records he had provided.

FINAL PROPOSED BUDGET

The General Secretary reported on the budget estimates for the next 4 years. He indicated that the budget given in his report at the opening plenary session, which called for an IUGG allotment to IAGA of $10,000 per year, instead of the present $6,000, had had an effect in that the IUGG Finance Committee has recommended that the IAGA allotment be increased to $8,500 per year. The new 4-year budget, which is included in the minutes of the Executive Committee, was approved by the assembly.

PROPOSED 1969 IAGA GENERAL ASSEMBLY

Father Romana, in the name of the Chief Delegate from Spain, invited the IAGA to have a General Scientific Assembly in Spain sometime during the first two weeks in September in 1969. He indicated that a similar invitation was being extended to IASPEI. The invitation was accepted unanimously by acclamation by the assembly delegates. (The proposal to hold an IAGA General Scientific Assembly in Spain in 1969 was later approved by the IUGG Executive Committee). Father Cardus added a comment to the effect that visas, if required, would be made available to everyone.

EXECUTIVE COMMITTEE NOMINATIONS

Dr. Laursen, Chairman of the Nominating Committee, was called upon to submit the Executive Committee nominations for the years 1967-1971. The following names were submitted for approval and acceptance by the general assembly:

President:	Prof. Takesi Nagata (Japan)
Vice-Presidents:	Mme. V. A. Troitskaya (USSR)
	Prof. E. Thellier (Fr.)
General Secretary:	Dr. L. R. Alldredge (USA)
Members:	Prof. Marcel Nicolet (Belg.)
	Rev. J. O. Cardus (Spain)
	Dr. R. M. Caseverde (Peru)
	Dr. F. S. Johnson (USA)
	Dr. J. G. Roederer (USA
	Dr. R. Turajlic (Yug.)

The general assembly voted unanimously for the above officers.

* * *

President Nicolet gave a vote of thanks to the President of the Local Organizing Committee, Professor Vonderschmitt, and to the Secretatiat for their able assistence in helping make the IAGA General Assembly a success.

Professor Nagata, President-elect, gave his thanks to the assembly for their vote of confidence for the next 4 years.

President Nicolet closed the meeting, asking that the new Executive Committee meet with the past Executive Committee for a few minutes immediately afterward.

REPORTS OF IAGA ORGANIZATIONAL UNITS

The conduct of the assembly, including the management of technical sessions and business meetings, were managed by those who held office during the period 1963-1967. (A complete list of the IAGA organizational units and officers contributing to the XIV General Assembly is given in the first four pages of **IAGA Bulletin** No. 24.)

COMMISSION I
OBSERVATORIES AND INSTRUMENTS
E. Thellier — Chairman

A business meeting and review of magnetic observatories and instruments was held Tuesday morning, September 26, 1967. Professor E. Thellier, Chairman of Commission I, opened the meeting at 9.00h before a large assembly.

After having welcomed the participants, the Chairman stated that the meeting would be devoted to the presentation of the reports of the five working groups, with discussion after each report. The following reports were distributed and presented:

1. Magnetic Observatories, Prof. G. Fanselau.
2. Magnetic Instruments (Ground and Air), Mr. J. H. Nelson.
3. Magnetic Instruments for Space, Dr. J. P. Heppner.
4. Comparison of Standards, Dr. V. Laursen.
5. Instruments for Earth's Currents; no report was sent by Prof. L. Cagniard.

As a result of the discussion, the following items were suggested for the different working groups:

1. The simplification of magnetic observations by the use of nuclear and fluxgate magnetometers.
2. The semiautomatic digitization of analog records.
3. Digital form of hourly values.
4. Automatic observatories with digital and analog recording facilities.
5. Modernization of the existing magnetic observatories.
6. Code-form of magnetic observatories.

The report of the working groups are presented below.

WORKING GROUP I-1, MAGNETIC OBSERVATORIES
G. Fanselau — Reporter

(Professor G. Fanselau, at the last minute, found he could not attend the assembly, but he sent the following report covering the activities of his working group during the last 4 years.)

A list of observatories was published in **IAGA Bulletin** no. 20. As had to be expected, the list was not complete, and it was inaccurate in quite a number of points. Fortunately, a good many suggestions as to corrections have been made, which are at present being collected. These corrections will be published as a supplement to the list of observatories. All observatories are urgently requested to check the list and send corrections to Professor G. Fanselau, so that the supplementary details can be published quickly.

The problem of establishing a suitable observatory code, with the particular view to employing such a code in computing, has been discussed. The Working Group has suggested a code number with six places, with the first three characterizing the pole distance and the remaining three indicating the geographic longitude. This ensures an exactness in the position of the observatories of about 100 km. If several observatories are signalled by the same number, an additional seventh place might be added. In general, however, six places should be sufficient. Numbers would at any rate be more suitable for computing than letters, and most observatories are not equipped with computers large enough to allow the feeding of letters.

Apart from the code number, of course, letter symbols will continue to be used as abbreviations for the observatories and are of great significance.

The Working Group is preparing a card index on observatories listing important instrumentation characteristics of the observatories. At the present time, entries in this card index are based on 1962 data so that many particulars will require supplementation. For the time being, cards will be sent only to observatories that have replied to the circular inquiry raised by the Working Group. These observatories are kindly requested to fill in the necessary supplementations and changes and send the cards back as soon as possible so that the card index can go to press. All interested observatories are requested to include important changes in apparatus and data processing equipment. Such a response would considerably improve the accuracy of the observatory card index.

The 1965 IQSY conference in Madrid decided that an inquiry should be made of the observatories concerning the further submission of observational data to WDC's. There was also a discussion of whether or not the WDC's should collect observational material issued in digital form. A questionnaire was sent to 185 observatories. Seventy-five of them answered, all of which agreed that the WDC's would persist after the IQSY. The observatories think it practical to collect microfilm reproductions of normal magnetograms, including calibrations as well as lists of hourly values of the geomagnetic elements. Different opinions exist about the time required for preparing that material. The statements range from 1 month to 1 year for microfilms, and from 3 months to 1 year for hourly mean values.

Thirty percent of the responding observatories feel that the WDC's should continue to collect the same amount of material as during the IQSY. Forty percent of the responding observatories feel that only microfilm reproductions of normal magnetograms and mean hourly values should be collected.

Thirty-seven observatories voted for special departments in the WDC's that should collect material in a form useful for automatic processing. Nineteen observatories are against it. In this connection, some questions were asked about instruments with digital output. Up till now only nine stations have instruments with digital output. Two stations have instruments for automatic evaluation of the geomagnetic registrations. This evaluation is connected with digital output, and therefore these two stations have digital output too, even if it is obtained in an indirect manner. Sixty stations (of the 75 respondents) have no digital instruments. There are different forms of output: punched cards, paper tape, and magnetic tape. Twenty-five observatories plan to develop new instruments for digital output or to buy them in the near future. A like number of observatories do not intend to buy instruments with digital output. Seven observatories could not give a definite answer concerning this problem.

The circular inquiry on supplying the WDC's had been linked with the question to which extent the observatories should publish geomagnetic yearbooks. The time for publishing these yearbooks and their maximum and minimum content have been of particular importance. The result of this inquiry was published in **IAGA News** No. 5.

The inquiry regarding the necessity of geomagnetic yearbooks was answered by only 30 observatories. They all think it is very necessary to publish yearbooks. Not one observatory voted against such publication, but there is a general feeling that it is necessary to discuss the content of the yearbooks during the next IAGA meeting.

Geomagnetic surveying is to a certain extent endangered by the increasing use of high voltage direct current for energy transport by cable. Only in a very few cases is the cable equipment operated in a bifilar way, i. e., with a cable each for the two conducting directions. Naturally there is no magnetic disturbance in such a case. For technical reasons (lower expenses) the two cores of the cable are operated against ground; asymmetric currents can thus cause considerable disturbances. Things become particularly precarious if submarine cables are operated in a unifilar way only. The Conference Internationale des Grands Reseaux Electriques (CIGRE), Study Committee No. 10, High Voltage Direct Current (HVDC), has been contacted to ask for a list of HVDC-transport hitherto known or being planned. This information has been obtained and lists the following installations known so far:

1. A 100-kV submarine cable operating on negative polarity and using the sea as a continuous return is being built from Vastervik (Sweden) to Visby (Gotland). The current rating is 200 amps and the direction of the cable east to west.

2. A submarine cable connection is being built between Dungeness (England) and Echinghen (France) using two submarine cables operating at + 100 kV and – 100 kV and carrying a full load current of 800 amps. The two cables are laid very close together so there is no danger of interference with ships' magnetic compasses, and although the midpoint is grounded at one end, the supply authorities are not allowed to use earth return in substitution for one of the cables. The direction of the cables is roughly northwest to southeast.

3. A line is being built in New Zealand between Belmore in the South Island and Haywards in the North Island. The connection comprises 335 mi. of overhead line on the South Island, a submarine crossing of the Cook Straight (25 mi.) and 25 mi. of overhead line from Cook Straight to Haywards, which is a little north of Wellington City on the North Island. The circuit is bipolar with an operating voltage of ± 250 kV and a full load rating of 1200 amps (600 MW). The submarine cable route is approximately east to west, so there is no significant magnetic interference. The midpoint of the d. c. transmission circuit will be grounded at both ends and it is expected that in times of emergency with one pole out of commission the earth will be employed.

4. In Sardinia and Italy a d. c. transmission scheme is being constructed between the northern end of Sardinia and the mainland of Italy to permit the transmission of 200 MW at minus 200 kV to ground. The circuit will comprise about 85 km of overhead transmission line on Sardinia, 14 km of submarine cable for the Sardinia-Corsica crossing, 156 km of overhead line in Corsica, 102 km for the crossing from Corsica to Italy a little north of the island of Elba, and some 50 km of overhead line from the coast to San Dalmazio. It is intended to use the sea continuously as a return conductor between an electrode north of the town of Piombino and an electrode at the northern end of the island of Sardinia. The direction of the cable for the Sardinia-Corsica crossing is approximately north to south, but there is little shipping in this area, and the general direction of the cable from Corsica to the mainland will be a little to the north of west from the Corsica coast and there should be no serious interference.

5. The Konti-Skan project between the Swedish network and the Danish network will comprise a d. c. link including 75 km of submarine cable for crossing the Kattegatt and 90 km of overhead lines in Sweden and Denmark. The rated power is to be 250 MW and the rated voltage to ground 250 kV. During the first stage single pole transmission is to be employed, the sea being used as the return conductor. The direction of the submarine cable is approximately east to west. It is intended that at a later stage the link may be extended to double pole transmission, possibly for 500 MW ± 250 kV.

6. In Japan a 50/60 cycle frequency changer of 300-MW capacity is being built. This is basically a d. c. transmission scheme with zero transmission line length between two terminal equipments, so that the magnetic effects should not be significant. The list has been forwarded to the Head of Commission II — Geomagnetic Charts — with the request to use these data for marking such areas of disturbance in the geomagnetic charts.

(The Working Group Reporter suggested that the topics discussed below be dealt with in the scientific sessions during the St. Gall Assembly.)

Unification of Long Observation Series. Long observation series of the geomagnetic observatories contain valuable scientific data. For the scientist dealing with such problems it is a painful task — which as often as not can hardly be solved — to unify these observation series in a way allowing the general treatment of the observation material thus modified. It seems an urgent task, therefore, to request all observatories concerned with long series to devote themselves as far as possible to a unification of their observation results. This unification is particularly concerned with the pointing out of jumps in the observation values that can be caused in different ways, as, for instance, by a shifting of the whole observatory work to a neighboring station, by a change-over to new instruments, and new methods of observation, calculation, and evaluation. An instability arising from this is often not well known and cannot always be fully realized by scientists outside the observatory concerned. General cooperation should be organized to facilitate the use of long observation series for scientific work. Above all, approximate statements should be made about the reliability of principal bases and other instrumental data, since experience has shown that observations dating far back are not as accurate as present ones. An approximate reliability is essential to a determination of the physical significance of the values obtained.

The unification problem is of particular importance to the studying of the secular variation and, perhaps, its temporal and local changes. It goes without saying that a strict unification will amount to a lot of work and is in most cases not done by the observatories. It would, however, suffice for the observatories to point out the presence of jumps or instabilities so that such phenomena are critically studied or even left out when making use of long observation series. So it would be most desirable if these data (which do not require too much effort) could be made available at least by the most important observatories.

Use of Geomagnetic Coordinates. For an evaluation of certain procedures in the ionsphere and in the magnetosphere it is useful to have at hand registrations in geomagnetic coordinates so that features of certain types of variation can be determined quickly. A component in geomagnetic coordinates was established at the Niemegk observatory some time ago, which proved to be useful in the evaluation of special occurrences. The question might be raised whether it would not be practical if a certain number of especially chosen observatories decided also to register at least one component in geomagnetic coordinates, particularly for the observation of pulsations.

Influence of the Inner Part of the Geomagnetic Variation Field at Each Observatory. Geomagnetic soundings proved that some observatories have been built on geotectonically disturbed subsoil. Consequently the variations may be influenced by the endogenously induced part of the field, with this influence being dependent on frequency. It is of course well known that this influence is mainly related to the vertical component. For this reason, in deliberations concerning the ionosphere, only the horizontal components are taken into consideration. It would be very desirable if each observatory gave information on this in case it knows about an influence by induced parts of the geomagnetic variation field. For statistical analyses on current vortex in the ionosphere such data can sometimes be very valuable.

Comparison of Groups of Observatories. For about 10 years, momentous values of Central and East European groups of observatories have been compared with each other. The comparison is extended to all three elements of the geomagnetic field. In the course of 10 years these comparisons have become much more accurate; they offer an opportunity to notice jumps and changes in the principal basis of each single observatory. Such comparisons of groups of observatories would be welcomed for other areas as well. The amount of work is small — the result, however, of great significance. Such comparisons could practically be looked upon as a beginning or continuation of the unification of long observation series at observatories.

Distribution of Observatories. A constant repetition of potential calculations of the geomagnetic field is essential to a sufficiently accurate determination of the temporal changes of the parameters (which have gained an ever-increasing importance).

Particularly with a view to computing it seems necessary to take as a basis for these calculations a permanent network of stations so that potential calculations are made easier. Statistical analyses on the accuracy of the approximation of the geomagnetic field (H. Kautzleben) on a worldwide scale have shown that comparatively few stations can be taken as a foundation for such potential calculations. Their number is approximately several thousand. It goes without saying that not all these locally bound stations for potential calculations can be looked upon as magnetic observatories. Nevertheless it seems expedient to include a certain part into this network of stations as fixed points for the determination of the secular variation and the absolute level. By far the major part of these stations will be so-called secular stations of land surveying, for the representative characterization of which a certain surrounding area would have to be surveyed. For fixing the stations one should fall back on as many existing observatories as possible ; if occasion arises, small observatories should be set up in suitable places, e. g., on islands in the ocean. Recommendations for the setting up of observatories should take these views into consideration.

* * *

The report was discussed in detail by the Working Group, which met at 17.30h on September 26. Those present were: A. P. De Vuyst, Belgium; E. I. Loomer, Canada; Ch. W. Wagner, German Democratic Republic; D. Vopple and K. A. Wienert, Federal Republic of Germany; S. R. Malin, United Kingdom; R. Dubois, United States; and R. Turajilic, Yugoslavia.

Members of the Working Group experienced in computer processing of data feel that the six-digit code previously considered by the Working Group has, besides other shortcomings, the distinct disadvantage of not being mnemonic. A. P. De Vuyst and S. R. Malin are of the opinion that three capital letters will be sufficient. Further investigation will be necessary in order to arrive at a universally acceptable solution.

In view of the ever-growing need for observatory data in digital form the Working Group strongly suggests that observatories investigate the possibilities for changing to digital recording. The fact that at the present time no definite proposals exist as to the form in which data should be made available should not be a serious obstacle to introducing digital recording, because any type of record (punched cards, punched tape, magnetic tape) can be transformed to a type acceptable for future WDC's. The sampling rate should not be less than one sample per minute.

The Working Group obtained agreement on a yearbook which should contain at least:

1. An introduction explaining methods of observation, changes in methods of observation and computation, changes in equipment, results of comparisons with other observatories, and explanations to the tables.
2. Indication of observatory position in geographic and geomagnetic coordinates and elevation in meters above sea level.
3. If possible, corrections to instruments used in the determination of baseline values to meet the International Magnetic Standards.
4. If possible, exorientation angles of recording magnets.
5. Tables and/or graphs of observed and adopted baseline and scale values.
6. Monthly tables of D, H, and Z or X, Y, and Z in the usual manner.
7. Annual means of all elements (D, I, H, Z, X, Y, and Z) obtained at previous sites and at the present location of the observatory.
8. K-indices and character figures.
9. Special events (SC, SI, etc.)

Items 8 and 9, although useful, could be omitted since they are published elsewhere.

Remarks on new methods of observation and computation, instrumental developments at the observatory, and expedients improving the quality of the observations published either in the introduction or appendix of the yearbook would be of great help to staffs at other observatories. Unfortunately, at the present time no journal exists that would accept such notes and that is generally available at observatories. It also seems that observatory workers, impressed by the developments in recent years, are hesitating to make known their achievements to colleagues.

It seems that the collection of annual means of observatories published by Cain and another collection by Leaton, which will be published in the near future, are covering to a large extent the requirements for corrected observatory data. Both collections are based on published observatory data and were sent for proof and comments to the individual observatories. Numerous unexplained erratic changes in the data series still remain. Therefore, observatories are requested to study their history in order to find explanations for such changes and to make them known.

On quiet days, 2 or 3 hours after midnight, none of the magnetic elements is affected appreciably by diurnal variations. Therefore, at that time of the day, the difference in any element between two observatories not too far apart will be constant over periods of several months. This fact has been utilized by a group of Central European observatories since 1955 for checking the performance of instruments. At present seven observatories are participating in the scheme. Data are exchanged for 02h 00m GMT of the 10 quiet days of every month.

Variations of the differences between any two observatories are indicating shifts in the absolute level of instruments. In the early days of the scheme, the variation of differences was considerable. Efforts of the participating observatories to improve the methods of observation have resulted in fairly constant differences.

It is recommended that observatories not too far apart exchange data in the above mentioned manner. Variations of differences should not be used for the adjustment of baseline values because this might result in undesirable effects.

WORKING GROUP I-2, MAGNETIC INSTRUMENTS (GROUND AND AIR)
J. H. Nelson — Reporter

Belgium

Dr. A. De Vuyst, Centre de Physque du Globe, reports that at the Centre de Physique du Globe at Dourbes, an ASMO equipment with analog and digital recording has been in operation for 1 year; a communication about the running of this equipment is to be presented in St. Gall.

The measurements of the H and Z components according to the compensating or adding method have been reviewed. To this end, a simple set of Helmholt coils that may be adjusted very easily has been built (cost of the prototype, about $4,000 at the Askania firm).

Just now, a new set is being built, which will allow the measurements of H, Z (Nelson), D, I (Bacon) and F. The Helmholtz coil can turn around a vertical and horizontal axis and it will thus be possible to eliminate artificial components and to get absolute measurements with the help of the vector proton magnetometer; the object of the apparatus is to get a universal instrument. The apparatus is in process of construction, so it is difficult to estimate its cost.

At the present time, constant current sources of high precision can be found. With such equipment it is possible to replace the whole electric equipment accessory to the vector proton magnetometer. The Working Group should recommend the use of such power sources since they facilitate the measurements greatly. One model is available from John Fluke Manufacturing Company, Seattle, Washington, USA, and costs about $2,000. With a 2-amp output the accuracy is still 10 microamp.

Bulgaria

Classical magnetic instruments are used for absolute magnetic measurements. An Elsec proton-precession magnetometer will be used this year (1967) for aeromagnetic measurements.

Canada

A portable 1-gamma proton magnetometer; weight 7 kg; price about $7,000; available from Barringer Research Ltd.

A portable 1-gamma proton magnetometer; weight 7 kg; price about $3250: available from Sandar Geophysics Ltd.

A portable 10-gamma proton magnetometer; weight 5 kg; price about $3100; available from Barringer Research Ltd.

An airborne/oceanographic proton magnetometer; weight 27 kg; price about $16,500; available from Barringer Research Ltd.

A three-component (fluxgate) station magnetometer; weight 26 kg; price about $6000; available from Sharpe Instruments of Canada Ltd.

A three-component (fluxgate) station magnetometer weighing 8.5 kg (not including batteries or cable) is being used which is essentially a transistorized version of the three-component recording fluxgate magnetometer developed for the IGY (Serson, P. H. An electrical recording magnetometer, Can. J. Phys. **35**, 1387-1394, 1957).

A portable fluxgate magnetometer for D and I is used, in conjunction with a proton magnetometer for F, at repeat stations for the determination of secular change, and at Arctic magnetic observatories for determination of baseline values. Accuracy of D and I observations depends on the accuracy of reading the graduated circles of the theodolite on which the fluxgate is mounted — $\pm$ 0.2 minute of arc for the instrument used.

The main emphasis in instrumental development at the Dominion Observatory since 1963 has been on lightweight portable equipment suitable for battery operation at unattended field stations, particularly for the study of anomalies in electrical induction in the crust and upper mantle by both magnetic and telluric observations.

For this purpose, the model DM fluxgate magnetometer appears ideal, but there are difficulties in recording its output in a form accessible to digital computers. At present, simple magnetic tape recorders (Limpet Logger, Dobit-MacInnis, Edinburgh, Scotland), producing a form of digital code that can be translated to punch cards, are used in parallel with simple spring-driven chart recorders. Both recording devices suffer from insufficient resolution if the range is made broad enough to avoid off-scale conditions. This difficulty has been overcome through the use of a transistorized device that adds or substracts a known voltage whenever the quantity being recorded exceeds a preset limit.

With a light aircraft, one man can operate simultaneously half a dozen such stations, spread over 1000 km in Arctic conditions. The capacity of the recorders is such that if the stations are visited every 2 or 3 days, periods ranging from 1 or 2 minutes to 24 hours can be studied.

The model DM recording magnetometers are also used during the occupation of repeat stations for the determination of secular change.

With the addition of band-pass filters and Helicorders (Geotechnical Corporation, Garland, Texas) the model DM fluxgate magnetometers have been installed at four magnetic observatories in Canada for the study of pulsations in the range of 1-sec to 1000-sec periods. The recording speed is 15 mm/min, filling one sheet of paper per day for each component. Maximum sensitivity is 0.3 gammas/mm.

In 1963, experimental results from a three-component proton magnetometer recording on punched paper tape were reported. Although successful runs of several days duration were obtained, difficulty was experienced with the mechanical reliability of the tape punches in unattended operation, and the project was put aside to await the availability of suitable digital magnetic tape recorders.

By the time incremental digital magnetic tape recorders suitable for use in the field and at isolated stations appeared, considerable improvements in the performance of fluxgate magnetometers indicated that they might provide a more practical approach to an automatic observatory for Canadian conditions. A proton-precession magnetometer measuring F could be included in the system to give a check on the drift of the fluxgates.

The first application by the Dominion Observatory of digital magnetic recording was in the three-component airborne survey of 1965. In spite of a delay in the delivery of the recorder, which forced recording without any preliminary tests, tapes which could be read by the computer were obtained. In 1966, two magnetotelluric stations recording on digital tape were used in a study of underground induction in Newfoundland.

France

Although equipment used for measuring the data on conventional magnetograms is not ordinarily considered to be a type of "magnetic instruments," such equipment is certainly of interest to anyone who requires magnetic data in digital form. Dr. R. Schlich, of the Observatoire Géophysique du Parc Saint-Maur, Institut de Physique du Globe, has sent a copy of a publication with the title: "Traitement semi-automatique d'enregistrements analogiques, application aux magnétogrammes," by R. Schlich and M. Palomares. A resume of the article is to be presented during the IAGA meetings.

Hungary

Since 1964 the Geophysical Observatory, Tihany, has used a proton-precession magnetometer with a sensitivity and absolute accuracy of one gamma. The manufacturer is Gamma Optical Works.

At the Geophysical Department of the Loránd University Eötvös, Budapest, a proton-precession magnetometer was designed. The sensitivity of the instrument is 1.5 gammas, absolute accuracy is 3 gammas.

Permanent recording will be started this year (1967) at Eotvos, with a translatometer, which is a static instrument serving for measuring the gradient of the magnetic field.

Japan

Recent developments in magnetic instruments in Japan as reported by Ietsune Tsubokawa, Earthquake Research Institute, The University of Tokyo:

1. Saturable core instruments.

a. Fluxgate magnetometers for ground use — According to the combination of the methods of cancellation of the geomagnetic field (permanent magnets or solenoids) and the system of recording (analog, digital, punched tape or their combination), several kinds of magnetometers for ground use have been developed and are now being used.

Manufacturers: Hitachi Mfg. Co. Ltd.; Nihon Electric Co. Ltd.; Sokkisha Co. Ltd.

b. Airborne magnetometer — Under the WMS project, the Hydrographic Office developed a three-component airborne magnetometer in which sensors are placed on a mounting stabilized with a gyroscope. The sensitivity of the sensor is $\pm$ 10 gammas and the absolute accuracy is about $\pm$ 50 gammas or so.

Manufacturer: Sokkisha Co. Ltd. and others.

2. Proton precession magnetometer.

a. Instruments for measuring F — Various kinds of instruments for ground, shipborne and airborne uses have been developed. For the purpose of taking the difference of the fields of two separately located stations, Rikitake and others designed a differential proton magnetometer under the project of earthquake prediction in Japan. In unit magnetometer, precessional signals are amplified, multiplied and counted during the preset time. The counted number is directly proportional to the intensity of the field, and is recorded by an analog recorder, printed digitally, and also punched on a paper tape. Operations of a set of magnetometers are synchronized by programmed signals from the crystal clocks of respective instruments, being calibrated by JJY standard time signals.

The synchronized punched tapes are brought together and the difference of the fields are read by a read-out device. The accuracy of detection of difference is about $\pm$ 1 gamma.

Manufacturer: Sokkisha Co. Ltd.

b. Vector proton magnetometers — Vector proton magnetometers after the principle proposed by Tsubokawa in 1958 are operated in the Kanozan Geodetic Observatory of the Geographical Survey Institute and the Kakioka Magnetic Observatory of the Meteorological Agency.

The effect of insufficient cancellation of the field component and of imperfect orientations of the instrumental axes are eliminated in principle by suitable operation of the magnetometer-theodolite. In the Kanozan Observatory continuous and absolute observations are being made, while in the Kakioka Observatory this type of instrument is used for the purpose of checking the electromagnetic standard magnetometers (one is a rotating-coil detector type and the other a sine galvanometer) and also determining the baselines of the magnetographs. The discrepancies between the proton magnetometer and the two standard magnetometers are assumed to be less than $\pm$ 0.2 gamma.
Manufacturers: Sokkisha Co. Ltd.; Nihon Electric Co. (NEC)
Estimated cost: about $40,000.

c. Combination of proton magnetometer with other type of instrument — Nagata and Oguti designed a portable absolute magnetometer by placing a proton magnetometer head on the top of the mounting of the rotating coil of an earth inductor magnetometer which measures the direction of the field (D and I).

Tsubokawa proposed a suitable position of the head in the earth-inductor magnetometer theodolite to eliminate the effect of the separation of the head from the inductor coil and thus to enable all the observed values to be effectively those in the center of the instrument. He concluded that one extremity of the horizontal axis of the theodolite on which a rotating inductor is mounted is most favorable. A magnetometer based on this principle is now under construction.

Kato and others combined a fluxgate magnetometer, which measures the direction of the field, with a proton magnetometer for F. To avoid disturbances due to the magnetic property of the core and the exciting field of the proton head, these two instruments are placed separately.

d. Airborne magnetometer — After the principle of Tsubokawa, the Geographical Survey Institute developed an airborne proton magnetometer that measures three components of the field.

3. Optically pumped magnetometer.

a. Instrument for general use — Ogawa of Kyoto University is now developing an optically pumped magnetometer with a symmetrical spectrum. It will reduce errors caused by the asymmetry of the combined spectrum of the various Zeeman sublevels. Right and left circularly polarized light is separately introduced into each part of the cell containing the alkali vapour, and the errors caused by the variations of temperature, light intensity, and angle between the direction of magnetic field and light beam are expected to be reduced considerably.

b. Sea-borne optically pumped magnetometer — Nagata and Oguti have developed a sea-borne optically pumped magnetometer using magnetic resonance absorption of Rb 85. The magnetometer consists of two parts, i.e., a fish and shipborne recorder. The water watertight fish, 2 m in length and 10 cm in diameter, contains a dual set of Rb sensors in order to minimize the effect of the angle of the detector. The overall accuracy is said to be about 5 gammas in absolute value, with readings being accurate to 0.5 gamma with respect to each other.

c. Rocket-borne magnetometer — Optically pumped magnetometers were launched by Japanese rockets. Their characteristics were as follows:
Sensitivity: 0.01 gamma
Absolute accuracy: 1 gamma
Working principle: optically pumped cesium vapor
Manufacturer: Mitsubishi Electric Company Ltd.
Estimated cost: about $10,000

Rumania

Professor L. Constantinescu, Acting Research Director, Centrul de Cercetări Geo-Fizică, Academia Republicii Socialiste Române, reports that four transportable geomagnetic variographs with suspended magnets are being used for field recordings to obtain data concerning the local peculiarities of the Sq variations and of some types of geomagnetic disturbances. Two of the variographs are manufactured by Askania in West Germany; two are produced in the USSR by IZMIRAN, Academy of Sciences of the USSR. The German instrument sells for about $12,000; the Russian instrument is reported to cost about $4,000.

Sweden

Two Elsec proton-precession magnetometers are used regularly, one for survey work and the other at the Lovo observatory. Braunbeck coils are being constructed to provide for the measurement of component intensity according to a modified Serson method.

Kiruna has been operating for several years a magnetic recording system employing conventional field sensors and sampling three-component data at a rate of 120 readings per hour. An electronic computer is used to process the data, producing hourly mean values, Q and K indices, maximum and minimum values, etc.

United States

Four observatories of the Coast and Geodetic Survey, are now equipped with rubidium magnetometers recording in digital machine-readable form. Fredericksburg and Dallas have the ASMO (Automatic Standard Magnetic Observatory), recording the vector field once each minute on punched paper tape; Castle Rock has the ASMOR (ASMO-Remote), recording the vector field six times each minute on digital magnetic tape, the recorder being located more than 100 km from the sensor unit. Newport has the Triple-Sensor, recording each of the three elements D, H, and Z every 10 seconds on digital magnetic tape and recording each of three elements continuously on an FM analog magnetic tape system for micropulsations. All four systems have performed satisfactorily at times but are subject to some interruptions due to malperformance of various components.

All U.S. observatories are using the proton magnetometer for absolute measurements of field intensities. Seven of them are equipped with biasing coils to permit measurement of H and/or Z in addition to F.

Three-component fluxgate (saturable core) magnetometers recording on rolls of chart paper were used at the four IQSY stations in the Pacific area. A similar instrument, but designed more compactly and equipped with gimbal suspension for automatic leveling, has been used at one of the Antarctic observatories for the past two years. All of these instruments record D, H, and Z. The H and Z fluxgates are equipped with a pair of balanced compensating magnets (one of each pair being mounted on a bimetallic strip for temperature compensation) to reduce the field component to a zero mean value.

A semiautomatic magnetogram scaling machine, built to Coast and Geodetic Survey specifications, has been in use since the early part of 1967 for converting standard magnetograms to digital form on IBM-compatible magnetic tape. As many points as desired per hour of magnetogram record may be digitized at a maximum rate of about 100 points per second. Speed of following the magnetic trace depends on the amount of magnetic activity on the gram and on the operator's skill, and is completely under control of the operator. The average magnetogram requires about 20 minutes for digitizing all three magnetic components (and the temperature trace, if desired).

Ten of the Coast and Geodetic Survey oceanographic vessels, and twelve of the U.S. Navy oceanographic ships are equipped with towed marine (proton) magnetometers, and continuous total-field magnetic profiles are recorded while under way during normal ship operations. The newer systems employ all solid-state electronics, recording directly in gammas on magnetic tape or punched paper tape.

For recording micropulsations the Lamont Geological Observatory in New York is using a rubidium-vapor magnetometer for F measurements, combined with fluxgate sensors for the D and I components.

The Institute of Earth Sciences, a component of ESSA, with headquarters in Boulder, Colorado, reports the results of a series of tests made on the self-oscillating rubidium 85 magnetometer which forms the magnetic sensing unit of the ASMO at the Castle Rock Observatory. In summary, the following changes of standard were observed, when compared with the proton-precession magnetometer:

Magnitude of change	Period of observation	Probable cause
7.4 gammas	—	Substitution of a different rubidium sensor
6.6 gammas	—	Retuning of radio frequency oscillator
1.8 gammas	10 months	Not known; operation undisturbed

The Institute is planning to undertake a study of the rubidium magnetometer, with a view to increasing the stability and reliability of the rubidium instrument through "locking on" to a single line in the energy level spectrum rather than to a group of lines as is now done.

The National Aeronautics and Space Administration (NASA) has installed at Greenbelt, Maryland (near Washington), a magnetic test facility for testing and calibrating magnetic instrumentation to be used in rockets and satellites. The test facility consists primarily of two large 3-axis Fanselau (or Braunbeck) coil systems. The smaller system is about 6 meters in diameter; it employs a single rubidium magnetometer for testing and controlling the three orthogonal components of the field (some seventeen times per second for each component) to maintain a constant zero field at the center of the coils. The system is also equipped with controls for establishing a rotating field, about any axis, of any intensity up to 60,000 gammas, to stimulate tumbling of a space vehicle within a fixed magnetic field, and there is available a nonmagnetic high-vacuum chamber which can be used inside the coils. The larger coil system is similar to the smaller one, but is twice the diameter (about 12 meters) and has three separate rubidium sensors for maintaining a constant field.

Since 1963, the U.S. Naval Oceanographic Office has made the following additions and improvements to its magnetic survey instrumentation in connection with Project Magnet:

1. A helium optical pumping magnetometer has been installed in a tow-configuration aboard the C54 survey aircraft. The resulting high sensitivity total-field data supplement vector measurements on board the aircraft. A towed optical pumping magnetometer is also undergoing tests on board the Super Constellation aircraft (NC-121). In addition, a proton precession magnetometer has been successfully operated on board the Super Constellation.

2. A cesium optical pumping station magnetometer and a single fluxgate station magnetometer are available for use during special detailed surveys.

3. A digital magnetic tape recording system became operational aboard the Super Constellation. This system has a capacity of 40 channels (160 characters), a variable sampling rate (up to 5 per second), and records all data in a direct input format to the IBM 7074. A similar system is being installed aboard the other Project Magnet aircraft (NC-54).

4. A navigational satellite receiver was operated in flight on a round-the-world Project Magnet survey during April-June 1967.

Air Force Cambridge Research Laboratories continues to operate a network of six horizontal-intensity magnetographs in Peru, Sweden, Greenland, and the United States. The sensor is a conventional suspended-magnet Ruska variometer. Recording is in a "variable-area" mode, providing an analog record that can be readily digitized by a special analyzer and the results are made available on punched cards.

* * *

The Working Group convened at 17.30h on September 27, 1967, under the direction of Reporter J. H. Nelson. Fourteen members and guests were present. The report of the Working Group, which had been distributed earlier, was discussed briefly, particularly as to how it might be made more useful. The discussion led to the suggestion that the Reporter prepare a brief description of any new equipment, working principle, or application of magnetic instruments — if possible, together with reference to a source of additional information — and try to get this information published in a journal that would receive wide distribution to IAGA members — such as **IAGA News, Journal of Geophysical Research,** or perhaps **Journal of Scientific Instruments.**

The Working Group also recognized the need for a "standard" observatory in South America, where instruments can be compared for maintaining suitable absolute calibration standards at some location closer than Rude Skov in Denmark. It was agreed that a suggestion be given informally to the Working Group on Comparison of Standards to give consideration to this idea as a suitable subject for a resolution of IAGA.

WORKING GROUP I-3, MAGNETIC INSTRUMENTS FOR SPACE

J. P. Heppner — Reporter

During the last 4 years apparently no magnetometers were developed from principles that were not well known prior to 1963. Instead, magnetometer development was oriented toward improving the capabilities and realiability of existing types. Particular emphasis was placed on the use of associated electronic systems that would permit temperature control, more rapid sampling, greater accuracy and sensitivity, measurement of a wider range of field intensities, and satellite on-board processing and storage of data for later transmission to earth. Some illustrative examples are given below:

1. In the USSR Cosmos satellites, methods were used that permitted the Larmor frequency of proton precession to be counted in flight, stored, and later transmitted to surface stations.

2. In the low altitude polar orbiting series of U.S. OGO satellites, the Larmor frequency from a rubidium vapor magnetometer was both counted and stored in flight twice per second for later transmission and telemetered directly by means of a wide bandwidth transmitter. In this series OGO-2 and OGO-4 were launched, respectively, in October 1965 and July 1967 and are still functioning properly.

3. In the eccentric orbit series of OGO satellites bias fields were used to provide vector as well as scalar measurements from a rubidium vapor magnetometer. In this series, OGO-3 is still functioning perfectly after 16 months in orbit and providing measurements over the range of 3 to 18,000 gammas.

4. An optical pumping helium magnetometer was used successfully for weak field measurements on a Mariner probe by employing an analog feedback system.

5. Fluxgate (saturable core) magnetometers were most extensively used for vector measurements in weak fields. In the U.S. IMP and Pioneer series, accurate zeros were established by reversals of the sensor axes by using the satellite spin or by incorporating mechanisms that suddenly rotate the sensors relative to the spacecraft body axes.

6. Dual-range fluxgates were used on the OGO-1 and OGO-3 satellites to measure fields as strong as $\pm$ 500 gammas while maintaining a precision of a quarter of a gamma in fields of $\pm$ 30 gammas. In the anchored IMP (lunar orbiting) series, automatic range switching was used to select scales of $\pm$ 24 and $\pm$ 64 gammas.

7. On Pioneer satellites a correlation computer was used to increase the equivalent sampling rate in a system where telemetry bit rates were severely restricted.

8. On all satellites in the OGO series, search coil magnetometers were also flown for measurements of field oscillations in the frequency range of a fraction of one hertz to 1000 hertz. These instruments overlapped in frequency other instruments designed for study of VLF waves.

In addition to improvements in satellite instruments substantial improvements were made in rocket-borne magnetometers. Rubidium and cesium vapor instruments were used successfully in investigations of the equatorial electrojet, auroral electrojets, and midlatitude Sq currents. It is apparent that during the past 4 years the use of optical pumping magnetometers reached a state of maturity.

The rather substantial achievements in space magnetic field measurements are attributable to other factors besides the design of magnetometers. These include: improvements in facilities for testing magnetometers, the design of spacecraft in which strict attention was paid to reducing the magnetism of structures and components, and improvements in the information handling and telemetry systems of the spacecraft.

In the future it appears that improvements will continue along the basic lines of the past but that there will be new challenges. These include particularly:

a) the design of magnetometers to accurately measure fields that are less intense than one gamma, such as the fields that may be encountered at great distances from the sun, and

b) the design of rapid sampling vector magnetometers for measurements accurate to a few gammas in fields as strong as 0.6 gauss. Progress on this item must necessarily be accompanied by developments that will allow the three-axis orientation of the sensors to be known to several minutes of arc in inertial space.

WORKING GROUP I-4, COMPARISONS OF STANDARDS

V. Laursen — Reporter

The Committee on Comparisons of Magnetic Standards was set up at the 1936 Edinburgh meeting of the Association of Terrestrial Magnetism and Electricity. When the future activities of the IAGA were brought up for discussion at the 1963 Berkeley meeting, it was decided to continue the comparison program and to entrust it to a Working Group of Commission I. During the period under review the membership of the Working Group has been as follows: V. Laursen, Reporter (Denmark); B. R. Leaton, (Great Britain); E. LeBorgne (France); J. H. Nelson (USA); L. S. Prior (Australia); V. F. Shelting (USSR); and K. Yanagihara (Japan).

The comparison observations have been carried out, as in previous report periods, by means of calibrated QHM-magnetometers sent by air freight from the Rude Skov observatory to the participating observatories and back. In addition the Service on Comparison has been cooperating actively in three World Magnetic Survey missions by sending sets of calibrated magnetometers with the WMS experts for the purpose of comparing these magnetometers with the standard magnetometers in the countries visited. Comparison observations under this joint program have been made by Dr. K. A. Wienert during the WMS Mission No. 1 to countries in Africa in 1964, Dr. J. M. Stagg during the WMS Mission No. 2 to countries in South America in 1965, and Dr. K. A. Wienert during the WMS Mission No. 3 to countries in the Mediterranean area and the Middle East in 1966-1967.

It should be mentioned that the comparison program of the WMS missions included also a comparison of standard values of Z by means of a BMZ-magnetometer which UNESCO had placed at the disposal of the WMS Board.

As in previous periods, a set of association QHMs has formed part of the instrumental equipment of the nonmagnetic vessel **Zarya** of the USSR. The constants of these instruments were checked when **Zarya** called at Copenhagen in April 1966 and in June 1967.

The complete list of comparisons carried out is as follows:

(1) A comparison by means of QHM-magnetometers No. 228, 229, and 230 between Rude Skov and the observatory at Tananarive (Madagascar).

(2) A comparison by means of QHM-magnetometers No. 513, 514, and 515 between Rude Skov and the observatory at L'Aquila (Italy).

(3) A comparison by means of QHM-magnetometers No. 480, 481, and 482 between Rude Skov and the observatories at Freetown (Sierra Leone), Accra (Ghana), Addis Ababa (Ethiopia), and Nairobi (Kenya). This comparison was carried out by Dr. Wienert during WMS Mission No. 1 .

(4) A comparison by means of QHM-magnetometers No. 90, 91, and 92 between Rude Skov and the observatories at Vassouras (Brazil), Las Acacias (Argentina), Pilar (Argentina), Peldehue (provisional site, Chile), La Paz (Bolivia), Huancayo (Peru),

and Fuquene (Colombia). This comparison was carried out by Dr. Stagg during WMS Mission No. 2.

(5) A comparison by means of QHM-magnetometers No. 228, 229, and 230 between Rude Skov and the Wien-Kobenzl observatory (Austria).

(6) A comparison by means of QHM-magnometers No. 90, 91, and 92 between Rude Skov and the observatories at Pendeli (Greece), Istanbul-Kandilli (Turkey), Ksara (Lebanon), Teheran (Iran), Quetta (Pakistan) and Misallat (Egypt, UAR). This comparison was carried out by Dr. Wienert during WMS Mission No. 3.

(7) A comparison by means of QHM-magnetometers No. 477, 478, and 479 between Rude Skov and the Niemegk observatory (German Democratic Republic). This comparison was carried out by Mr. Kring Lauridsen of the Rude Skov staff, who brought the QHMs with him to Niemegk and who made comparisons also of the standard values of D and Z.

(8) A comparison by means of QHM-magnetometers No. 477, 478, and 479 between Rude Skov and the Fredericksburg observatory (USA).

(9) A comparison by means of QHM-magnetometers No. 228, 229, and 230 between Rude Skov and all Spanish observatories. This comparison has not yet been completed.

The results of the comparisons are given below in the form of differences between observatory standards of H.

June 1964 Rude Skov — Tananarive = –23 gammas
(the Tananarive standard based on QHMs 303 and 304)
Oct. 1964 Rude Skov — L'Aquila = –6.5 gammas
(the L'Aquila standard based on the Askania theodolite)
Nov. 1964 Rude Skov — Freetown = –13 gammas
(the Freetown standard based on QHMs 506 and 507)
Nov. 1964 Rude Skov — Accra = –14 gammas
(the Accra standard based on QHMs 495, 496, and 497)
Dec. 1694 Rude Skov — Addis Ababa = –22 gammas
(the Addis Ababa standard based on QHMs 377, 378, and 379)
Dec. 1964 Rude Skov — Nairobi = –21 gammas
(the Nairobi standard based on QHMs 397 and 398)
Oct.-Nov. 1965 Rude Skov — Vassouras = 2 gammas
(the Vassouras standard based on the Toepfer magnetometer)
Nov. 1965 Rude Skov — Las Acacias = –8 gammas
(the Las Acacias standard based on QHM)
Nov. 1965 Rude Skov — Pilar = –8 gammas
(the Pilar standard based on the Askania magnetometer)
Nov. 1965 Rude Skov — Peldehue = 0 gammas
(the Peldehue standard based on the Askania magnetometer)
Dec. 1965 Rude Skov — Fuquene = 3 gammas
(the Fuquene standard based on the Askania magnetometer)
Oct. 1966 Rude Skov — Niemegk = 3.6 gammas
(the Niemegk standard based on the Schmidt and Wahnshaff theodolites)
Dec. 1966 Rude Skov — Fredericksburg = –0.3 gammas
(the Fredericksburg standard based on Sine Galvanometer No. 1 and the proton vector magnetometer)

For some of the comparisons actually carried out the final results are not yet available.

At Rude Skov a method has been developed for the direct determination of H by means of the IAGA proton magnetometer, using the 2-m Helmholtz coil of the observatory for the compensation of Z. The standard values from which the above differences have been derived are mainly based on these direct determinations.

As in previous reports, it should be pointed out that the Rude Skov standard can by no means claim to be an international standard for horizontal force. In this connection it is thought that the observatories taking part in the comparison program will be interested in the following summary of all the comparisons which have so far been carried out between Rude Skov and Cheltenham/Fredericksburg by means of QHMs:

April 1948 (QHMs 33, 51, 52) Rude Skov — Cheltenham = 3.0 gammas
Dec. 1949 (QHMs 90, 91, 92) Rude Skov — Cheltenham = –0.6 gammas
Dec. 1949 (QHMs 29, 58) Rude Skov — Cheltenham = 3.1 gammas
Mar. 1951 (QHMs 34, 50) Rude Skov — Cheltenham = 4.6 gammas
May-Sept. 1953 (QHMs 50, 51, 52) Rude Skov — Cheltenham = 2.5 gammas
Aug. 1956 (QHMs 32, 33, 34) Rude Skov — Cheltenham = –1.6 gammas
Oct.-Nov. 1958 (QHMs 477, 478, 479) Rude Skov — Fredericksburg = 0.6 gammas
Nov. 1961 (QHMs 477, 478, 479) Rude Skov — Fredericksburg = 0.6 gammas
Dec. 1966 (QHMs 477, 478, 479) Rude Skov — Fredericksburg = –0.3 gammas

SYMPOSIUM ON RECENT DEVELOPMENTS IN GEOELECTRIC AND GEOMAGNETIC INSTRUMENTATION

A symposium on recent developments in geoelectric and geomagnetic instrumentation was held by Commission I, Wednesday morning, September 27, 1967.

The symposium was suggested by Professor S. K. Runcorn, and at the meeting in Copenhagen of the Executive Committee it was decided to hold it during the General Assembly in 1967. Professor E. Thellier, Chairman of Commission I, was charged with the responsibility for the symposium and Professor Runcorn agreed to act as secretary. Many letters were sent to different services inviting them to participate. A total of 13 communications were received by Professor Runcorn. Unfortunately he was unable to assist at the meeting and Professor Thellier took the chair.

Two papers were withdrawn (I-4 and I-12). All the others were presented and it was possible to accept four short extra papers. In a general way, the papers dealt mainly with the description of different nuclear magnetometers and on the transistorized versions of this instrument. The most interesting ones, including the paper by Professor De Vuyst read the day before, were on digital recording of the variations of the geomagnetic field. Abstracts of the papers presented can be found in **IAGA Bulletin** No. 24, pp. 41-45. Abstracts of four of the extra papers follow.

"A Newly Developed Integrated Circuit Proton Precession Magnetometer," by J. Mac Dowall.

The present state of integrated circuit technology is reviewed. Integrated circuits are used to build a magnetometer with the Serson phase lock system, which operates under conditions of local interference due to leaking power lines, etc. This development allows the construction of an instrument that is robust enough for air or ground survey work.

A direct 1-gamma readout circuit is incorporated and a facility is included to allow the direct drive of BCD (1-2-4-8) printers and analog recorders. The total weight of the unit is 17 lbs., including self-contained rechargeable batteries.

"The Digital Conversion System and Data Link at the University of Alberta," by David Rankin.

The Geophysical Observatory of the University of Alberta, located 56 km southeast of the university, is connected on a telephone line with the laboratory in Edmonton. Fifteen channels of seismic and electromagnetic data are transmitted in digital form. A complicated selection system gives a minimum sampling rate of three per second for some channels for a total of 90 words per second. At the laboratory, the data are written onto digital magnetic tape that is compatible with the IBM 360-67 computer. At the same time digital-to-analog conversion provides paper analog records that are interchangeable with direct analog recorded records. Simultaneous analog-to-digital conversion of records that have been recorded on seven-channel FM magnetic tapes is also being carried out.

"A Helicopter-Borne Electromagnetic Prospecting and Metal Detecting Aid," by J. MacDowall.

Two coils were mounted at the ends of a fiber glass tube 30 ft. long. The axis of the transmitter coil was coincident with the tube and this coil was driven by a 400-cps oscillator. The receiver coil is orthogonal to the transmitter and therefore has null coupling with the transmitter. Null coupling is maintained despite the vibrations of the tube by a simple passive Invar wire suspension system which causes the receiver coil to rotate into the plane of null coupling when the tube is bent during flight. The resulting system is equivalent to maintaining coil alignment to less than 1 second of arc. This technique can also be applied to gradient magnetometers. The in-flight noise level of the system was found to be about one part per million of the primary field measured at the receiver. This represents a tenfold reduction over previous similar systems.

"On Coils Generating Homogeneous fields," by T. A. As.

A purely homogenous field can be created inside a coil, which has the form obtained by the revolution of an ellipse about an axis, which is parallel to one of the principal axes and which intersects the ellipse. The theory gives the possibility of constructing compact coils for strong homogeneous fields.

COMMISSION II
MAGNETIC CHARTS
E. H. Vestine — Chairman

Commission II met jointly with the World Magnetic Survey Board (WMS) in open session at 09.00h, September 26, for consideration of progress and new proposals connected with geomagnetic surveys. The deliberations are adequately described under the report of the WMS Board in an earlier section of this bulletin. In the afternoon session, work leading up to the initiation of four resolutions urging prompt forwarding of survey data to WDC's emphasizing opportunities afforded for crustal studies using ocean magnetic anomaly profiles, provision of mean hourly values of magnetic observations since 1840 in machine-readable form, and machine-readable data also for survey values was begun. These were passed later in a business section at 14.00h on September 28, and forwarded to the IAGA Secretary. The need for improved data on magnetic secular change was especially emphasized.

P. H. Serson presented a review of progress since the Berkeley meeting in land and airborne magnetic surveys. For land magnetic surveys he found in the last 10 years that there had been occupation of 1,325 repeat stations, of which 240 were new stations, with about 14,385 other stations not likely to be reoccupied. Coverage on the Antarctic Continent was greatly improved. Airborne magnetometer profiles were about 200,000 km for Canada, 80,000 km for France, 50,000 km for Japan and adjacent waters, 120,000 km for the United Kingdom and 1,250,000 km for the United States.

M. M. Ivanov reported on Ocean Shipboard Surveys of the **Zarya**, the nonmagnetic ship of the USSR. (See **IAGA News** No. 5, pp. 20-25.) These covered a substantial part of all navigable oceans during the past decade, with provision of both repeat stations for secular change and other values. It was reported that the **Zarya** is no longer seaworthy and it was urged that other maritime nations attempt continuing the work now terminated by the ship.

J. P. Heppner in a paper read by J. C. Cain reviewed magnetic surveys by earth satellites during the period 1964-1967. Proton magnetometers aboard Cosmos 26 and Cosmos 49 operating between latitudes $\pm$ 49° and up to heights of 490 km surveyed the earth for a number of weeks in 1964, with values of accuracy about 30 gammas. Satellite 83C of the Applied Physics Laboratory obtained regional coverage near ground-based receiving stations to an accuracy of about 18 gammas in low latitudes. OGOs 2 and 4 in 1965 and 1967, respectively, are obtaining a number of months of coverage using a rubidium-85 magnetometer to about 10-gamma accuracy on very nearly a polar orbiting basis. B. R. Leaton reported on cartography problems related to preparation of magnetic charts covering the World Magnetic Survey.

On Thursday, September 28, an afternoon session was devoted to maps of the earth's surface and harmonic analysis for mapping purposes in the case of a spheroidal earth. It was shown that maps derived from analysis for a spherical earth require a small correction in the north and vertical component if the spheroidal character of the earth is taken into account. A highlight of the meeting was the formal presentation of the results of the Japanese World Magnetic Survey Charts complete with an attractive volume of particulars about the survey. An abstract dealing with survey results of Cosmos-49 by N. P. Benkova, S. Dolginov, L. O. Tijurmina, and T. N. Cherevko was received but not presented.

A joint technical session with Commission III, dealing with field analysis, was held at 14.00h on October 5.

A preliminary outline of the program for the Symposium on Description of the Earth's Magnetic Field, to be held in Washington, D. C., USA, October 22-25, 1968, was worked out. The symposium will be held at the U.S. National Academy of Sciences in Washington, D. C. Mr. J. H. Nelson of the U.S. Coast and Geodetic Survey (ESSA) is Chairman of the Local Arrangements Committee. Drs. E. H. Vestine and V. Laursen are cochairmen of the scientific program. The World Magnetic Survey Board and Commissions II and III will contribute most to this symposium. The following is a preliminary outline of the topics to be covered:

1. Ocean and Airborne Surveys
   (a) **Zarya**
   (b) Other oceanographic vessels
   (c) Airborne surveys
2. Satellite Surveys
3. Outer Magnetosphere Surveys
4. Regional Charts
5. World Charts
   (a) U.K.
   (b) USSR
   (c) USA
6. Adopted Grid Point Values for WMS
7. Secular Change
8. Interpretations Pertaining to the Earth's Core
9. International Geomagnetic Reference Field
10. Magnetic Anomalies (Interpretation of crustal features)
    (a) Atlantic ridge
    (b) Ocean ridge
    (c) Land anomalies

Leaders in the various fields will be invited to give reviews, and contributions of papers will be encouraged. Symposium tours will be arranged to nearby geomagnetic facilities.

WORKING GROUP II-1, LAND AND AIRBORNE SURVEYS
P. H. Serson — Reporter

The Working Group met at 17.30h on September 26. Only eight or nine members of the Working Group and guests were present. Mr. Nelson proposed for discussion a resolution urging all countries, in view of the active and urgent need of the three organizations who compile world magnetic charts (in the USSR, U.K. and USA), to transmit at the earliest practical date all magnetic survey data to one of the World Data Centers or directly to one or more of the agencies producing world charts. There was general agreement that the idea was good, but the resolution was to be worded in such a way that there should be no suggestion of trying to endanger or nullify any established procedure under international agreements for the exchange of data through WDC channels.

Dr. Serson's summary of progress in land and airborne magnetic surveys since 1963, given below, is based largely on private correspondence and the following references:

Heppner, James P., The world magnetic survey, Space Sci. Rev., 2. 315-354, 1963.

IUGG Chronicle No. 66, pp. 198-207, December 1966.

Le Borgne, E., and J. Le Mouel, La nouvelle carte magnétique de la France, Institut de Physique du Globe, Note No. 15, Paris, 1966.

Le Borgne, E., and J. Le Mouel, Les stations de la France métropolitaine pour le Levé Magnétique Mondial, Institut de Physique du Globe, Note No. 18, Paris, 1966.

McWilliams, J. and J. Byrne, A magnetic survey of Ireland for epoch 1965.5, Department of Transport and Power, Meteorological Service, Dublin, 1966.

Ostenso, Ned A., Geomagnetism, Trans. Am. Geophys. Union, 47, 303-332, 1966.

Report on aeromagnetic survey in Japan. World Data Center C2 for Geomagnetism, Kyoto, 1967.

van der Linden, J. Regional magnetic surveys in Australia, Australian Antarctica, and the Territory of Papua and New Guinea during 1963, Bureau of Mineral Resources, Geology and Geophysics, No. 1965/218, Canberra, 1965.

van der Linden, J., Preliminary isomagnetic maps of Australian Antarctic Territory and adjoining areas for the epoch 1965.0, Bureau of Mineral Resources, Geology and Geophysics, No. 1966/158, Canberra, 1966.

WMS Notes No. 1, WMS Secretariat, National Academy of Sciences, Washington, January 1964.

WMS Notes No. 2, WMS Secretariat, National Academy of Sciences, Washington, October 1964.

WMS Notes No. 3, WMS Secretariat, National Academy of Sciences, Washington, January 1966.

Land Surveys

Table I lists by country or area the number of magnetic stations occupied during roughly the last 5 years, not including observatories. The stations have been classified, rather arbitrarily, as first-order or second-order. First-order stations are further divided into repeat stations and new stations. A repeat station is one which has been occupied at least twice during the last 10 years. (A station is counted only once, no matter how often it has been occupied.) A new first-order station is one which is considered likely to become a repeat station within the next 10 years. Second-order stations are not necessarily inferior in quality of observations. The distinction is that they are not considered likely to be reoccupied. They are divided into three-component and one-component stations.

The total number of repeat stations is 1,325. By comparison, Dr. Vestine in his analysis of the field for 1905-1945 had available some 2,000 repeat stations, but many of them would not have qualified under the definition of an active repeat station adopted here. Certainly there has been no marked increase in the number of repeat stations over the last 30 years, and the number may have decreased considerably.

One might have expected the WMS to result in an increased number of first-order stations. This has in fact happened in a number of new countries that had not previously had a systematic program of magnetic surveys, but the majority of these stations are classed as new rather than repeat. This increase is more than nullified by the decline in the number of repeat stations in countries with a long history of magnetic observations.

The WMS project itself may have contributed to a decrease in repeat stations by prompting many countries to review critically their existing survey procedures. The application of airborne survey methods has resulted in a clearer distinction between ground stations for the determination of secular change and secondary stations for mapping purposes. Some countries now confine their land surveys entirely to repeat

TABLE I

LAND MAGNETIC SURVEY STATIONS

Country or Area	First-order Repeat	First-order New	Second-order 3-comp.	Second-order 1-comp.
Antarctic	35		100	1,900(F,D)
Argentina	55			250(D)
Australia	50			1,000(D)
Belgium			130	
Bolivia	10		75	
Brazil	90	30		
Canada	100		10	
Chile	10			200(H)
Columbia	130			
Democratic Republics of Europe*	80		2,100	
Denmark		20	20	
Ethiopia				700(Z)
Finland	40			
France	15	15		
German Federal Republic	30			
Ghana		35		
India	60		500	
Iran		50	250	
Ireland (North and South)	45	15		
Italy	20	10		
Japan	100		800	
Mexico	20			
New Zealand	60			
Norway	10			
Oceanic Islands	30	5	200	
Pakistan	60		200	
Peru	65			
Portugal	many		many	
Rhodesia and Nyasaland	5	15		
South Africa	50			
Spain	many		many	
Sweden	10			
Thailand		45		
United Kingdom				55(F)
USA	130			
Yugoslavia	15		10,000	
Total:	1,325	240	14,385	4,105

* Includes Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, and Rumania.

stations, leaving the collection of small-scale detail to airborne magnetometers.

Some countries listing 1,000 or more stations found that very few were in fact being repeated, and decided to concentrate on the more frequent reoccuption of a few carefully selected stations, well distributed over their territory. Auxiliary stations are often established near the repeat stations, to guard against loss of secular change information in case the original station has to be abandoned. The period of observation at each station is lengthened to several days, to permit more effective removal of the effects of transient changes in the field. In some countries, such as Australia, Canada, and the USA, portable variometers are operated at repeat stations which are distant from magnetic observatories, so that the repeat station becomes in effect a temporary magnetic observatory. This philosophy is carried one stage further in the USSR, where the main contribution to land observations for the WMS has been the establishment of many new permanent magnetic observatories. If by a study of accurate annual means from a network of permanent observatories one can learn the laws that govern secular change, a great number of older field observations can presumably be brought up to date for the purposes of the WMS.

Concerning the number of the second-order stations, it is difficult to estimate the trend, because they are, and always have been, so unevenly distributed. One might think that 14,400 three-component stations would make an impressive contribution to knowledge of the geomagnetic field, but two-thirds of these stations are in one country, Yugoslavia. Of the remaining 4,400, 2,000 are in the German Democratic Republic and 1,000 in Japan, leaving very few for the rest of the world. It would appear unlikely, therefore, that the WMS will silence the long-standing complaints of magnetic cartographers about the unsatisfactory number and distribution of land magnetic stations.

This report cannot give details of surveys of individual countries, but the remarkable survey of Yugoslavia should be mentioned. From 1958 to 1960, some 300 stations were established, covering the country at a mean spacing of 26 km. Since 1960, more than one quarter of the country has been covered at a mean spacing of 2.6 km, giving the astonishing total of 10,000 three-component stations. Thirteen repeat stations are occupied regularly, and a three-component survey of the Adriatic Sea has been made by ship.

The international contribution to data in the Antarctic is gratifying, with 35 repeat stations, 100 three-component stations and 1,900 single values, mainly of F. The density is of course low and the distribution uneven, but it is a great improvement over the situation of 20 years ago. Australia, Chile, New Zealand, Portugal, and the United Kingdom have made a considerable effort to reoccupy stations in the oceanic islands. Some of these stations do not strictly meet the definition of repeat stations since they had not been occupied since the Carnegie Institution surveys, but they have been included because of their great importance in indicating secular change over large ocean areas.

Special mention should be made of the cooperative WMS program of six Democratic Republics of Eastern Europe: Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, and Rumania. Observations in the various countries have been reduced to a common epoch with common standards, and special surveys have been carried out along national boundaries, to permit the preparation of unified regional charts. Ireland furnishes another example of international cooperation. Northern Ireland and the Republic of Ireland collaborated in the conduct of their survey, the analysis of data, and the publication of charts.

Airborne Surveys

From the point of view of the WMS, the most important airborne surveys are of course those carried out by the U.S. Naval Oceanographic Office, in Project Magnet. Since 1963, about 1 million kilometers of widely spaced lines of three-component observations have been obtained over the oceans, mainly in the Southern Hemisphere, but also with considerable coverage over the Arctic Ocean. In addition, 260,000 km have been flown in closely spaced surveys of regions of particular geological interest, the most notable of these being the survey of a belt 160 km broad across the USA at latitude 40°N, with lines 8 km apart.

The results of the three-component airborne survey of Japan and surrounding water have been published very elegantly, with a complete set of charts, and a description of techniques. The method of measurement used by the Geographical Survey Institute is of special interest. Bias fields are applied to a proton precession magnetometer in such a way that D and H can be calculated from the magnetic tape records on the ground after the survey.

The only other country operating a three-component airborne magnetometer was Canada. A survey of the Arctic Ocean and Canadian Arctic islands was completed in late 1963. In 1965, a survey of Norway, Sweden, Finland, and Denmark was carried out, with lines 37 km apart. It was organized and paid for by the four Scandinavian countries. Iceland was surveyed in similar detail. The Norwegian Sea, Greenland Sea, and most of Greenland were covered at a line spacing of 150 km.

It is difficult to compile figures on airborne surveys of total intensity, but they are certainly being flown at the rate of several million line-kilometers per year. For geological purposes the flight lines are usually less than 1 km apart, so that the total area covered by detailed surveys is small, possibly amounting to no more than 2 or 3 percent of the earth's surface. In the early days, little attention was paid to absolute levels, which either went unrecorded, or were discarded in the preparation of the anomaly charts. Now, especially when surveys are organized by government agencies, strict standards of absolute control are usually enforced, so that it is possible to derive absolute values from the published charts. Precession and resonance type magnetometers have greatly facilitated absolute control.

TABLE II

AIRBORNE MAGNETIC SURVEYS

Country	Elements Measured	Line — km
Canada	D H Z F	200,000
France	F	80,000
Japan land	D H F	30,000
sea	XYZ	20,000
United Kingdom	F	120,000
USA	D I F	1,250,000

A total-intensity airborne survey of the entire British Isles, with a line spacing of 2 km, has recently been completed and published. Canada and the Scandinavian countries are approaching 50 percent coverage by high-quality detailed total-intensity surveys, and complete coverage may be expected in 5 to 10 years. Several developing countries have acquired total intensity surveys under the auspices of UNESCO and the Colombo Plan.

Special mention must be made of the total-intensity survey of France, carried out with a cesium vapor magnetometer at a line spacing of 10 km, as a contribution to the WMS. Portable recording stations were operated on the ground to provide corrections for temporal variations, and the survey was planned so that the aircraft was never more than 150 km from such a station. In spite of these precautions, it was necessary to adjust the survey values to remove discrepancies at the intersections of lines. After a careful adjustment and analysis, it is concluded that the total-intensity map of France for epoch 1964.5 has an absolute accuracy of 3 to 4 gammas.

In conclusion, it should be mentioned that several university and government groups in Canada, the United Kingdom, and the USA have conducted extensive, widely spaced airborne total-intensity surveys, often in connection with oceanographic research. The University of Wisconsin in the USA has made a significant contribution to WMS data through its surveys of the north and south polar regions.

COMMISSION III
MAGNETISM OF THE EARTH'S INTERIOR
T. Nagata — Chairman

The session on "Review of Magnetism of the Earth's Interior," was started at 09.00h, September 28. In his opening remarks Chairman T. Nagata called attention to the fact that geomagnetic methods have been extremely widely used with great success in studies of the earth's uppermost parts, in particular over ocean areas, and emphasized that more basic research of the nature of magnetization of the earth's crust and the ocean floor must be carried out within the framework of the Commission.

Dr. T. Rikitake gave a review of recent developments with regard to the electrodynamics and the electromagnetic induction in the earth's interior. Dr. V. P. Orlov's review paper on recent geomagnetic secular variations was read by Dr. Nagata. Dr. E. Thellier reviewed the recent tendency of archeomagnetism and indicated the future direction of this research. Dr. A. Hahn gave a review of recent developments on geomagnetic anomalies, and Dr. A. J. Zmuda reviewed recent results of analyses of the geomagnetic field and reported the present situation in regard to the International Geomagnetic Reference Field.

Because Dr. C. M. Carmichael and Dr. D. Doell were absent during this session, Dr. T. Nagata gave brief reviews of rock magnetism and palaeomagnetism. He pointed out as the most conspicuous in recent rock magnetism studies the study of magnetic properties of natural rocks, which are subject to complex conditions of mechanical stress, and indicated the present importance in palaeomagnetism of precise measurements of intensity and direction of natural remanent magnetization of rocks and dating of these rocks.

Later, Dr. Carmichael himself presented his review of rock magnetism during the business session of Working Group III-4, and Dr. A. Cox, representing Dr. Doell, also later presented the review of Working Group III-6.

The reports of the various working groups follow.

WORKING GROUP III-1, ELECTRODYNAMICS
E. C. Bullard — Reporter
T. Rikitake — Deputy Reporter

After the 1963 Berkeley Assembly, there were two occasions for reviewing progress of theories on the origin of the earth's magnetic field and its secular variation, including reversal of the dipole field. These were the Second Benedum Symposium on Earth Magnetism held at the University of Pittsburgh in 1964 and the Symposium on Stellar and Planetary Magnetism at the University of Newcastle upon Tyne in 1965.

Very few papers on the steady-state dynamo problem have been published. One such paper is by Stevenson and Wolfson (1966), who studied steady states of a homogeneous fluid dynamo by prescribing the drive force of the fluid motion instead of the velocity. Unfortunately, however, they could not prove or disprove the existence of a steady state.

Study of nonsteady dynamo has been made by a number of workers on the basis of various models. Rikitake (1966a) examined nonsteady states of an Inglis model, a visual aid for understanding the dynamo processes in the earth's core, and found that the model performs an oscillation that achieves a reversal of the field only when an extremely large disturbance is given to its steady state. Time-dependent behaviors of a Herzenberg model, in which two similar rotating spheres are assumed in an infinite conducting medium, was studied by Rikitake and Hagiwara (1966). It was found that the dynamo is unstable and performs oscillations similar to those of a disk dynamo. The time-constant of the above models are exclusively of the order of 10^3 - 10^4 years.

Lowes and Wilkinson (1963) have extended their study of a laboratory model of the Herzenberg dynamo to nonsteady states and are scheduled to report on the time-dependent behavior, of the model, including reversals, at this assembly.

Theories on the westward drift have been further developed by Hide (1966), Rikitake (1966b), and others. Attempts to estimate the velocity of fluid motion at the core's surface were made by Vestine (1965), Vestine and Kahle (1966) and Rikitake (1967).

References:

Hide, R., Free hydromagnetic oscillations of the earth's core and the theory of the geomagnetic secular variation. Phil. Trans. Roy. Soc. London, **A**, 259, 615-650, 1966.

Lowes, F. J. and Wilkinson, I., Geomagnetic dynamo: a laboratory model. Nature, 1988, 1158-1160, 1963.

Rikitake, T., Electromagnetism and the Earth's Interior. Elsevier Pub. Co. Amsterdam. 1966a.

Rikitake, T., Westward drift of the equatorial component of the earth's magnetic dipole. J. Geomag. Geoelect. **18**, 383-392, 1966b.

Rikitake, T., Non-dipole field and fluid motion in the earth's core. J. Geomag. Geoelect. **19**, 129-142, 1967.

Rikitake, T. and Hagiwara, Y., Non-steady state of a Herzenberg dynamo. J. Geomag. Geoelect. **18**, 393-409, 1966.

Stevenson, A. F. and Wolfson, S. T., Calculation on the dynamo problem of the earth's magnetic field. J. Geophys. Res. **71**, 4446-4447, 1966.

Vestine, E. H., The world magnetic survey and the earth's interior. J. Geomag. Geoelect. **17**, 165-171, 1965.

Vestine, E. H., and Kahle, A. B., The small amplitude of magnetic secular change in the Pacific area. J. Geophys. Res. **71**, 527-530, 1966.

A joint business meeting for Working Groups III-1, Electrodynamics, and III-3, Electromagnetic Induction, was held at 17.30h on Tuesday, September 26. It was attended by F. J. Lowes, I. Wilkinson, H. Morgenroth, A. Kahle, D. M. Russel, W. Kertz, B. Caner, and U. Schmucker.

The Reporter, T. Rikitake, presented progress reports, which were supplemented by the WG members when necessary. It was pointed out that relatively few people are working on the theories of the origin of geomagnetism. In contrast to this, it is really striking that we have found a number of geomagnetic variation anomalies in Japan, South America, and so on, in addition to those which had been known before.

The Reporter has been asked by Dr. H. Wiese to discuss the possibility of calling the anomalies as revealed by geomagnetic variation observation "electromagnetic induction anomalies." It is decided, however, not to fix such terminology.

No resolutions were proposed by the Working Groups because it was felt that the resolutions adopted at Berkeley have been and will be good enough.

WORKING GROUP III-2, SECULAR VARIATION

V. P. Orlov — Reporter

(Dr. Orlov was unable to attend the assembly and his report was read by Dr. Nagata.)

Before 1964, compilation of world isoporic charts was carried on under the leadership of Dr. Nagata in Japan, who prepared secular variation (SV) charts for the periods 1950-1955 and 1955-1960. World isoporic charts were compiled in England, the USSR, and the USA. Investigations of the SV-field drift were conducted by Dr. T. Yukutaki in Japan and by Dr. B. R. Leaton in England (**Royal Observatory Bulletin**, No. 57, 1962). All the above investigations were based on the available, rather insufficient, data. Therefore, in all cases the charts were schematic and could have essential errors (especially for the oceans).

For the 5-year period 1960-1965, a careful SV-investigation was carried out by Dr. Leaton and his colleagues. The results were presented as a set of spherical harmonic coefficients. Isopores for the epoch 1965 were plotted on the USA world magnetic charts. During the period 1960-1965 the network of magnetic observatories became somewhat larger and data accuracy became higher for a number of observatories as a result of the introduction of proton magnetometers. However, these data were still insufficient for compiling accurate isoporic charts.

In 1966-1967, workers at IZMIRAN (USSR) could use a number of additional data mainly for SV in the oceans. Those were the data obtained by the ship **Zarya** for 1957-1965 and the results of comparison of the satellite Cosmos-49 data with the data of the **Zarya, Vema,** the Japanese Antarctic Expedition, and the magnetic survey by Project Magnet. On the basis of all the above data SV-charts were compiled by graphic methods for all seven elements of the SV-field. Spherical harmonic analysis was performed using δX, δY, δZ values taken from graphically made SV-charts. The results of this analysis are presented as a set of 48 coefficients and as isoporic charts.

During 1964-1967 a number of analytical and theoretical SV-investigations were published. These are the works by Nagata, Yukutake, Rikitake, Hide, Vestine, Kautzleben, Barta, Leaton, Cain and Slaucitajs et al. The works by Burlatskaya and Petrova on archeomagnetism were published as well.

At the colloquium of the World Magnetic Survey, held in October 1965 in England, the need for an International Geomagnetic Reference Field (IGRF) was discussed and it was decided to prepare this problem for consideration at the XIV General Assembly of IUGG in 1967. To begin the discussion Dr. Leaton distributed to the members of the Working Group on Analyses (Reporter, Dr. Zmuda) and to the other scientists concerned a proposal for an IGRF and its SV-model for the epoch 1965. Since this, there has been a lively correspondence, representing the opinions of interested scientists. Dr. Cain's investigation of IGRF models are of great interest and importance. The Working Group on SV has to take an active part in the discussion of the IGRF problem.

The main purpose of the SV-Working Group activity is to obtain a precise picture of the SV-distribution all over the earth's surface. For this, by direct correspondence with magnetic observatories, the collection of annual means of magnetic elements was organized, as well as the compilation, reproduction, and distribution of summaries among all the magnetic observatories, organizations, and individual scientists concerned. Two summaries have already been distributed, and the third one is being printed.

In the future it is necessary to include the results at repeat stations of various countries in the compilation of isoporic charts. At present, as a rule, these data are published with great delay and cannot be used for such compilation. It is necessary to ask organizations of all countries to report these data, even unpublished ones, and information on SV, especially for the oceans and continents of the Southern Hemisphere needs to be increased.

To investigate the secular variation of the geomagnetic field in the Antarctic, a special international service should be organized, having the following tasks:

1. Investigation of the geomagnetic field secular variation in time (from year to year).

2. Investigation of the distribution picture of the mean 5-year values of the secular variation of the territory of Antarctica and adjoining regions of the Atlantic, Indian and Pacific oceans.

3. Investigation of the secular variation distribution in different parts of Antarctica.

To carry out the first task it is necessary to go on with the continuous registration of the magnetic field variations accompanied by definition of basic values for the present net of the magnetic observatories and stations on the territory of Antarctic. As a result of these observations monthly and annual values could be obtained in absolute units.

It would be ideal if these stations covered the whole Antarctic territory by a regular net with spacings of 500 to 700 km. However, because of the difficulty of organization and high cost such a net is not feasible. As a substitute, a net of repeat stations located mostly along the Antarctic shore would suffice, accompanied by a small number of stations within the continent and on the islands to the north appriximately up to 40° southern latitude.

The investigation of the more detailed picture of the secular variation distribution in separate parts of Antarctica is not included in the obligatory minimum program.

Such investigation by separate states is recommended in addition to the obligatory program. The periods and the program of repeat observations at the additional stations might be settled by the states concerned.

The results of the repeat observations at the stations of the minimum program net should be sent to the World Data Centers not later than a year after the observations are made.

The main cause of the poor accuracy of world isoporic charts is that the vast ocean areas remain almost without coverage as the number of magnetic observatories on the islands is quite poor. Since the organization of a large number of new observatories is a difficult and costly matter, more repeat stations should be established on a number of islands in the Atlantic, Indian, and Pacific oceans. These stations should be reoccupied approximately every 5 years.

A suggested list of the islands is given below. This list enumerates about 60 new locations of magnetic stations.

RECOMMENDED LIST OF REPEAT STATIONS

The Atlantic Ocean

No.	Name	Lat.	Long.	State
1.	Is. Spitsbergen	78 N	15 E	Norway
2.	Is. Medveshii	74 N	18 E	Norway
3.	Is. Yan-Mayen	72 N	352 E	Norway
4.	Iceland (North)	67 N	344 E	Iceland
5.	Reykjavik	64 N	338 E	Iceland
6.	Greenland Angmagssalik	66 N	322 E	Denmark
7.	Greenland c.Farvel	60 N	318 E	Denmark
8.	Newfoundland	49 N	304 E	Canada
9.	The Bermuda Islands	32 N	295 E	Great Britain
10.	Is. Guadeloupe	16 N	298 E	France
11.	Cape Verde Is.	16 N	336 E	Portugal
12.	Is. Barbodas	13 N	301 E	Great Britain
13.	Is. San-Paulo	0 N	330 E	Brazil
14.	Is. Ascension	8 S	346 E	Great Britain
15.	Is. Saint Helena	16 S	354 E	Great Britain
16.	Is. Trinidad	20 S	330 E	Brazil
17.	Is. Tristan da Cunha	37 S	348 E	Great Britain
18.	Is. Gough	40 S	350 E	Great Britain
19.	Is. South Georgia	54 S	324 E	Great Britain
20.	Is. Bouvet ya	54 S	4 E	Norway
21.	Is. South Sandwich	57 S	334 E	Norway

The Indian Ocean

No.	Name	Lat.	Long.	State
1.	Andaman Is.	12 N	93 E	India
2.	Is. Suqutra	12 N	54 E	Great Britain
3.	Nicobar Is.	8 N	93 E	India
4.	Is. Ceylon, south part	6 N	81 E	India
5.	Is. Borneo-Brunei	5 N	115 E	Great Britain
6.	Maldive Islands	4 N	73 E	Great Britain
7.	Seychelles Islands	4 S	56 E	Great Britain
8.	Chagos Archipelago	6 S	72 E	Great Britain
9.	Cocos Islands	12 S	97 E	Great Britain
10.	Is. Madagascar, north part	12 S	50 E	France
11.	Madagascar, south part	26 S	46 E	France
12.	Is. Rodrigues	20 S	64 E	Great Britain
13.	Is. Reunion	21 S	56 E	France
14.	Island St-Paul (Is. Amsterdam)	38 S	77 E	France
15.	Islands Croset	46 S	51 E	France

The Pacific Ocean

No.	Name	Lat.	Long.	State
1.	Aleutian Islands	53 N	173 E	USA
2.	Aleutian Islands	52 N	184 E	USA
3.	Aleutian Islands	55 N	196 E	USA
4.	Is. Midway	28 N	182 E	USA
5.	Bonin Islands	27 N	142 E	USA
6.	Marshall Islands	10 N	169 E	USA
7.	Is. Clipperton	10 N	251 E	France
8.	Is. Palmyra	6 N	198 E	USA
9.	Galopagos Islands	0 N	270 E	Ecuador
10.	Marquesas Islands	10 S	220 E	France
11.	Fiji Islands	17 S	178 E	Great Britain
12.	Is. New Caledonia	21 S	165 E	France
13.	Is. Easter	27 S	250 E	Chile
14.	Kermadec Islands	30 S	182 E	New Zealand
15.	Chathan Islands	44 S	184 E	New Zealand
16.	Is. Dowgerty	59 S	240 E	New Zealand
17.		59 S	260 E	New Zealand

Australia

1.	Headland	20 S	119 E
2.	Darwin	12 S	131 E
3.	Townsville	20 S	146 E

In summary, the main problems of the SV-investigation are:

1. To get a reliable, as close as possible to the real one, picture of SV on the earth as a whole.

2. To get an optimal mathematical expression of this picture.

3. To carry out theoretical work to explain phyical processes resulting in secular variations of the geomagnetic field.

4. To get a satisfactory forecast of the SV-distribution for the next 5 to 10 years.

The work plan for the next few years should include the following:

1. Continued collection of annual values at the worldwide net of magnetic observatories and compilation and distribution of the summaries of these values every year.

2. Collection and distribution of information about the work done in the field of investigating SV in separate countries (observation results at repeat stations, maps of isopores, and articles on SV).

3. Collection and distribution of information on the work of investigating SV-anomalies caused by physical processes in the crust and upper mantle.

4. Assistance in the exchange of results of experimental and theoretical SV-investigations.

SCIENTIFIC SESSION ON SECULAR VARIATION AND ELECTRODYNAMICS
September 30

Dr. Nagata took the chair at this session in the absence of both Dr. Orlov and Dr. Rikitake.

Three extensive works on the morphology of geomagnetic secular variation over the earth's surface were presented by the Soviet, British, and American groups. The Soviet work (Orlov et al.) dealt with the secular variation during 1960-1965, the British work (Malin) dealt with that from 1942.5 to 1962.5, and the American (Cain et al.) with that from 1900 to 1965. McDonald and Stearns (read by Alldredge) also discussed the main behavior of secular variations since 1835. Results show that (1) the dipole moment is decreasing; the centered dipole is rotating westward (counterclockwise);

(2) the nondipole field is drifting westwards; (3) and the dipole is shifting northwards. The last paper showed that the magnetostatic energy of the dipole component is decreasing, whereas that of the nondipole one is increasing, which suggests that the energy is being transferred from the dipole to the nondipole field.

All isoporic charts shown in this session have remarkably large variations in the Southern Hemisphere, in particular around and near the Antarctic Continent. More observations in the Antarctic area were requested in the course of discussions of these results.

In regard to the reversal of the geomagnetic field, Lowes and Wilkinson demonstrated their experimental results of periodical reversals obtained by the two-cylinder apparatus based on the Herzenberg model.

An interesting communication concerned the comparison of geomagnetic latitudes of simultaneous auroral displays in Europe and China in ancient times (Fukushima et al.), showing an appreciable change of the location of the geomagnetic pole during the past 1,000 years.

WORKING GROUP III-3, ELECTROMAGNETIC INDUCTION
T. Rikitake — Reporter

It has been a difficult problem to study electromagnetic induction within the earth when the lateral distribution of electrical conductivity is nonuniform. Hobbs and Price proposed the use of surface integrals instead of spherical harmonic functions. With the aid of high-speed computers, the new method can well be applied to various induction problems in a nonuniform sphere.

Anomalous behavior of geomagnetic variations and telluric currents at stations on islands and nearby coastlines has been noticed frequently in recent years. In this session, similar results observed on the Hawaiian Islands and the eastern coast of Canada were reported.

In a few papers various methods of studying the conductivity distribution in the crust and mantle were discussed. It was pointed out that the "North Germany Anomaly" as revealed by geomagnetic observations is likely to be caused by highly conducting sediments.

Conductivity Anomalies in the Crust and Upper Mantle

Geomagnetic variation anomalies known by 1964 have been summarized by this reporter (Rikitake, 1966a), and not much can be added to what was reported in **IAGA News** No. 5 about the study of conductivity anomalies in the crust and upper mantle as revealed by geomagnetic variation anomalies.

Anomalies In Japan

Spectral analysis techniques have been applied to the study of the well-known Central Japan Anomaly. A marked tendency for ΔZ (vertical component) of geomagnetic bays and similar changes to increase at observatories in the central area of Japan and to decrease at those situated at the marginal area becomes clear at a period of 160 minutes or thereabouts.

Sasai (1966) has shown how the ratio of ΔZ to ΔH (horizontal component) changes at a number of Japansese observatories as the frequency of variation increases, and intensive investigation by Kato (1966) and his collaborators recently brought out another outstanding anomaly in northeastern Japan. They found for bay-like events having periods shorter than 3 hours that ΔZ at a station situated at the northern end of Honshu Island is directed upwards when ΔH points northwards. At an observatory on Hokkaido Island about 200 km to the northeast, however, ΔZ indicates a downward change. Also, they observed practically no change in the vertical field at a point some 200 km south of the station. Observations at stations further south showed a gradual increase of downward ΔZ, which appears to be the continuation of the Central Japan Anomaly. The Northeastern Japan Anomaly disappears when the period of a geomagnetic variation is longer than 3 hours.

Anomalies In The Canadian Arctic

Intensive studies have been conducted of the Mould Bay Anomaly, which is characterized by an extreme suppression of short-period fluctuations in Δ Z. In order to test an idea that a high-temperature isotherm, 1,400°C or so, must reach a depth of 10-20 km there, heat flow measurements (Law et al., 1965) were made, but no high heat flow values supporting this idea were observed. Observations by variographs around Mould Bay indicated that the anomaly covers an area of some 200 km - 300 km, with a sharp boundary where the surface of the conducting layer deepens from 40 km to about 100 km within a distance of 50 km (Whitham, 1965; Yukutake and DeLaurier, 1965).

A strong tendency for the magnetic vectors of short-period variations to be confined to a northwest-southeast direction has been found since the IGY at Alert, at the northern end of Ellesmere Island. A possible explanation of the Alert Anomaly would be to assume an upheaval of about 100 km of the 1,400°C isotherm to within 25-30 km of the earth's surface (Rikitake and Whitham, 1964), the length of the upheaval portion being estimated as a few hundred kilometers. Magnetotelluric observations recently made at Alert (Witham and Anderson, 1966) proved, however, that the above model does not account for the phase relation between geomagnetic changes and earth currents.

Anomalies In The USA

Observations that supplement Schmucker's study (Schmucker, 1964) on the California Coastal Anomaly and the Texas Anomaly have been made. Larsen and Cox (1966) conducted telluric observations off California and preliminarily suggested that a high-conducting underground layer lies fairly close to the sea bottom. In relation to the edge effect of the Pacific Ocean, Lambert and Caner (1965) presented an interpretation of the enhancement of Δ Z found on the Pacific coast of Vancouver Island by taking into account a dipping of the high-conducting mantle towards land in addition to the true ocean effect.

Heat flow measurements over the Texas Anomaly area have given an interesting result. According to Vacquier (1966), heat flow values are large immediately above the upheaved portion of the conducting mantle and small above the depressed portion.

Anomalies In The South America

The study of geomagnetic variation anomalies has been extended recently to South America, notably by the Department of Terrestrial Magnetism, Carnegie Institution of Washington. Schmucker et al. (1964) reported that very little anomaly was found for Sq in Peru. But Δ Z during a magnetic storm differs distinctively from station to station, and they concluded that the subsurface conductivity structure in southern Peru must be very complicated. No pronounced coastal anomaly of Δ Z has been observed; Δ Z for a bay at a station close to the coast is opposite in sign from that due to the ordinary coastal anomaly. To account for such a reverse coast effect, it is suggested that the high-conducting mantle under the ocean off Peru is deeper than that under the land.

A reversal in Δ Z has been observed between coastal stations and those near the eastern slope of the Andes (Schmucker et al., 1967). Called the Andean Anomaly, the reversal is accompanied with an intensified Δ H indicating a local concentration at about 60 km depth of internal induction currents that flow along a zone of high conductivity under the crest of the Andes.

Other Anomalies

Parkinson (1966) has continued his experimental work on a spherical sheet that simulates the oceans with copper plates. Most of the Australian anomalies (Parkinson, 1964) seem to be explained by the oceanic conduction and a conducting path north of Australia, which is probably not provided by the shallow water between Australia and Indonesia.

Bullard (1966) noticed an anomaly similar to that at Mould Bay in Scotland. Lubimova (1966) pointed out a high heat flow that is accompanied by geomagnetic variation anomaly somewhere around Lake Baikal. Wiese (1965, 1966) has been successful in correlating anomalies to major tectonic structures in Eastern Europe. Geomagnetic and magnetotelluric work has also been active in Germany (Kertz, 1966).

Geomagnetic Variation Anomalies On Islands

A number of important findings in regard to geomagnetic variation have been brought to light recently (Mason, 1963, 1964; Elvers and Parkins, 1964; Sasai, 1967). It has become clear that Z varies from place to place on an island. Reversals in sign of Z are often found for rapid geomagnetic fluctuations between northern and southern stations on an island. Such an island anomaly is at present thought to be caused mostly by electric currents induced in the surrounding sea.

Experimental And Theoretical Studies

Analyses of existing geomagnetic data have been made by a few workers in the hope of inferring the conductivity deep in the mantle (Yukutake, 1965; Currie, 1966, 1967; Smylie, 1965; Banks and Bullard, 1966). Roden (1964) conducted an induction experiment on a model simulating the sea around Japan Islands. Much theoretical work has also been done on electromagnetic induction in a conductor of particular shape, such as a conductor having an undulating surface, hemispherical sheet, and so on (Rikitake, 1964, 1965, 1966b; Ashour, 1965a, 1965b; Yukutake, 1967). Ashour and Chapman (1965) made a calculation possibly applicable to interpretation of the effect of an island on geomagnetic variations.

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WORKING GROUP III-4, ROCK MAGNETISM
C. M. Carmichael — Reporter

Research in rock magnetism independently and as an integral part of paleomagnetic studies has increased considerably since the last assembly in Berkeley in 1963 and the last Working Group meeting in Pittsburgh in 1964. This review will list a number of the most active areas of research and some of the people and laboratories involved.

Theoretical Studies on the Magnetization of Oxide Grains

The intrinsic nature and location of the magnetization of oxide grains has been the subject of different investigations with different interpretations. One interpretation of the TRM produced in weak fields as a function of grain size by Ozimas of Tokyo suggests a single domain behavior of restricted volumes of the grain similar to that proposed earlier by Verhoogen. Koboyashi and Fuller of Tokyo and Pittsburgh attribute the low temperature memory effect to small, highly stressed regions within a crystal.

Another interpretation of measurements on TRM versus grain size by Parry of Sydney due to Dickson, Everett, Parry and Stacey of New York, San Francisco, Sydney and Brisbane considers grains larger than 17 microns to be multidomain and their TRM independent of grain size. Smaller grains have a few interdependent domains and a TRM strongly dependent on grain size.

Banarjee and O'Rielly of San Francisco and Newcastle have found large coercivity at low temperature in Ti-bearing magnetite polycrystalline grains. Using electrical conductivity and Mossbauer techniques they conclude that Fe^{2+} ions occupy tetrahedral sites. Frölich and Loffler of Potsdam have examined the ilmenite-hematile system and the order-disorder self-reversal problem, including the effect of various 3^+ and 4^+ cations in the lattice.

Piezomagnetism

Nagata of Tokyo and his group have examined several aspects of piezomagnetism, including the irreversible component of PRM under uniaxial stress up to several Kb. Nagata has given a theoretical explanation of this phenomenon.

Kume at Osaka has measured the effect of hydrostatic pressure on TRM of single crystals of magnetite and has found the intensity to decrease with increasing pressure. Kowai has measured the effect of hydrostatic pressure on a hematite crystal.

Syono and Ishakawa of Tokyo have made measurements of magnetocrystalline anisotropy and magnetostriction constants of the magnetic-ülvospindel system.

Low Temperature Magnetization

Koboyashi and coworkers at Pittsburgh have continued work on the low temperature memory phenomenon and found that it is suppressed in large crystals and in very small ones. Koboyashi and Fuller of Pittsburgh attribute the memory phenomenon to energy in highly stressed regions of the crystal.

Susceptibility Anisotropy

The anisotropy of metamorphic and sedimentary rocks is being studied by Daly and Bequand of Professor Hellier's laboratory park St. Maur, and Rees and coworkers of Southampton have studied anisotropy in depositional sediments experimentally and theoretically.

Thermal and A. C. Analysis

Detailed studies on the identification of magnetic minerals through their magnetic response to thermal and a.c. demagnetization has been undertaken in a number of laboratories. Working with Frölich and Volkstadt at Potsdam, Bannerjee has studied the conversion and Curie temperatures of maghemite. Bucha, also with Frölich and Volkstadt, used high field thermal demagnetization to examine a number of iron, sulfur and titanium oxides. Bucha at Prague has identified chemical changes in oxides on heating and used thermal curves as a semiquantitative analysis method. Kropacek at Prague has done similar work using a.c. and steady field demagnetization.

Chan at Sydney has examined partial TRM carefully, using a furnace and magnetometer. Madame Petrova and coworkers at Moscow have examined a wide range of spirel and rhombohedral iron titanium oxides from both igneous and sedimentary rocks. They have found several instances of partial and complete self reversal in both types of minerals. Hargraves of Princeton has found a rock in which the remanence is due to oxide dust in silicates.

Oxidation States and Reversal

In addition to the Mull lava case of Wilson and Ade-Hall of London (now of Liverpool) several more cases of correlation between reversed polarity and high oxidation state have been found by Wilson and Haggerty and Watkins of Florida. No satisfactory answer has been found for the correlation. Carmichael and Palmer of London, Ontario, have found a range of oxidation states in lavas of Nova Scotia, all of which are normal.

Hovard and Lewis and Bhimasankoram of London have found partial and complete self-reversal properties in spinels and in pyrrholite, respectively, using natural and synthetic specimens.

Red Sediments

The cause of the magnetization of red sediments has been examined by Collinson of Newcastle and by Strangway and coworkers of Cambridge, Massachusetts. It would seem that the remanence is due both to grains and to cement in a rather complex way.

HIGHLIGHTS OF THE SCIENTIFIC SESSIONS ON ROCK MAGNETISM
C. M. Carmichael — Reporter

The meetings reflected a marked increase in research interest in rock magnetism in the past few years. Twenty-one scientific papers were presented in two sessions and a number of the paleomagnetic papers contained rock magnetism investigations. These papers were contributed from laboratories in 10 countries: France, USA, Japan, Canada, Czechoslovakia, Russia, East and West Germany, Britain, and India. Active research was reported in the fundamental cause of the magnetization of minerals, pressure-induced magnetization, low-temperature memory, and magnetization of red sediments. Considerable interest was shown in studies of suitability of magnetic minerals for intensity measurements.

A very interesting development was reported by Soffel of Munich, who has succeeded in preparing surfaces of magnetic grains to observe magnetic domain movement under the action of applied magnetic field and uniaxial pressure.

WORKING GROUP III-5, ARCHEOMAGNETISM
E. Thellier — Reporter

Les recherches archéomagnétiques qui, inaugurées en Italie et en Suisse au debut du siècle, n'étaient conduites qu'en France durant les années trente et quarante, se sont depuis développées dans plusieurs pays.

On sait que cette recherche consiste essentiellement à déterminer la direction et l'intensité du champ magnétique terrestre durant les siècles antérieurs aux deux ou trois derniers pour lesquels cette variation séculaire est connue d' après les mesures directes, au moins pour la direction. On utilise pour cela l'aimantation "thermorémanente" que les roches volcaniques et, surtout, les terres cuites ont acquises du fait de leur refroidissement dans le champ terrestre. Sur de tels corps demeurés en place, on peut retrouver la déclinaison et l'inclinaison du champ terrestre a l'époque de leur refroidissement (le dernier refroidissement dans le cas des fours et foyers de toutes sortes). Sur des objets déplacés après cuisson, comme les tuiles et les briques, on pout retrouver l'inclinasion mais à condition de disposer d'un nombre important de ces objets de même provenance; vingt est un nombre raisonnable permettant d'atteindre une précision de l'ordre du degré analogue à celle qu'on obtient avec les fours et foyers bien échantillonnés. Il faut remarquer qu'il est beaucoup plus facile de dater archéologiquement des briques, c'est-à-dire une construction, que des fours d'un atelier de potiers, par exemple, qui a pu exister sur le même site durant des siècles. Il faut noter que ce problème, primordial, de datation est le plus difficile, le procédé au carbone radioactif n'étant d'aucun secours à cause de son imprécision.

En ce qui concerne la détermination de l'intensité du champ, elle peut se faire aussi bien sur de objets déplacés ou non. Cette methode cependant demande beaucoup de soins et d'attention aussi bien dans le choix des objets mis en étude que dans la conduite de la longue suite d'opérations nécessaires. Pour chaque objet, plusieurs de ces opérations successives constituent des tests de qualité qui souvent conduisent à le rejeter, ce qui signifie que tout le travail effectué jusque-là est perdu. On ne saurait trop insister sur la difficulté qu'il y a à effectuer des mesures d'intensité ayant vraiment quelque signification.

Parmi les groupes nationaux actuellement actifs en recherche archéomagnétique, les uns étudient seulement l'inclinaison ou l'intensité, d'autres la direction (déclinaison et inclinaison) d'autres enfin, la direction et l'intensité. La liste approximative des ces groupes, classés dans un ordre arbitraire est la suivante:

En Chine, un petit groupe a commencé des recherches.

En Inde, ont été effectuées des recherches sur l'intensité.

En l'U.R.S.S., on peut considerer l'existence de deux groupes: l'un à Moscou (inclinaison sur briques et intensité) et un à Leningrad sans doute moins engagé jusqu'ici.

En Tchécoslovaquie, les recherches portent surtout sur l'intensité.

En Angleterre, les groupe de Cambridge (direction sur fours et foyers) semble être en sommeil, alors que le groupe d'Oxford, étudiant aussi la direction sur des fours, vient d'étendre son activitie a des recherches d'intensité.

Le groupe de Paris (inclinaison sur briques, direction sur fours — et incidemment sur coulées volcaniques historiques — et intensité) travaille en collaboration avec des archéologues de France et des pays limitrophes, aussi bien que d'Afrique du Nord et du Cambodge. Il apporte également aide aux archéologues autrichiens fouillant en Turquie et aux chercheurs egyptiens.

En Irlande, des déterminations de directions ont été faites sur des coulees volcaniques historiques.

Aux Etats-Unis où les recherches archéomagnétiques ont commencé récemment, le groupe de Pittsburgh, très actif au départ (mesures d'intensité), aurait cessé cette rerecherche alors qu'un groupe, en Arizona, utilisant des datations dendrochronologiques, développe son activité rapidement.

La plupart des groupes, actuellement actifs, présenteront leurs résultats nouveaux, avec un rappel des anciens, aux réunions scientifiques de notre Commission, en évoquant celles des groupes qui leur sont plus ou moins liés. Au lieu de donner une idée de tous résultats acquis, le rapporteur pense qu'il est mieux de présenter quelques remarques générales sur l'archéomagnétisme.

De fait, ce champ de recherches est nécessairement très limité parce qu'il nécessite des objets bien datés, par des méthodes archéologiques, et que le flux d'un tel matériel, vraiment valable, est très lent. L'opinion du rapporteur est que donner à un jeune chercheur un problème archéomagnétique comme sujet de thèse est dangereux pour lui. S'il travaille vraiment sérieusement, il créera des appareils qui risquent de n'avoir guère d'originalite; il fera un nombre considerable de measures dont beaucoup seront à rejeter parce qu'elles n'auront pas satisfait à des tests de valeur plutôt sévères et, après des années de travail, il se retrouvera avec des résultats plus ou moins limités dans le temps et valables pour une aire géographique relativement étroite. Le danger est alors que, anxieux d'avoir des résultats présentables et des publications, utilisant ses propres résultats et ceux des autres groupes, il se lance dans de trop faciles, mais combien fragiles, généralisations.

Dans cette voie, il aura peut-être la tentation de faire de vastes extrapolations à partir de l'idée de variations séculaires sinusoïdales de la déclinaison et de l'inclinaison. Cette idée qu'avait suggérée l'apparente régularité de la variation de la direction du champ dans l'Ouest de l'Europe, reste indéracinable dans beaucoup d'esprits, même de certains géomagnéticiens. Et c'est si facile, partant de là, de reculer vers un lointain passé avec peu de résultats. Afin de rappeler qu'une telle idée, en évidente contradiction avec ce que nous savons de la variation séculaire actuelle sur le globe (dérive Est-Ouest et considérable importance de champ non-dipôle), le rapporteur présente les courbes de variation de D et I (courbes d'après Bauer), pour les deux derniers milliers d'années dans la région de Paris. La plupart des points correspondant aux siècles antérieurs aux trois derniers se placent sur une courbe aux boucles multiples se développant loin de l'ovale "coupable," qui n'a jamais été parcourue, même partiellement, depuis 2000 ans, antérieurement aux trois derniers siècles.

Un autre danger est dans la transformation de directions de champ en un lieu, en pôles virtuels. Bien entendu, la représentation ordinaire par le vecteur champ au lieu considéré et le pôle virtuel est strictement équivalente, mais seulement équivalente; le champ représenté est toujours le champ réel (somme d'une partie dipôle et d'une partie non-dipôle qui peut-être considérable) et sa représentation par un pôle ne lui a donné en rien un caractère plus général et mondial.

Ce que nous avons à faire, et ceci durant plusieurs années encore, est de déterminer, sans idée préconcue, les variations du champ magnétique terrestre, durant les temps historiques. Ces recherches devront être faites dans des régions aussi dispersées que possible sur le globe avec, évidemment et malheuresement, les limitations imposées par la pauvreté archéologique de certaines contrées.

Finalement, et à parler franc, le travail ainsi défini est difficile, il demande beaucoup d'efforts et d'attention et il peut paraître peu glorieux. L'opinion du rapporteur est qu'il est cependant très utile et intéressant. Ce que nous devons esperer, c'est que les géophysiciens, qui peuvent entrer en relations avec les archéologues de leur pays, nous aident soit en créant de nouveaux laboratoires archéomagnétiques — ce qui n'est pas si simple si on les veut vraiment valables — soit en recueillant des matériaux et en faisant les mesures dans les quelques laboratories bien équipés qui existent actuellement, soit enfin, en attirant seulement l'attention des archéologues sur l'intérêt d'une coopération archéomagnétique.

Highlights of Scientific Session on Archeomagnetism

After Professor Thellier had given seven papers coming from his institute in Paris, the archeo-direction of the geomagnetic field was discussed based on North American data by Du Bois, British data by Aitkens, Russian data by Burlatskaja et al., and French and South European data by Thellier et al. Substantial agreement was found in regard to the locus of secular variation of the virtual magnetic pole among these data as well as the previously reported Japanese data, at least during 600 years, from 1000 AD to 1600 AD.

Based on the above result, Aitken prefers the idea that the real geomagnetic axis pole had such a variation as mentioned above, whereas Du Bois and Burlatskaja and Petrova favor the idea that the majority of the observed variations are attributable to the westward drift of the nondipole field, which had been proposed by Yukutake et al. However, Thellier argued that data are still not sufficent to draw any final conclusion.

WORKING GROUP III-6, PALEOMAGNETISM
R. Doell — Reporter

(As Dr. R. Doell was unable to attend the assembly, Dr. Allan Cox presented the report, the main substance of which consists of the individual national reports prepared for the IAGA meeting. Dr. H. Soffel prepared a special summary, and Dr. G. N. Petrova prepared a brief summary of the very extensive work now being done in the USSR.)

Paleomagnetic research has been especially active in the field of geomagnetic reversals. A potassium-argon time scale for reversals dating back 1 million years has been developed and has been used to correlate marine and continental sediments. It has also been used to interpret magnetic anomalies over midoceanic rises to obtain rates of sea floor spreading. Russian workers have been especially active in extending reversal studies to older rocks and have found that the spacing between reversals was much longer in the early Paleozoic. Reversals have been extensively used in Germany for the correlation of tertiary basalt.

Paleomagnetic investigations have also been applied to tectonic problems on a regional scale. Examples include paleomagnetic investigations of the bending of the Japanese islands and the paleomagnetic investigation of tectonics in southeast Europe by the newly formed Carpatho-volcanic Geological Association, consisting of Bulgaria, Yugoslavia, Rumania, Czechoslovakia, Poland, and the Ukraine. Work has continued on the classic problem of obtaining paleomagnetic pole positions. In Germany work has been concentrated on the Tertiary, in Japan and the United States on the Cretaceous, and in Russia on the attempt to cover all epoches.

Work has begun on determining the intensity of the geomagnetic field in the ancient past. The experimental difficulties are enormous and the results obtained to date rather ambiguous, but there is at least a suggestion that superimposed on oscillations with a period of about 10^4 years there is a long term increase in the average level of the field, beginning in the Paleozoic.

Paleomagnetic Research in The USSR
G. N. Petrova — Reporter

Many new systematic paleomagnetic investigations were made, with emphasis on those epochs for which there were few previous results.

Increased emphasis has been placed in all investigations on establishing the paleomagnetic reliability of the results. Routine reliability procedures include field tests for magnetic stability, such as fold tests; elimination of viscous components by a.c. demagnetization, heating, or the time method; and identification of magnetic minerals by x-ray or petrographically. Published tabular data have always been checked for reliability by these methods.

The stratigraphic distribution of intervals of normal and reversed polarity has been established in Russia for all geological epochs, and deep-sea sediment cores studied from the Atlantic Ocean, and the polarity zones have been used to correlate between oceanic and continental sediments.

The intensity of the geomagnetic field in the Pliocene has been determined from progressive heating experiments on lavas and baked sediments. Its limits vary from 1.5 to 0.7 times the present intensity of the field. In zones of transitional polarity, a decrease in field intensity to 0.2 to 0.3 of its normal value invariably occurs.

From analyzing the large amount of data now available, the following conclusions may be drawn:

1. Inversions of the field are real and occur globally.
2. The regime of polarity changes is different in different epochs.
3. In most epochs the geomagnetic field was that of a dipole with superimposed secular variation.
4. The positions of different average poles are different for different regions of the surface. This difference cannot be explained without some geological assumptions.

Highlights of Scientific Session on Paleomagnetism
Allan Cox — Reporter

New data were presented leading to refinements in the radiometric time scale for the past 4 million years. The occurrence of brief polarity changes, termed "events," with durations of 50,000 years or less is now well documented. Preliminary evidence for the occurrence of such an event within the past 60,000 years was presented.

New data concerning fluctuations in geomagnetic field intensity indicate that during the past several million years the intensity of the field has varied by a factor of about four. Superimposed on this varying field, there has been a steady increase in average level during the past 500 million years. Prior to this, however, there is evidence that the field was as strong as it is now.

Several new pole positions were presented.

Minutes of Meeting of Working Group III-6, October, 1967
Allan Cox — (Acting for R. R. Doell)

It was resolved that:

1. A joint symposium be held with IASPEI at the meeting in Spain on the "Evolution of the Earth" to include subjects of continental drift and sea floor spreading.

2. The subject of geomagnetic intensity be included in the Spain symposium on secular variation.

3. A symposium on geomagnetic reversals be held in Spain.

4. Rock magnetism and paleomagnetism workers should be sparing in inventing new jargon, bearing in mind the wide interest in their results by workers in other fields.

It was recommended that:

(a) Future meetings of rock magnetism and paleomagnetism working groups be scheduled jointly, but that archeomagnetism be scheduled separately.

(b) If possible, working groups be scheduled to meet before submission of summaries by the reporters.

WORKING GROUP III-7, GEOMAGNETIC ANOMALIES
A. Hahn — Reporter

This report goes back to the conclusions of the Working Group session in 1964 at Pittsburgh, which stated:

"It is recommended that in the interpretation of geomagnetic anomalies the structure of the crust as it is known by seismic measurements and by petrological studies be taken into account more than has been done in the past. For this purpose two types of studies are encouraged:

1. Comprehensive studies on the magnetization values of metamorphic rocks in connection with their petrological character and their geological importance (frequency in the earth's crust). It has been decided that Dr. Morely should collect these data and evaluate them for the use of the interpretation of anomalies. The members of the working group are requested to send data . . . to Dr. Morley.

2. Studies concerning quick methods for interpretation of geomagnetic anomalies by more detailed model bodies."

On point 1 we have not been very successful so far. Dr. Morley received only two collections of values from T. N. Simonenko and from A. Hahn. Furthermore, he expressed some doubt concerning the procedure as it was provided for, namely a simple cataloging of magnetization values versus rock type because, as he argued, rock types are so manifold that the schemes used so far do not show any clear correlation to the magnetization. He suggested that, rather, some other scheme is needed that may be utilized more successfully for our purpose.

This point will be discussed in the session of the Working Group on October 4.

On point 2, with respect to the interpretation methods, it can be stated that in all areas of interpretation methods known so far new developments have been published. This is demonstrated by the examples given below.

Trial and Error Methods

Sharma (1967) has published a monogram for obtaining the field of three-dimensional bodies, which, according to him, is very suitable for a simultaneous determination of the magnetic and the gravity field of a body. Bosum (1967) has described a method for finding the horizontal cylinder, thin plate or broad dyke, all two-dimensional models, which best approximate a measured anomaly in the form of a profile.

The method is based on the principle of least squares and is fully automated by a computer program.

Direct Methods for Depth Estimation

Here the papers of Bhattacharyya (1966) should be mentioned. He introduced for the depth estimations of vertical rectangular prisms the Fourier analysis of the magnetic field, which yielded values not only for the depth of the top of these prisms but also, by considering only a part of the spectrum, for the depth of their bottom.

Direct Determination of Magnetized Bodies

Some new principles used before in other scientific branches have been applied here. One of them is the application of the likelihood function in the determination of parameters of model bodies starting from the measurement of an anomaly. This method has been introduced by Goltzman (1965). Another method, still under development, is that of Wachholz (1967), consisting of the application of the method of deconvolution, which is well known in the processing of seismic data.

Evaluation of Isolated Profiles

An attempt to evaluate profile measurements at sea has been made by Neidell (1966), who has considered the spectra of magnetic and gravity profile measurements together with an echo sounding profile. He found some peaks in the spectra, which he interpreted as a tendency of recurrence of volcanoes, sea mounts, and other structures of elongated nature in some preferred distances.

A new instrument, the gradiometer, has appeared on the market. It should have some advantages over the conventional magnetometer, because the vertical gradient is less affected by varying fields of far distant sources than is a field component. The area of practical application is still being studied. One convincing application of a gradiometer has been reported by Heirtzler (1967), who observed magnetic variations on a drifting ice-island and some 1,000 ft below and was able to locate a few magnetized bodies beneath the sea floor, in spite of the high amplitude of the time variations of the magnetic field occuring in this region.

The second point of the conclusions of the Pittsburgh session concerned the problem of how to establish a world chart showing a characterization of the short period anomalies that are normally omitted as "noise." The U.S. Naval Oceanographic Office and the German Geological Survey had been requested to cooperate to devise the best plan for such a world chart. In response to this request, magnetic profiles of Project Magnet covering the NW Indian Ocean and the northern Atlantic have been evaluated. The short anomalies of the profiles in intervals of a few 100-km lengths were represented in such a way as to show the amplitude and the predominant wavelength of these anomalies. The work has been partially supported by UNESCO. The U.S. Naval Oceanographic Office has kindly submitted all necessary data.

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Heirtzler, J. F., Geophys. Prosp. **15**, No. 2, 194-203, 1967
Neidell, N. S., Geophys. **31**, No. 1, 122-134, 1966
Sharma, P. V., Geophys. Prosp. **15**, No. 2, 167-173, 1967
Wachholtz H., Paper read at EAEG meeting, Stockholm, 1967.

Highlights of the Scientific Session on Geomagnetic Anomalies

Patterns of anomalies running parallel to the ocean ridges have been analysed. The high degree of symmetry with respect to the central line of the ridge gives strong support to the hypothesis that these anomalies are produced by a basaltic layer that is generated at the central line by ascending magma and is moving steadily away from this line towards both sides. When the ferrimagnetic minerals in cooling down pass the Curie temperature they are magnetized parallel to the earth's magnetic field present at that time. The reversals of the field thus produce stripes with alternating direction, resulting in the observed anomaly pattern. Patterns of this type have been reported to be present in the northern Atlantic, in the Arctic Basin, and along the Indo-Pacific Ridge. In the Arctic Basin the Lomonosov Ridge appears to be a detached segment of the Eurasian continental shelf and the Alpha Cordillera appears to be an inactive mid-ocean ridge.

Several approaches to determine the lower limit of the crustal magnetic sources have been made based on statistical considerations applied to magnetic survey data in continental areas. If it can be supposed that there is a layer of homogeneous magnetization that has horizontal planes as upper and lower boundaries, one can estimate this lower limit of the ferrimagnetic material in the crust to lie at a depth of 20-25 km. This result has been obtained by the application of three different methods to three different surveys. There is a high probability that this depth is to be identified with the Curie depth. The Curie temperature is unknown, however.

WORKING GROUP III-8, ANALYSIS OF GEOMAGNETIC FIELD

A. J. Zmuda — Reporter

This Working Group considered harmonic descriptions with a view towards making a recommendation for an international geomagnetic reference field (IGRF) epoch 1965.0 for the field of internal origin. The group consisted of the following: N. P. Benkova, J. C. Cain, P. F. Fougere, N. Fukushima, J. D. Kalinin, H. Kautzleben, B. R. Leaton, J. F. McClay, T. Nagata, and the Reporter. The group received valuable contributions from L. R. Alldredge, E. C. Bullard, L. Hurwitz, A. B. Kahle, D. G. Knapp, J. H. Nelson, V. P. Orlov, N. V. Pushkov, and E. H. Vestine.

A considerable divergence exists in the judgments on what should constitute the IGRF. Only a summary of the salient features of the discussions can be given here.

An IGRF should satisfy a number of needs, including those for (1) the removal of trend in studies of anomalies, (2) the preparation of magnetic charts, and (3) the calculation of the field for the upper atmosphere, which is important in studies of trapped particles and ionospheric currents. While there were suggestions that the reference field take the form of values at specific grid points, the majority favored a spherical harmonic series, and the first major problem arose on the question of how many terms should be used in the series for the main field and in that for the secular variation. For the main field all recognized the need for at least 20 coefficients and all would accept 48 (up to $n=m=6$) but a marked dichotomy existed on the use of additional terms. Those opposed to more terms argue that the additional coefficients are unstable in the sense that they vary markedly from one harmonic analysis to another, particularly when the amount and/or the distribution of the raw data changes. Those in favor of adding terms beyond $n = m = 6$ argue that these terms do improve the theoretical description of the field. On the number of terms for the secular-change field, opinions are more varied but not as strongly held, so that agreement could probably be reached on 48 terms, up to $n = m = 6$, and using only first derivatives.

Another problem area was on the question of whether the harmonic coefficients should be those from one specific set or whether they should represent a composite set. Is there a "best" field? These questions relate intrinsically to the assumptions made in harmonic analysis of surface data and to the way an IGRF is to be used. The question of how to use the reference field, particularly with respect to surface data, cannot be avoided, and a recommendation for a set of coefficients has little, if any, value if their usage is not prescribed. The earth's surface resembles an oblate spheroid more closely than it does a sphere, and surface component measurements are made with respect to the local vertical due to gravity and to directions in a plane normal to this vertical. Until rather recent times and in a practice compatible with the precision of the available data, it was customary to assume that the earth is a sphere of radius 6371.2 km, that the measured components are along the unit vectors for a true sphere, and that geodetic and geocentric colatitude are equivalent. The observational data were then analyzed with spherical harmonics to yield the coefficients, g_n^m's and h_n^m's.

With the improved data now available, it is important to take into account the oblateness of the earth and the differences between the measured surface vector components and those referenced to a true sphere (J. C. Cain, S. Henricks, W. E. Daniels, and D. C. Jensen, NASA Rept. X-611-64-316, 1964; A. B. Kahle, J. W. Kern, and E. H. Vestine, J. Geomag. Geoelect. 16, 229-237, 1964; A. B. Kahle, J. W. Kern, and E. H. Vestine, Rand report RM-4750-NASA, Sept. 1965; J. C. Cain, "Models of the earth's magnetic field," in Radiation Trapped in the Earth's Magnetic Field, ed. by Billy M. McCormac, D. Reidel Pub. Co. Dordrecht-Holland, 1966). One asks now if it is valid to combine harmonic sets that include effects of the earth's oblateness with those that do not.

With respect to the use of an IGRF it was suggested that the IGRF be referenced to a sphere of radius 6371.2 km; that the coefficients be used with solid spherical harmonics; that the oblateness of the earth be taken into account by approximating the earth's surface by the Kaula ellipsoid-equatorial radius of 6378.165 km and a flattening factor of 1/298.3; and that surface component data be transformed to components referenced to a sphere before comparisons with computations are made. (Transformation equations may be found in the reports of Cain et al. 1964; Kahle et al., 1964, 1965; and Cain, 1966.) If desirable, these equations could be incorporated into a recommendation.)

Principal questions were and still are the following: Should a composite or an individual field be chosen? How many terms should the harmonic series contain? How should the IGRF be used? This is just about where the problem started, but hopefully solutions can be found during the meeting scheduled here.

Digital Data Interchange

The Working Group had an Ad Hoc Committee for Digital Data Interchange composed of the following: J. C. Cain, Chairman; C. O. Bostrom, B. R. Leaton, T. Oguti; V. F. Schelting; and R. Schlich. This committee considered the growing need for magnetic data in machine-readable form and recommended establishing three world digital centers for geomagnetism. These centers should receive, file, and catalog machine-readable magnetic field data to be supplied in standard formats to interested parties. The Committee formulated a resolution which was transmitted to Professor Nagata for action by the IAGA Executive Committee.

Business Meeting of Working Group III-8
A. J. Zmuda — Reporter

This Working Group did not pick an IGRF as additional study and analysis is required before a durable choice can be made. It was decided that harmonic sets would be accepted for consideration until March 15, 1968, and that comprehensive assessments would be presented at the October 22-25, 1968, Symposium on the Description of the Earth's Magnetic Field in Washington, D. C.

It is recommended that this Working Group, which is being transferred to Commission II, in conjunction with the World Magnetic Survey Board make a choice for an international geomagnetic reference field at the Washington meeting.

Scientific Session on Analysis of Earth's Main Magnetic Field
A. J. Zmuda — Reporter

D. E. Winch stated that for fields of internal origin the earth's oblateness has no significant effect on estimates of spherical harmonic coefficients. Oblateness is, however, important for determination of the external field. Field components were used with Cartesian components to separate external and internal fields and to determine the dipole axis. The quadrupole and octopole fields are both increasing.

A. J. Zmuda compared the magnetic results obtained with satellite 1964, 83C with a harmonic description and showed that the spatial variation of the differences between computed and observed values could not be accounted for by adding terms beyond $n = m = 6$.

F. T. Heuring compared the observations obtained with satellite 1964 83C with the fields computed using the harmonic descriptions being considered in relation to an IGRF. He concluded that the GSFC 12/64 field was the best field available.

H. Kautzleben used the statistical theory of stochastic functions in the description and analysis of the main field. The variances for the components X, Y, and Z are nearly constant all over the earth's surface and about $\pm$ 350 gammas for X and Y and $\pm$ 550 gammas for Z.

L. R. Alldredge used 20 radial dipoles at a common distance of 0.14 earth radii from the center to fit the surface field to an rms of 28 gammas.

K. L. McDonald and D. E. Watson computed a sixth degree harmonic analysis of the geomagnetic field for epoch 1835. The paper was presented by L. R. Alldredge.

J. C. Cain discussed a model he proposed for an IGRF derived using all magnetic survey data available for the interval 1900-1964 plus field observations from the OGO-2 satellite. One series of main field coefficients with first and second derivatives gives a good fit to the data for the entire period 1900-1960.

E. Dawson, whose paper was presented by Paul Serson, compared recently derived harmonic sets with Canadian-Scandinavian observations and found differences in the Z-charts of the order of 600 gammas, differences which point out the need for an IGRF.

The paper scheduled by A. Chargoy was not presented.

N. P. Benkova compared the Cosmos 49 data with a harmonic field description of 1960 and used the differences to generate a new set of coefficients that compares well with Cain's 12/66 field and Leaton's B field for an IGRF.

H. Stockhard compared the U.S. Coast and Geodetic Survey's D-chart with the Project Magnet observations. He found that the differences in the New Zealand area are small, i.e., less than 0.1°. There are areas, however, where the differences are as large as 4-5°.

COMMISSION IV
MAGNETIC ACTIVITY AND DISTURBANCES
A. T. Price — Chairman

The business and review-of-progress meeting of Commission IV was held at 14:00h on September 27.

In his opening remarks, the Chairman referred to the great loss sustained by the Commission by the death of the previous Chairman, Julius Bartels, who had inspired so much of the work of the Commission, and was in a very real sense, its founder. The Commission members stood for a few moments as a mark of respect to his memory.

The Chairman then spoke of the considerable progress that had been made since the last assembly in the many scientific areas and activities covered by the Commission. Twelve working groups had been formed at the last assembly, and 12 written reports had been received by the Chairman from the working group reporters. These reports had been duplicated and copies were available at the meeting. There was not time to read the reports in full at the meeting, but each reporter (or someone acting on his behalf) gave a brief summary of his report and comments were invited from the meeting. The reports are presented later in this section.

Following the progress reports, a business meeting was held, at which views were expressed by the working group reporters concerning the future organization of the Commission. It was suggested that more effective progress could be achieved in some studies if the number of working groups was reduced by combining overlapping or closely associated groups. Action on this suggestion was deferred to a later meeting, when it was endorsed by the Commission and later approved by the Executive Committee.

A proposal by S. Chapman, seconded by T. Nagata, that a Geomagnetic Program Committee be set up for the Active Sun Year was endorsed by the Commission and later included in a more comprehensive proposal at the IAGA General Assembly.

A committee headed by R. W. H. Wright is planning a Third Symposium on Equatorial Aeronomy. Present plans call for it to be held November 3-10, 1968, in southern India. It was agreed that IAGA should support this symposium in the same way it supported the second symposium, which proved very stimulating to equatorial studies.

PLENARY SESSION
A. T. Price — Chairman

It is a little early to be able to recognize all the scientific highlights of the Commission IV meetings, particularly as one of the important sessions, that on geomagnetic pulsations and hydromagnetic waves has not yet been held. From the papers already read, however, and the progress reports received from the 12 working groups, it is possible to see a number of important lines of progress emerging.

In addition to the five ordinary meetings of Commission IV, a Symposium on Conjugate Points Experiment was held, consisting of another four meetings. This in itself illustrates the growing importance of studies of magnetic and other phenomena at magnetically conjugate points, and much valuable information about the magnetic sphere is coming from these studies.

The symposium was opened by J. G. Roederer with a general review on conjugate point phenomena. A review of the results of the earlier Conjugate Point Symposium, at Boulder, Colorado, was also given. The second session was devoted to magnetic observations at conjugate points of high and middle latitude. The third session dealt with optical and radio observations, and the final session with phenomena not associated with energetic particles. It is planned to publish the papers presented at the symposium by special arrangements made by IAGA.

Much insight has been gained into many types of micropulsations and the general microstruture of magnetic disturbances. Pulsations of pc 1 type have been found to precede the beginning of a magnetic storm, and long-lasting series of these pulsations are often observed during 3 to 7 days following a storm. Many studies of other pulsations have also been made, and the records of pulsations and standard records of geomagnetic disturbance open new possibilities for investigating the processes occurring in the magnetosphere.

The detailed studies undertaken by Dr. Mayaud of K and non-K variations in connection with the production of the atlas of K indices have revealed many features of ionospheric currents and other field sources that require further study, as well as showing the need for, and pointing the way to, various improvements in the definition and derivation of activity indices.

Another very important development is the use of large computers for data processing and for solving some of the elaborate mathematical problems arising in the study of worldwide magnetic variations. One use that has been suggested is the automatic evaluation and construction of representative ionospheric current charts for several epochs every day, using the mean hourly values from a suitably distributed set of observations. On quiet days the daily variation currents would probably clearly emerge. On disturbed days, it may be possible to interpret the representative current system obtained and refine the analysis to determine the daily ionospheric currents.

An important observational development of great interest in Sq studies is the detection and evaluation by means of suitably instrumented rockets of the ionospheric currents believed to be the source of the daily variations. No specific papers were read on this topic, but it is referred to in one of the working group reports.

Finally, mention should be made of the equatorial electrojet. Further observational and theoretical studies indicates that it is a more complex phenomenon than originally supposed, and projects for further studies are being planned.

SCIENTIFIC SESSIONS

Dr. J. A. Jacobs reported that, in the session on "Geomagnetic Disturbances and Activity Indices," held on September 29, Dr. P. N. Mayaud's paper (IV-42), "A Propos du Mode de Calcul de l'Indice Planetaire Kp et d'un Nouvel Indice," produced a lively discussion on the physical meaning of magnetic indices. It was made clear that the old Kp index would be continued.

Dr. V. A. Troitskaya presented three papers, (IV-44), (IV-45) and (IV-46, on magnetic disturbances. Some discussion followed on the question of assigning magnetic activity indices to micropulsations. Some felt that activity indices derived from micropulsations should be better than the present Kp index.

The paper "Time Structure of the Geomagnetic Variations: Sq and Pulsations" (IV-47) by G. Franselau was read in summary only in the absence of the author and the last two papers (IV-48 and IV49) were postponed to allow for a business meeting of Commission IV.

The scientific session held Tuesday afternoon, October 3, on "Magnetic Diurnal Variations and Ionospheric Current Systems," differed from the program printed in **IAGA Bulletin** No. 24 in the following respects:

The paper "Geomagnetic Disturbances and their Local Gradients" (IV-49) by H. Schmitt was moved to this session.

The paper "A Practical Method of Analysis of the Daily Geomagnetic Variations" (IV-60) was read by H. Maeda.

Following the presentation of the paper "Automatic Calculation of Daily Ionospheric Current Systems," (IV-61) by D. J. Stone, fundamental problems involved in the method of analysis were discussed by A. T. Price, W. G. Kertz, and M. Sugiura. A question was raised regarding the method of removing disturbance fields. The paper "'A Motion Picture Representation of the Geomagnetic Daily Variation Sq and its Seasonal Variations" (IV-67) was a very unusual and interesting contribution. It was received with very great interest and appreciation.

D. G. Osborne reported that in the session on "Equatorial Electrojet and Solar Daily Variations," held October 4, discussion was slight, becoming lively only in relation to the electrojet model proposed by J. Untiedt. Silence may not always have indicated agreement and two general questions, pertinent to many of the papers, need to be considered. One is how far theoretical descriptions can be modified for better fit with existing data, since there is much noise in these data and much freedom in choosing arbitrary parameters for the "scaling" of models. The other question is how much interpretation should be given to the data before their presentation; for example, in deducing ionospheric current systems by eliminating other parts of the magnetic variation.

THE PERMANENT SERVICE OF GEOMAGNETIC INDICES
J. Veldkamp — Reporter

The Permanent Service of Geomagnetic Indices is charged with collecting and publishing magnetic character figures and data on rapid magnetic variations.

The work of the Permanent Service is carried out at three institutes:

1. The Meteorological Institute at De Bilt (Netherlands), where the Permanent Service has its office and where magnetic character figures are received in monthly or half-monthly reports from more than 100 observatories. The data from the key stations are sent to Göttingen and lists of rapid variations are forwarded to Tortosa. The K indices and C figures are tabulated, the mean value Ci is calculated, and the international quiet and disturbed days are determined.

2. The Geophysical Institute at Göttingen (Federal Republic of Germany) where the planetary 3-hour Kp indices are derived from the K indices from the key stations as well as the daily character figures Ap and Cp. Quarterly indices from polar observatories are also collected.

3. The Geophysical Observatory at Tortosa (Spain), where data are collected on

rapid variations, such as storm sudden commencement, geomagnetic bays, pulsations, solar flare effects, etc.

The work is organized in such a way that a certain number of results concerning a particular month are generally ready for publication about the 25th of the following month. The Geophysical Observatory at Göttingen distributes half-monthly tables of Kp and Ap indices for about 100 observatories, as well as 27-day recurrence diagrams. Tables of daily international character figures Ci and of selected quiet and disturbed days are issued monthly from De Bilt. In addition, the same data are published monthly by the Space Disturbances Laboratory, ESSA, Boulder, Colorado. The results are assembled and published quarterly and distributed to the participating observatories and other interested institutes. The data are also published in the **Journal of Geophysical Research.** Preliminary data on rapid variations appear in the quarterly reports. All data are published in final form in the **IAGA Bulletin** No. 12 of each year.

The work of the Permanent Service of Geomagnetic Indices is supported by yearly subventions from the Federation of Astronomical and Geophysical Services (FAGS). For the years 1963-1967 the subventions were as follows: 1963, $4,000; 1964 $3250; 1965, $2550; 1966, $3400, plus $1000 from IAGA; 1967, $1700 (first allotment).

In view of the decreasing allowances from FAGS it will be necessary to find supplementary funds from another source; only under care-free circumstances can the Permanent Service carry on effectively the work of collecting and editing geomagnetic data.

WORKING GROUP IV-1, MAGNETIC ACTIVITY INDICES
P. N. Mayaud — Reporter

Several persons have suggested that the Director of the Service of Kp be a member of the Working Group; such a modification would seem to be very useful and will be submitted for approval of the association. On the other hand, according to the statutes of FAGS, the Director of the Permanent Service of Geomagnetic Indices is a member of the Working Group.

A full report on the progress of the Permanent Service was given by the Director, Professor Veldkamp, immediately preceding this report. The association can only express its gratefulness to Professor Veldkamp, who has assured the direction of the Service for 20 years, the more so as the obligations of this service have been growing rapidly for the past few years.

Resolution 3 of IAGA at the last assembly recommended that observatories measuring indices K_H and K_D send tables of these data to the Permanent Service, in order that research workers wishing to use them may ask that they be provided with them. At present, 11 observatories are doing so.

Resolution 5 of IAGA at the last assembly recommended that high latitude observatories make measurements of the R index, indicating the absolute hourly range in each horizontal component expressed in tens of gammas. Up to the present, two Canadian observatories have sent such data to the Permanent Service through a communication to the Reporter of the Working Group. During the assembly, it will be useful to ask whether other observatories have measured such indices and, if so, whether they can be communicated to the Permanent Service. A recapitulative table showing data received could be published in the **IAGA Bulletin** No. 12 of each year so that research workers wishing to use the data may ask that they be sent to them. Q indices are regularly sent to the Permanent Service by the observatory at Sodankylä.

Concerning these three types of indices, the following arrangement might be suggested. Observatories would send their data to the World Data Centers, which are better equipped than the Permanent Service to provide copies. The bulletins would then give only a recapitulative table about each of them; a different symbol would be used in the table indicating that the data have been sent only to the WDC's or that they have been published in the yearbooks of the observatories. Thus, the bulletins would include information on the different measures of magnetic activity that are at the disposal of research workers.

In the interval between the two assemblies, a rather heavy correspondence was exchanged between the Reporter and the members of the Working Group. The Reporter wishes to thank all those who collaborated actively.

In February 1964, the composition of the first part of the atlas of K indices was submitted to the members of the Working Group. The comments received very defintely contributed to an improvement of the text. Unfortunately, Professor Bartels, to whom the Reporter had sent this text, died shortly afterwards, and the Reporter would like once again to express deep regret that Professor Bartels was unable to continue the direction of this work and to oversee its completion.

A misunderstanding has existed in the minds of many observers concerning the K index (measured without elimination of s. f. e.'s) and the K' index (measured with elimination of s. f. e.'s). Only the first one was published in the tables of **IAGA Bulletin** No. 12 (cf. the introductions), but some observatories sent the K' instead of the K. The Reporter submitted to Professor Bartels, in a letter of December 11, 1963, what was to be the object of the circular of June 18, 1964 (the suppression of index K'). This circular was signed jointly by the Director of the Permanent Service and the Reporter after the advice of the members of the Working Group had been obtained. At that time, the K' indices had never been published to any extent and did not seem to be used in the computation of Kp. The principle of an index K'p was in fact mentioned in the **Journal of Geophysical Research** in 1959 (pp. 295-298) and seems to have been computed (J. Geophys. Res. 1950, 215) for six 3-hour intervals of 1949, although at least one s. f. e. of the same year, that of March 31, 1949, seems not to have been eliminated. After that, no mention was made on of an idex K'p.

Dr. Siebert, in charge of the computation of Kp, informed the Reporter that the K' were infact used in the computation of Kp from approximately 1956 or 1957. Consequently, the effect of the circular of June 18, 1964, was suspended for the Kp observatories at the request of the Secretary of IAGA.

A proposal will be submitted for the approval of the association to once again use the original principle of the K'p index. From January 1, 1968, if an s. f. e. is confirmed, a K'p index would be computed from the K' indices and would be given in a supplementary table even if it does not differ from the Kp index. The means now available certainly permit a determination, in the interval of time previous to the diffusion of the monthly tables of Kp, whether the s. f. e.'s are true or not. The **IAGA Bulletin** No. 12 of each year includes in the same way a supplementary table concerning the K'p indices.

The composition of the second part of the atlas was completed in the summer of 1965. The text was submitted to Professor Price, Chairman of Commission IV, who had the kindness to read the manuscript very carefully and to suggest improvement. The atlas was sent to the observatories last spring. The Reporter is quite aware that it might have caused some problems, and the assembly should be the occasion of fruitful discussions to clarify any of these problems.

In March 1966, a circular was sent to the members of the Working Group and to various other persons. It covered problems raised about the manner of computing the Kp index and suggestions concerning the improvement of the measure of the planetary level of magnetic activity. The answers were in general positive. Since then, the Reporter has undertaken some preliminary computations with a view toward determining an index distinct for each hemisphere. A report about these problems will be presented during the General Assembly and the Working Group will be consulted for purposes of deciding whether action must be undertaken.

It might be useful to mention the initiative taken by Dr. Siebert of the Geophysical Institute of Göttingen (circular of May 1966) to make up a card index of all publications using or refering to indices Kp, Cp, ap, or Ap. The publication of this card index could be very beneficial. Also, Professor Chapman and Dr. Siebert plan to publish, in the third volume of **Geomagnetism** (S. Chapman, J. Bartels and M. Sugiura), all the magnetic and solar activity data that are available from 1884 to 1965. Such a document will certainly be of great interest and perhaps the publication of reprints covering only these data should be considered.

IAGA Bulletin No. 18 published in 1962, containing the Kp and ap from 1932 to 1961, seems to have been the basis for numerous works undertaken in the last few years concerning the problem of the existence (or nonexistence) of a lunar influence on magnetic activity. One can only hope that this problem, so hotly debated, will be the subject of discussion during the assembly.

The correlation observed between solar wind and the Kp index, particularly through the observations made on board the satellites Mariner 2 and IMP 1, is probably one of the most important results of the last few years.

Some other lines of research related to magnetic indices: The description of magnetic activity in the Antarctic by Rourke and by Lebeau and Berthelier; the quantitative measure of the recurrence of magnetic perturbations by Meyer; the detection of a universal time component of the magnetic activity by Michin; the determination of a 22-year cycle of magnetic activity by Chernosky; the definition of an index AE (auroral electrojet) of activity by Davis and Sugiura; and, finally, a preliminary study of the long series of R indices of Canadian observatories by Wilhjem. The last two works should be stressed; the first of these two could perhaps be a first step toward a definition of a new quantitative index of the level of activity for the auroral zone; the second could lead to the definition of a measure of the level of activity inside the polar caps, where the activity has properties that are entirely different from those of the auroral zone.

The Working Group on Magnetic Indices met at 17.30h, September 26. The principal subject of the discussion was the problem of eliminating the solar flare effects (s. f. e.) on the Kp index and the determination of new planetary indices. The resolutions proposed by the Reporter on each of these problems was accepted for presentation to Commission IV. (These resolutions were later adopted by IAGA; see IAGA Resolutions Nos. 12 and 13 given in a later section of this bulletin.)

The following information explains more about the new indices proposed by the Reporter. These proposed indices of magnetic activity fulfill a scheme described by J. Bartels in 1940, to compute, for each 3-hourly interval, the arithmetic mean of the K indices from observatories whose distribution in longitude is uniform. As this operation is made separately for the Northern Hemisphere and the Southern Hemisphere, one has available, on the one hand, an index Kn (or An) and an index Ks (or As), and, on the other hand, an index Km (or Am), the mean value of Kn and Ks. Thus the variations of the magnetic activity are characterized for each hemisphere and on a worldwide scale.

A preliminary computation of such indices for a 3-year sample from 10 northern and 6 southern observatories indicates the following:

1. The systematic difference between indices Kp and Km (varying from zero to one unit between Kp $= 0_0$ n and Kp $> 6_0$)arises chiefly from the fact that the Kp index corresponds to a measure of the nocturnal level of the activity, while the Km index is a measure of the true level of the activity; the scattering of Km's corresponding to a Kp of a given value (about 32 percent of these Km's have between them differences higher than two-thirds of one unit, and, sometimes, the difference reaches two units) arises chiefly from the fact that the longitudinal (or latitudinal) distribution of the Kp observatories is not sufficiently uniform, while the distribution of the Km observatories is nearly so.

2. Comparison of Kn's and Ks's shows the existence of a systematic difference between the levels of the activity in each hemisphere, which varies with season, as well as that of a large scattering of Kn's (or Ks's) corresponding to a Ks (or Kn) of a given value (about 32 percent have between them differences higher than one unit). The measure of the activity in each hemisphere taken separately seems therefore to have a real interest.

3. The study of the mean daily variation, in universal time, of the 3-hourly indices am, an, and as confirms the existence of the U.T. component due to the daily variation of the orientation of the dipole axis. Furthermore, it permits one to discover the existence of two other U.T. pseudo-components of the planetary magnetic activity whose amplitude is of the same order of magnitude as that of the U.T. component. One

of them, brought about by the shift of the auroral zones in relation to the geographic poles (causing a variation, with longitude, of the solar lighting of the auroral zone) is out of phase from one hemisphere to another but has the same phase at any season. The other, connected with the variation of the total force F along each of the auroral zones (the Hall current bringing about the auroral electrojet would be proportional to F) has the same phase in the two hemispheres and, evidently, at any season; its amplitude, as that of the variation of F, would be larger in the Southern Hemisphere than in the Northern Hemisphere.

In view of the above, the new indices characterize the magnetic activity better than Kp or ap indices are able to do.

WORKING GROUP IV-2, Dst
M. Sugiura — Reporter

This Working Group was formed at the XIIIth General Assembly of IUGG held at Berkeley in 1963 to study various methods of deriving a measure for the ring current intensity represented by Dst on a continuous basis, and to determine the most suitable method to be used for regular publication of Dst data. Recognition by the IAGA of the significance of the Dst index and its recommendation for publication of hourly values of Dst are indicated in Resolution No. 12 approved by the IAGA at the XIIIth General Assembly of IUGG.

At the Berkeley meeting, Kertz presented a paper describing a method of deriving 3-hourly Dst values from night values of H obtained at 27 observatories divided into eight groups, and his results for the IGY have been published (Kertz, 1964). Forbush (1962, 1964) has determined a Dst index by a similar technique and used his data to study time variations of the radiation belt and the absolute horizontal field due to the ring current. Sugiura (1964) derived hourly values of equatorial Dst for the IGY using eight low-latitude observatories, and compared his results with those obtained by Kertz and also with the ap index. Sugiura and Hendrix (1967) have published provisional hourly values of equatorial Dst for 1961, 1962, and 1963.

The following Dst data have been published so far:

1. Kertz's Dst index (Kertz, 1964) — This index gives 3-hourly indices, daily sum and daily mean, monthly mean values for the eight U.T. intervals, and the monthly mean of all intervals for the period May 1957 to December 1958.

2. Hourly values of Dst (Sugiura, 1964) — These are hourly values of Dst from July 1957 to December 1958. It gives hourly Dst plots for the same period, plots of Dst Ap for comparison and plots of Kertz's index and hourly Dst for comparison.

3. Hourly values of equatorial Dst (Sugiura, 1967) — These cover the period from January 1961 to December 1963.

Unpublished Dst data are as follows:

1. Forbush's Dst data.

2. Hourly Dst data for 1964 available on magnetic tape at World Data Center A for Geomagnetism (to be published shortly).

Various methods of data reduction have been used in studying Dst. Kertz (1964) used a method based on night values. He used three 3-hourly values, one before, one at, and one after midnight, for eight (longitude) groups of observatories. To smooth the data, running means of three values were taken with the center value weighed by two. The contribution from DS is reduced considerably because, roughly speaking, this variation changes its sign near midnight.

In preparing the observatory data the horizontal force H was geometrically transformed to the component parallel to the dipole axis and reduced to the value appropriate for dipole equator. For each observatory a linear correction was made for the secular variation under the assumption that the undisturbed periods August 22-24 and 26, 1957, and November 5-8 and 14, 1958, had the same ring current intensity.

Because of the limited number of observatories available, 3-hourly values of Dst appear to be the best that can be achieved in time resolution at present. This becomes a disadvantage when a greater time resolution is desired.

In recent years axial asymmetry in the disturbance field has been discussed extensively, and the question of how to eliminate DS from the Dst data is an important unsolved problem. This question applies to the method described below and is discussed later.

Sugiura (1964) used a method based on hourly mean values of H, which was improved later by Sugiura and Hendricks (1967). It uses hourly values of H obtained at low-latitude observatories. In the latter version of the method the hourly data from each observatory are corrected for the solar quiet daily variation Sq and for the secular variation in the following manner.

Mean monthly Sq was formed for each observatory and for each month from the 5 "local" days that have a maximum overlap with the 5 "international" quiet days. The noncyclic change was removed from Sq by measuring Sq from straight lines connecting midnight values. The observatory Sq determined for each year was expanded in a double Fourier series with month and local time as variables. Using this Fourier series, hourly values of a synthetic Sq variation were computed and substracted from the original hourly values.

Corrections for secular variations are necessary to obtain a long series of Dst covering many years with a meaningful common reference level. For these corrections the following procedure was adopted. For each observatory the annual mean value of H derived from the monthly selected 10 quiet days was expressed in a quadratic form in time and the coefficients were determined by the method of least squares.

Effects of the quiet-time ring current and the neutral sheet in the geomagnetic tail are important. Davis and Williamson (1963) found that even during a magnetically quiet period the energy density of the trapped protons with energies of 100 kev to 4.5 mev amounts to an appreciable fraction of the energy density of the earth's magnetic field. Hoffman and Bracken (1965) estimated the magnetic field due to this proton belt to be 9 gammas at the magnetic equator on the earth's surface. Their calculation is based on the measurement made by a proton detector aboard Explorer 12. On the basis of some preliminary data obtained by Davis, Akasofu et al. (1962) calculated the surface equatorial field of a model quiet-time proton belt to be 38 gammas. The intensity of the quiet-time proton belt is likely to vary with solar activity, but no measurements are available to discuss this variation quantitatively. Forbush (1964) has studied the solar cycle variation of the ring current field using observatory magnetic data, but his results have not been published.

The hourly values of Dst available so far do not allow for the quiet time proton belt and its solar cycle variation. Specifically, in the hourly Dst data for the IGY given by Sugiura (1964) the zero level was defined by the average of hourly values (after Sq is substracted) over all the quiet periods in which two or more successive days had ap not exceeding 7. Therefore the Dst values for this period do not include the magnetic field due to the average quiet-time ring current. For the Dst records (Sugiura, 1967) for 1961, 1962, and 1963 the annual means based on daily means of the monthly selected 10 quiet days were used to determine the base values. At latitudes below the Sq focal latitude the daily mean in H is raised above the zero level for H by the daily mean of Sq in this component, where Sq is measured from the midnight level. Since the Sq amplitude increases with increasing solar activity, a zero level determined from daily means tends to be too high during years of high solar activity, whereas the quiet-time ring current lowers our zero level. If the intensity of the quiet-time ring current increases with increasing solar activity, the zero level tends to be set too low when solar activity is high. Hence these two effects tend to cancel each other. It would have been better to use midnight values rather than daily means, but the latter were used simply because they are readily available in observatory books.

Besides the quiet-time ring current the effect of the current in the neutral sheet of the geomagnetic tail must be taken into account to determine the true zero level. A current sheet model for the neutral sheet has been used by Williams and Mead (1965). The exact amount of contribution from the neutral sheet current to the surface magnetic field and its temporal variations including those with solar cycle are not as yet known. When corrections are made for these effects, the remaining Dst is due to the trapped particles and to the current on the surface of the magnetosphere boundary.

By definition, Dst is the axially symmetric part of the disturbance field D, and the difference, D — Dst, is called DS. In low latitudes DS consists of two parts, one resulting from the return current from auroral electrojets and the other from an asymmetric ring current. The asymmetric disturbance field in low latitudes has been discussed by Akasofu and Chapman (1964), Parker (1966), and Cummings (1966), and has been observed in the magnetosphere by Cahill (1966). This asymmetric field is due to a partial ring current existing roughly in the quadrant 16h to 22h in local time. When such a partial ring current exists, Dst determined by the methods described above will be affected, and the contribution from the partial ring current will be smeared out. The contribution from the return current from auroral electrojets is difficult to assess. Since this part of DS is not exactly antisymmetric with respect to midnight, the method based on values near midnight do not eliminate this contribution completely. The same applies to the method using hourly values; the averaging over several observations or several groups of observatories does not eliminate DS.

It is recommended that the following problems be discussed by the Working Group at the IAGA Assembly at St. Gall:

1. The determination of reference level.
2. Removal of Sq.
3. The effect of the return current from auroral electrojets.
4. The effect of a partial ring current.
5. The effect of the neutral sheet of the geomagnetic tail.
6. The practical problem of publishing the Dst data.

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WORKING GROUP IV-3, CLASSIFICATION OF DAYS
G. Fanselau — Reporter

In the period reported on — i.e., from the Berkeley conference, 1963, to the conclusion of the present report — three circular letters were issued. On the whole, there has been a satisfactory response to these circulars. The following details are worth mentioning:

A classification of days for various statistical analyses on Sq and L was undertaken by different authors; for instance, by J. Bartels, G. Fanselau, C. U. Wagner and H. Wiese. On an international scale, a classification of days is being carried through for the 5 quiet and the 5 disturbed days of each month. The latter classification is known to be defective in several respects, since quiet days in a disturbed month often have the same degree of disturbance as disturbed days in a markedely quiet month. This classification can only be used as a general guideline, with the necessity of simultaneously consulting the A_k numbers.

Classification of days as have been used in the yearbook of the Miemegk observatory have proved to be more valuable for statistical purposes. This kind of classification offers a basis which is reasonably well established for such purposes, and this the more so since the days are not characterized by the degree of disturbance in itself but by an even distribution of disturbance over the whole day. There are plans to establish an international number; this will be a number of several places that assigns characteristic features to each day, so that computing is made easier. For this purpose solar-physical and ionospheric data will have to be determined apart from characterizing the geomagnetic conditions. Unfortunately, the members of the Working Group have not responded helpfully to the circulars. For geomagnetism, therefore, an index number has been suggested, the formation of which is as follows: The differences of the K numbers for the 3-hour intervals are taken as the basis, as was introduced by J. Bartels. The sum of the absolute amounts of the differences of two successive K numbers are used. For each day seven absolute amounts for the sum total are obtained this way. The arithmetical mean of the two differences from the first K number to the last one of the previous day and the last K number to the first one of the following day are then added. As a whole, eight absolute amounts of K differences are thus available. They yield — perhaps additionally divided by eight — a number x for the regularity of the quietness or disturbance of a day. If x is small, the day is continually quiet or disturbed; if x has greater values there is no such continuity and the day is characterized by discontinuous disturbance. In connection with the A_k numbers a sufficient classification of days based on geomagnetic observation is obtained that way. The Potsdam Geomagnetic Institute has done some statistical analyses along these lines that will be subject to discussion in St. Gall.

There have been copious discussions with several colleagues on a possible extension of the classification of days considering solar-physical and ionospheric observations. These discussions have not yet brought forth any tangible results. Most conducive to success were debates with the Czech colleagues, who have submitted several suggestions worthy of discussion.

All suggestions made so far in the field of the ionosphere were found to be frustrating because of the necessary experimental equipment and expenses.

WORKING GROUP IV-4, Sq
A. T. Price — Reporter

There has been no formal meeting of the Group during the last 4 years, but several members have met informally at various international conferences, and active contacts have been established with many other workers in the field. There has also been a close liaison with the Working Group on Equatorial Electrojet.

Availability of Data

Although observational techniques and the acquisition of data are not specifically the concern of this Group, the recent progress in these areas is of such great importance that it should first be briefly described in so far as it affects the progress of the Working Group.

A proposal for establishing during the IQSY some additional island stations in the Pacific, and reactivating some IGY stations, in order to obtain much-needed information about the Sq field in this area, was made to CIG by Chapman and Price in 1962. They also suggested that, if possible, open sea stations on floating platforms should be developed for use in some of the larger stretches of the ocean. A substantial and very valuable contribution to the suggested program has come from the U.S. Coast and Geodetic Survey (Nelson, 1967), which set up four temporary island stations on Koror, Midway, Majuro, and Adak for the period spring 1964 to January 1966. The stations were equipped with new type magnetometers and recorders that operated for 4 to 6 weeks without attention. The results are now being processed and will be available shortly on microfilm in the World Data Centers.

Encouraging progress has also been made with the development of open sea stations (Alldredge and Fitz, 1964). One important advantage of these would be the avoidance of certain anomalies, particularly in the Z variations, that were discovered by Mason (1962) on Christmas Island and Oahu Island and attributed by him to the edge effects of electric currents induced in the oceans. Similar anomalies were found by Elvers and Perkins (1964) on Puerto Rico (1964) in connection with the establishment of a new observatory at Cayez. There is no doubt that similar anomalies are present, to a greater or less extent, at all coastal stations on continents as well as on islands, and they may have to be taken into account in worldwide analyses of the Sq field, particularly when separating the field into parts of external and internal origin.

Studies of the Sq field are at present based almost entirely on tables of the mean hourly values of the three magnetic components, derived at each observatory by hand-scaling the magnetograms. A major advance in the technology of observing and recording magnetic variations is the development of an automatic standard magnetic observatory (Alldredge and Saldukas, 1966), in which the output is in digital form and immediately available for computer calculations. An early model of this automatic observatory was exhibited at the XIII Assembly of IAGA, and subsequent developments have indicated its tremendous potential for aiding Sq studies.

One other observational development of great interest is the detection and evaluation by means of suitably instrumented rockets of the ionospheric currents believed to be the source of Sq variations. These currents, first detected above the dip equator, have now been detected and measured in midlatitudes (Burrows and Hall, 1964; Davies et al., 1965). It is also worth noting that one of the objectives of the POGO satellite program (Cain et al., 1966) is to obtain measurements of the Sq field above the dynamo layer. A good coverage of the earth is being obtained with these satellites, and it may be possible to extract the Sq variations from magnetic measurements made in the satellite during certain time intervals. If this proves possible, it will be of great interest to compare the surface and upper atmospheric Sq fields, and this may lead to useful information about the field in areas like the Pacific where our knowledge is scant.

Worldwide Analyses of the Sq Field

An adequate knowledge of the daily variation field, and a full understanding of the associated phenomena, can only come from extensive and detailed analyses of mean hourly values of the magnetic elements at many stations. The availability of these data in turn depends very much on the labors of many observers, in hand-scaling their observatory magnetograms and processing the data to produce the tables of the mean hourly values. We acknowledge our great debt to the observatory personnel for these labors, and also to the World Data Centers for their help in collecting and distributing the data.

When the results of the worldwide analyses for IQSY data are available, it will be of great interest and value to compare them with the results already obtained for the IGY data. Also, it may be expected that the field derived (for different seasons and at various epochs GMT) for the IQSY will be a more accurate representation of the Sq field, because it is less likely to be contaminated by magnetic disturbances.

Three quite different methods of analysis were developed for dealing with the IGY data (Matsushita and Maeda, 1965; Mishin et al., 1966; Price and Stone, 1964; and

Price et al., 1967). All three analyses have taken into account two well-known facts: (1) that the Sq field is largely a local time field that can be roughly represented by a current system fixed relative to the sun, and (2) that there is a considerable control of the current pattern by the earth's main field.

Matsushita and Maeda, using data from 69 stations, divided the globe into three longitudinal sectors, and derived by the method of spherical harmonic analysis the worldwide local time variation field that would best fit the observations in each particular sector for each of the three seasons. To take account of the influence of the earth's main field on the Sq field, the dip latitude of each station was used in place of the geographic latitude. Thus the Sq current diagram which they obtain for each sector, and each season, gives a worldwide representative current system of constant form, which, if rotated round the earth with the sun, would give the daily variations at stations within that particular sector.

An alternative method of dealing with the changes with longitude of the Sq field throughout the Greenwich day has been developed by V. M. Mishin et al. (1966). In this method, spherical harmonic functions are again used to represent the field, but the data are the mean hourly values, averaged over a season, for one U.T. hour only, instead of the sequence of 24 hours used in earlier analyses to obtain the local-time part of the variations. The aim is thus to determine "instantaneous" systems of Sq currents for various epochs during the Greenwich day.

Mishin and his coworkers have used their method of analysis to infer the Sq current systems for 8 equidistant epochs U.T., i.e., for epochs at 3-hourly intervals throughout the Greenwich day. The data used were the mean hourly values averaged for the international quiet days of the equinoctial months of the IGY, from 68 stations having latitudes between 60°N and 60°S. Their results indicate significant U.T. changes in the pattern, position, and intensity of the northern and southern current vortices. The changes of intensity are particularly remarkable. These range up to 50 percent of the average daily value, the maximum values for both northern and southern vortices occurring at about 12h U.T. These results are rather surprising when it is remembered that the calculations are based on the averaged data for 20 quiet days.

Significant changes in the intensities of the current vortices within the Greenwich day were also found by Matsushita and Maeda (loc. cit.), but they are generally smaller and differ in other respects from those obtained by Mishin et al.

In view of the very different methods of treatment of the data adopted in these two analyses, one must expect some differences in the results. The results derived from any anlysis of Sq data are greatly affected by the assumptions upon which the method of analysis is based. This is particularly true of the relative amounts of current attributed to the northern and southern vortices. However, the sum, without regard to sign, of the northern and southern vortex strengths, i.e., the total current flowing between the two vortices, is certainly less affected by the method of analysis than are the strengths of the individual vortices. This sum is therefore a more reliable measure of the flow at any epoch of the ionospheric currents. Both the above analyses show significant variations in this total current flow during the course of the Greenwich day, and the trends are similar with a minimum round about 0h U.T. and a maximum near 12h U.T.

Some preliminary estimates of Sq currents for the same period by Price, Rogers and Stone (1967), by a quite different method, also show marked variations of current flow within a Greenwich day. Instead of using spherical harmonic analysis to interpolate and separate the field into parts of external origin, this was done by surface integral methods, based essentially on those developed by Price and Wilkins (1963) for treating the Polar Year data 1932-1933. These methods were, however, modified and developed to make them suitable for automatic treatment on a computer.

The main objectives were to study the changing features of the Sq field during a complete Greenwich day and the overall changes of pattern and intensity throughout the year. The mean hourly values for about 80 stations were used, and the external and internal parts of the field at the 6 epochs, 0h, 4h, 8h, . . . U.T. of the Greenwich day were determined for the averaged "local quiet day" data of each month.

Professor Chapman has pointed out that a routine daily plotting of ionospheric currents would be of great value to many investigators in geomagnetism and space science, and, in view of the variability of the current system during a Greenwich day, charts of the system plotted for 3 or 4 epochs each day would be of even greater value. The experience gained in the above analyses of IGY data suggests that it would now be possible, with the aid of a moderately large computer, to construct such charts.

A feasibility study of the completely automatic evaluation and construction of ionospheric current charts for individual epochs U.T., without having recourse to averaging the mean hourly values over a number of quiet days, is now being undertaken by Price and Stone. Charts thus constructed for several epochs U.T. for each day of the year will probably reveal the Sq current system (with some distortion) on most days, while additional representative current systems (not necessarily real ionospheric current systems) would emerge during magnetic disturbance. An outline of the steps in this automated process, as at present envisaged, will be given by Mr. Stone in a paper to be read during this assembly.

It is intended to test the suggested procedures using the mean hourly data for 1965. Assuming that these prove satisfactory, Chapman and Price propose that the International Association of Geomagnetism and Aeronomy should make arrangements for the construction and publication of ionospheric current charts for several epochs each Greenwich day on a continuing basis.

Statistical and Correlation Studies

Since the last assembly many statistical and time-series investigations of data from particular stations — sometimes covering several decades — and also correlation studies of data from several stations have been made (Brown, 1967; Chapman and Fogle, 1967; Gupta, 1967; Hutton, 1967; Mayaud, 1966; Onwumechilli and Ogbuehi, 1965; Ogbuehi et al., 1967; Osborne, 1962, 1964, 1966; van Sabben, 1966; Wagner 1967). Papers describing several of these investigations will be read during the present assembly. References to others already published are included in the bibliography at the end of this report. The Reporter is aware that his list of papers in this area of activity is far from complete and would welcome information about other papers.

Theoretical Studies

Our greatly increased knowledge of the properties of the magnetosphere, and the discovery of the solar wind, have suggested a number of interesting ideas and conjectures relating to the theory of the daily variations. One of these concerns the possible contribution to the Sq field of the electric currents produced on the magnetospheric boundary by the solar wind. Another concerns the modifications to the dynamo theory which may be required by the linkage of the ionosphere with the magnetosphere due to the high effective conductivity along the lines of force of the earth's main field.

The current system produced by the solar wind at the magnetospheric boundary has been studied in detail by Mead (1964). His calculations show that the resulting magnetic field at the earth's surface would be mainly a $P_2^{\,1}$ field, and would therefore be roughly similar in form to the observed Sq field. Its amplitude would, however, be only 2 or 3 gammas in midlatitudes if the magnetospheric boundary were at about 10 earth radii. It appears, therefore, that the magnetosphere surface currents do not make an important contribution to the observed Sq field.

There is, however, another daily variation field, quite different in form and mode of production from the above but also attributed to the effects of the solar wind. This is the Sq^p variation in polar regions, discovered by Nagata and Kokubun (1962).

The electrostatic coupling between the dynamo region and the magnetosphere, first examined theoretically by Farley (1960), was also discussed by Dougherty (1963), who indicated the desirability of more detailed theoretical and observational studies. The Sq variations at geomagnetically conjugate areas were examined by Westcott et al. (1963), who were unable to find any particular similarity or relationship of the Sq variations at conjugate stations. They inferred from their theoretical discussion that the coupling effect along a tube of magnetic force between conjugate areas would tend, in fact, to reduce any similarity in the current systems in these areas.

A modified dynamo theory that seeks to take into account the flow of current in the magnetosphere along the lines of force has also been developed by Maeda and Murata (1965). From their calculations, they estimate that the magnetospheric current produces a field of only about 1 gamma at the equator and that the corresponding return current in the dynamo layer affects the total Sq field by less than 10 percent.

Magnetospheric currents associated with the north-south asymmetry of Sq have also been discussed by van Sabben (1966), but he has approached the problem in a different way, namely by first seeking to determine the nature and magnitude of the magnetospheric currents from the observations and then accounting theoretically for their existence. He argues that during the equinoxes the **average pattern** of those currents that are confined entirely to the dynamo layer must be symmetrical about the dip equator, and that, therefore, the antisymmetrical part of the pattern is associated with magnetospheric currents.

The antisymmetric ionospheric winds that would be required to produce the ionospheric-magnetospheric currents deduced by van Sabben are found to be rather large, and he suggests, as an alternative possible cause, the electromotive forces arising from a nonionospheric source, such as the solar wind.

A generalised dynamo mechanism in the upper atmosphere incorporating many of the above suggestions has been described by H. Maeda (1966).

Ashour and Price (1965) have shown theoretically that, though there are no appreciable ionospheric currents in the night hemisphere, there will be induced earth currents extending right across this hemisphere. The magnitude and distribution of these night earth currents are of some importance in determining the correct baseline from which to measure the magnetic variations at each station in any detailed study of the Sq field.

The relative importance of solar radiation and gravitational tide in the dynamo theory of Sq has been discussed by Gupta (1967). He has concluded that the diurnal and semidiurnal periodicities present in the geomagnetic variations are much more closely related to solar radiation falling at the top of the atmosphere than to any tidal effects generated by gravitational forces.

Future Projects

This report reflects the considerable attention now being given to Sq studies, due in large measure to the stimulus derived from the IGY and IQSY programs. We ought now to consider how progress in these studies can be helped most effectively by the Working Group. One suggestion has been that specific research projects should be undertaken in different areas and the Working Group act as a coordinating committee for these projects. An example would be the development of the automatic evaluation of Sq charts as above described; another, suggested by Nagata, would be the investigation of the true baseline for the daily variations, this being of great importance for accurate local secular variation studies. It is hoped that the Working Group will give some consideration to these suggestions during the assembly.

Three proposals made by S. Chapman and A. T. Price were finally passed in modified form as IAGA Resolutions Nos. 6 and 9, which are listed in a later section of this bulletin.

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WORKING GROUP IV-5, EQUATORIAL ELECTROJET
D. G. Osborne — Reporter

Introduction

Large variations in the horizontal magnetic component at stations near the magnetic equator were attributed by Egedal (1948) to a narrow band of current in the ionosphere directed eastwards. This current is called the equatorial electrojet. A quantitative theory has been developed by Baker and Martyn (1953) and others suggesting that the current is a reinforcement, due to increased ionospheric conductivity near the magnetic equator, of the current system responsible for quiet day diurnal variation. Near the magnetic equator other special ionospheric effects have been observed. These include sporadic E, spread F, high drift velocities in both the E and F regions, and the alignment of irregularities along the direction of the magnetic field lines. It has been important to match magnetic measurements intended to give information about the equatorial electrojet with measurements on the ionosphere using other techniques.

At the XIII Assembly of the IUGG in August 1963, a Working Group on the Equatorial Electrojet was established in Commission IV, the commission concerned with magnetic activity and disturbances. Equatorial studies in different locations have several common features. Hot and humid climates do battle with equipment and experiments. Many observations need to be taken in isolated locations. Equatorial countries are mostly in the early stages of economic and industrial development and in many of them communication and transportation present serious difficulties. The need to compare observations made at many locations round the equator has made the Working Group on the Equatorial Electrojet serve primarily as a means of liaison between research workers interested in this field. A list of active research workers in this field can be obtained from the Reporter.

Several members of the Working Group attended the Second International Symposium on Equatorial Aeronomy held in Brazil in 1965. This provided a valuable opportunity for general discussion of research projects by workers from different equatorial locations and with interest over a wide range of ionospheric physics. It is hoped that the IAGA will give continued support to such symposia. A conference report, containing abstracts of all papers with diagrams that had been shown as slides, was published very quickly after the symposium and the editor, Dr. de Mendonca, should be congratulated on this. More carefully prepared papers were published in a special issue of the **Annales de Geophysique** (1956, **22,** fasc. 3) and have been made available also as a separately bound supplement as **IAGA Symposium** No. 5.

A joint meeting of these members of the Working Groups on Sq and Equatorial Electrojet who were present at the Second Symposium on Equatorial Aeronomy at Sao Jose dos Campos, Brazil, was held on September 13, 1965, (1) to consider recommendations to IAGA on definitions, terminology, and notations of various measures of Sq components; and (2) to discuss the possible need for a survey of observational work in equatorial regions.

Four recommendations were formulated, and were later adopted as Recommendations 19-22 of the Final Meeting of the Symposium on Equatorial Aeronomy. These recommendations read as follows:

(19) — The Symposium notes that the magnetic effects of the electrojet phenomena are quite complex. The Symposium recommends that every effort should be made to increase the number of simultaneous observations of the variations of all three magnetic elements at permanent and temporary stations near the dip equator.

(20) — The Symposium notes that there is considerable variation of the equatorial Sq current system ranges with longitude, and that there is evidence of temporal changes in intensity and width of the electrojet. The Symposium recommends that efforts should be made to study a sample length of the electrojet by organizing simultaneous observations for a period of one or more months of the variations of H, D, Z at the three permanent stations in Africa, together with two or more temporary stations, all as near the dip equator as possible.

(21) — The Symposium notes the large ranges of Sq (H) observed at Nairobi and elsewhere in East Africa, and the observed asymmetry of the ranges along a N-S line crossing the dip equator in several regions. The Symposium recommends that a special effort be made to get simultaneous observations at a number of stations along a roughly N-S line crossing the dip equator in East Africa and also in India and Ceylon. The lines should extend over a latitude range of at least 30°.

(22) — The Symposium recommends that the International Association of Geomagnetism and Aeronomy be asked to make recommendations clarifying many of the terms used in geomagnetism including, for example, the names of the various equators and the different measures used for ranges of the daily variations.

This reference to a joint meeting of members of the Working Groups on Sq and the Equatorial Electrojet illustrates the very close collaboration between these groups. It is hoped that this will continue. The value of the Symposium on Equatorial Aeronomy suggests also that it is appropriate to have a separate working group concerned with equatorial geomagnetism within IAGA.

Recent Research

Rocket measurements were made in the equatorial region before 1963 but many more have been made since then and are held to suggest (1) that there is an associated return current on either side of the jet; and (2) that there is a small nighttime current in the opposite direction to the jet.

Satellite studies on the ionospheric current system have become significant during the past 4 years though the precise interpretation of these has not always been easy. Difficulties appear to arise more from determining the precise location and attitude of the satellite than from measuring the magnetic field.

Electrojet studies using instruments at the earth's surface have been concerned mainly with attempts to find the relationship between magnetic variation and other measurements indicative of ionospheric properties. Relationships have been sought between magnetic variation and measured drift velocities in the E and F regions. Attempts have been made to confirm the suggestion that there is a threshold value of electrojet current above which sporadic E is produced, but preliminary reports suggest that these have encountered difficulties.

Research has continued on the measurement of equatorial electrojet irregularities using radar techniques and results give evidence of neutral winds in the electrojet. The variablity of observations from one day to another has prompted studies on the correlation between different quantities in search for a common cause. In radio, magnetic, and micropulsation studies there has been a growing interest in the analysis of behavior on individual days. This interest covers days when conditions are ordinary and also special days, such as those including an eclipse.

The comparison between magnetic measurements at different locations requires agreed standards of observatory practice. We are indebted to Dr. Wienert and Dr. Stagg for making survey visits to geomagnetic stations in Africa and South America. Dr. Wienert's findings have been published under IAGA auspices. The search for meaningful relationships between magnetic measurements made at different places and other ionospheric data obtained from earth-based instruments has shown that research projects cannot be planned in isolation. The further need to relate rocket and satellite studies to simultaneous observations from the ground of magnetic variation and other effects has increased the importance of cooperation in research.

In addition to the experimental research described, using rocket, satellite and ground measurements, attempts have been made to suggest theoretical models for the equatorial electrojet. Typically these give contours of equal current density in the ionosphere, from which it is possible to predict field variation at the earth's surface and field changes along satellite orbits and rocket trajectories. There has been increasing interest, both experimentally and theoretically, in questions concerning the fine structure of the equatorial electrojet.

Future Research

Rocket flights to take ionospheric measurements should become more frequent as improved technology reduces the cost. It has been suggested that with small improvements standard heavy guns firing vertically should be able to send ballistic missiles through the ionospheric E region. Such missiles would be much more economical than rockets. However, there are several technical problems to be overcome before this suggestion can be realized. It is necessary to design a payload that can withstand the heavy shock from the inital acceleration of the missile. It is necessary to obtain a gun of sufficient power to send a missile to the desired altitude. It is necessary to mount this gun so that it can fire vertically. It is necessary also to overcome the possible military and sociological objections that would arise from the use of guns rather than rockets for research purposes. At present rocket-launched detectors remain the only method of taking measurements inside and immediately above and below the electrojet region. Both rockets and gun fired missiles suffer from the necessarily short time of measurement during transit of the payload through this region. Methods of slowing up the descent to increase this measurement time should be investigated.

Satellite measurements may be expected to become much more important during the next few years than they have been in the past. Attempts should be made to make systematic measurements of field changes and changes of ionospheric currents from satellites during selected periods through a solar cycle. It is to be hoped that those countries capable of carrying out this project will make every effort to start observations near the sun spot maximum of 1968. Consideration should be given to the relative merits of satellites operating in polar orbits and those with an orbital plane that is near the equator.

Satellite measurements offer excellent prospects for comparative studies of longitudinal variation of the electrojet. When these studies are attempted using data from earth-based observatories they suffer from the inevitable displacement of the observatory from the center of the electrojet system. Satellites in polar orbits crossing the jet at different longitudes at approximately the same time would give a much clearer picture of the total structure of the equatorial electrojet than measurements at the earth's surface.

Measurements from the earth's surface should include attempts to measure the variation with latitude of magnetic variation near the equatorial electrojet. A proposed chain of stations in eastern Africa would be well suited for this purpose and the proposal has an added attraction since preliminary measurements suggest that the change of magnetic variation with latitude in this sector is very different from that found elsewhere. It is necessary to conduct further experiments on the relationship between magnetic fields, drift velocities, and sporadic E near the equatorial electrojet.

Attempts to construct physical models for the equatorial electrojet must depend on a better understanding of the plasma conditions in which the current is flowing. It is likely that satellite studies will contribute most to an understanding of the large-scale behavior of the electrojet and that rocket studies will permit the examination of its fine structure. Earth-based studies provide opportunity for investigating relationships between different characteristics of the electrojet region over long periods of time. Earth-based magnetic measurements indicate mean behavior of the jet, while radar and radio measurements give indication of fine structure and dynamic properties.

Tropical International Geophysics and Environmental Research (TIGER)

The importance of coordination for the planning of experiments on the equatorial electrojet has led to a suggestion that an International Center for Tropical Geophysics should be established. The initials TIGER could indicate a Center for Tropical International Geophysics and Environmental Research, and the initials are not wholly inappropriate. The need for this arises largely from recent technical developments. (Modern instrumentation, including satellites, can provide large quantities of information: the parallel development of computers makes it possible to analyse this data). The establishment of such a center is specially appropriate now that research in the newly developing countries in the tropics is organized locally instead of under the direction of institutions in the more developed countries. It is suggested that such a center should provide a meeting place for geophysicists on university staffs and in other parts so that groups concerned with particular projects could meet together to plan experiments for which observations would be conducted in the countries from which they come. Further meetings to discuss the interpretation of these data would take place at the center which would need library and computer facilities to make this possible. It would be appropriate if the center itself were situated in or near the tropics, but it is recognized that in order to arrange residential courses that will attract academic staff and other experts from all over the world it is necessary for the environment and facilities associated with the center to be attractive. Proposals for this were given by Osborne (1967) and were summarised in the **IUGG Chronicle,** No. 67 (February 1967, pp. 12-13). There has been considerable support for this suggestion and it will receive official encouragement from IAGA as well as from other relevant associations.

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WORKING GROUP IV-6, GEOMAGNETIC STORMS AND INTERPRETATIONS

S.-I. Akasofu — Reporter

This report consists mainly of a brief review of the works on geomagnetic storms and interpretations and a list of recent papers (1964 to date) on the following topics:

1. Fine structures of the solar wind
2. Magnetosphere formation
3. Magnetospheric tail
4. Storm sudden commencements
5. Main phase
6. Polar magnetic substorm
7. General

Both satellite and space probe observations of the solar wind during quiet sun years have increased considerably our knowledge of the so-called "M-region stream," although its origin on the sun and effects on the magnetosphere are yet to be investigated further. During the forthcoming active sun years, it is hoped that more will be learned about the solar plasma flow generated by solar flares. In particular, more knowledge is needed about magnetic fields, the degree of ionization, and temperature in the plasmas. Such parameters are expected to give some clue to an understanding of the origin of the plasma flow.

The Chapman-Ferraro problem has been studied extensively for the normal incidence of the solar wind on a magnetic dipole. However, it has become obvious that the interaction between the solar wind particles and the magnetic field is not a 'specular reflection' of the particles by the field. Thus, a simple extension of the Chapman-Ferraro theory cannot predict the formation of the magnetospheric tail. It has been proposed that some kind of 'viscous interaction' is important, although the basic processes involved are not understood.

The importance of the magnetospheric tail in interpreting geomagnetic storms has been stressed greatly by a number of workers. It is proposed that the tail behaves as a storage place of the solar wind energy, from which the energy for the main phase of geomagnetic storms is generated. However, the basic processes of the conversion of the magnetic energy in the tail to the storm energy is uncertain.

It has now been well confirmed that storm sudden commencements (ssc) are generated by an impact of an interplanetary shock wave on the magnetosphere, but the propagation of the effects of the initial impact toward the earth is a very complicated problem; namely, the propagation of hydromagnetic waves in the magnetosphere.

Since satellite observations have confirmed the growth of the storm-time belt, the so-called 'ring current,' its formation mechanism has become one of the most challenging problems in magnetospheric physics. One of the important clues to this process are the intense auroral and polar magnetic substorms that occur very frequently during the growth of the storm-time belt. In fact, it has been suggested that these two processes are a part of the same energetic process that takes place in the magnetosphere.

Both auroral substorms and polar magnetic substorms are, therefore, only different manifestations (in the polar upper atmosphere) of a magnetospheric process that is also responsible for the growth of the storm-time belt. This is quite important in understanding the cause of the auroral and polar magnetic substorms, in particular the origin of the electric field that drives the polar electrojet.

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WORKING GROUP IV-7, FORECASTING
J. Virginia Lincoln — Reporter

In the years since 1959 there have been several advances towards more successful forecasting of geomagnetic storms, especially those with sudden commencements. The origin of the 27-day recurrent storms continues to be debated.

A commonly applied sun-earth relationship has been that a sudden commencement geomagnetic storm is expected to begin within 1 to 2 days, or even sometimes 3 days, of the occurrence of an important 3 or 4 (very great) flare, regardless of its position on the sun. The probability of disturbance, however, is greater if the flare occurs in the sun's central zone. This has been demonstrated by Bell (1963) who reported that nearly half of the major flares, which were followed by disturbance, were located within 30° of the central meridian (CM ± 30°); furthermore, over the past three sunspot cycles, 80 percent of the very great storms arose from flares within 20° of CM, and all but one of the remaining very great storms were associated with flares in the 20° to 39° zone. It is also of interest to note that all but one of these flares associated with disturbances occurred in the northern hemisphere of the sun. During the past several sunspot cycles the characteristics of solar activity have manifested themselves mainly in the northern hemisphere, and it has been the northern hemisphere of the sun that has been the main source of great magnetic storms. Again according to Bell, the percentage of storms coming from the northern hemisphere increased with the intensity of the storm. Using as an index Σ^4 ap (the sum of the greatest four consecutive 3-hour ap indices during the storm) 50 percent of the moderate storms, $160 \leqslant \Sigma^4 ap \leqslant 299$, and 94 percent of the very great storms, Σ^4 ap $\geqslant$ 1000, were associated with the northern hemisphere.

Knowledge of the solar radio noise at the time of the solar flare assists in the prediction of geomagnetic disturbance. Dodson and Hedeman (1958) were the first to note that when a major solar radio noise outburst at frequencies $\leqslant$ 200 Mc/s occurs with its first part in the premaximum phase of a solar flare followed by a second part that is often more intense and of longer duration, geomagnetic disturbance may be expected to begin within 1 to 4 days. Special study has been made of type IV continuum radio burts which are usually followed by geomagnetic storms. The SHF radiation (observed in the 10 cm and 3 cm ranges), which is the initial phase of type IV bursts and is less directive than the VHF radiation characteristics of the following phase, has been used successfully by Pick (1961) and Caroubalos (1964) to forecast geomagnetic disturbance. In her study, Bell (1963) reported that, of 30 major flares accompanied by full range ($\geqslant$ 2800 Mc/s to $\leqslant$ 100 Mc/s) type IV outbursts, 87 percent were followed by geomagnetic storms within an interval of 10 hours to 3 days. The probability of storms following falls off for type IV events of more limited frequency range. Bell also reported that the likelihood of a major flare with a spectral type IV burst to produce a geomagnetic storm is independent of the magnetic classification of the sunspot. On the other hand, a $\beta\gamma$ or γ sunspot is about 5 times more likely to produce a major flare with associated type IV events than is an α or β sunspot of comparable area.

All of the above solar-geomagnetic storm relationships are enhanced if a solar proton event is observed within about 6 hours following the H-α flare. These are the events first recognized as polar cap absorption events (PCA) by Bailey (1957) and Reid and Collins (1959) on VHF scatter circuits, and by Reid and Leinbach (1959) on records from riometers at high latitudes (measurements of cosmic noise absorption through the ionosphere). Lange-Hesse and Rinnert (1965) are utilizing phase variations measurements on VLF signals propagated through the Arctic polar cap to identfy PCA; similar VLF techniques have been used for several years by the Geophysical Institute of College, Alaska, and by the Space Disturbances Laboratory of the Environmental Science Services Administration. Obayashi and Hakura (1960) and numerous other authors have pointed out that a very close relationship exists between PCA events and spectral type IV outbursts. PCA events rarely occur that are not preceded by type IV outbursts; and prolonged severe PCA events appear to be always preceded by them. Thompson and Maxwell (1960) stated that the probability of occurrence of PCA events is strongly enhanced if the type IV outburst has a particularly well developed continuum of great duration at metric and decametric wavelengths. Bailey (1964) in a study of the period July 1957 to September 1963 found that geomagnetic storms followed the onset of PCA events within three days 92 percent of the time. The PCA event thus appears to be the most reliable precursor of geomagnetic disturbance so far recognized.

Therefore, it is of great interest to identify the centers that produce outbursts of type IV, in order to predict that PCA events and therefore geomagnetic storms will occur. Pick (1961) and Boischot (1963) found that the solar flux density at 3 cm is clearly more enhanced than in general for these type IV centers. Tanaka and Kakinuma (1964) discovered that the spectral ratio of emission at 3 cm to emission at 10 cm is greater than the mean for these centers and is the order of one. Study of the sunspot regions by Ellison, McKenna, and Reid (1961), by Krivsky (1963), and by Martres and Pick (1962) shows that a fairly rare configuration is strongly related to that region's productivity of high energy protons. This configuration was named " δ configuration" by Zungel (1960) and is defined as the occurrence of spots of opposite polarity with 2° of one another and in the same penumbra.

Caroubalos (1964) has shown that centers associated with many type IV outbursts are capable of producing several successive geomagnetic disturbances. This fact can therefore be used for forecasting once a type IV outburst and associated geomagnetic storm has occurred. These centers are also usually grouped in "privileged areas of the sun." The flares associated with PCA usually occur on the western hemisphere of the sun. These "repetition centers" also seem to prefer certain Carrington longitudes on the sun. In the study by Caroubalos (1964) these longitudes were from 320° through 160° for "repetition centers" associated with sc's; no "repetition centers" occurred at 160° through 320°. Trotter and Billings (1962) upon summing their activity index for regions found that there was a persistent peak at about 90° longitude and that the rotation rate of the preferred location was close to that of the Carrington rate. Guss (1965) noticed that a different rotation period ordered the very energetic particle events, with a large fraction of the total flux of energetic particles coming from a region on the sun of very limited longitudinal extent. Wilcox and Schatten (1967) questioned the reality of the clustering in Carrington longitude since they found several other periods that ordered the PCA flares neatly. Haurwitz (1967) extended the sample of PCA flares by adding the famous great flares. She concluded that the PCA flare data are ordered in a significant and unique way by a rotation rate very slightly faster than the Carrington rate. This implies persistence of the active longitudes from one solar cycle to another. Haurwitz also found that solar radio bursts at meter wavelengths showed significant clustering, but no consistent clustering was found for sunspots over many sunspot cycles.

Since sunspot magnetic classifications assist in the prediction that an active center will produce proton flares, if such information is not available to a forecasting center, other solar observations have proved useful to predict that sunspots are of the δ configuration type. Ramsey and Smith at Lockheed-California Observatory, and Pick and Martres at Meudon Observatory, have found that there is a pronounced increase in the sporadic changes in chromospheric fine structure one or more days before major flare activity in such regions. Two sunspots or multiple umbrae in a single penumbra will be observed adjacent to or obscured by the plage region. There is often interaction of the new solar region with an adjacent old one. Rapidly changing shortlived absorption features also appear prior to or with the flares.

Though Snyder, Neugebauer, and Rao (1963) found a very close relationship between the velocity of the solar wind and geomagnetic Kp indices, it was not such as to provide a precursor to geomagnetic storms. Wilcox, Schatten, and Ness (1967) found an even stronger relationship during the winter 1963-1964 between the interplanetary magnetic field and Kp from IMP 1 satellite measurements. Although such satellite measurements as these cannot as yet be used to predict geomagnetic storms, real-time reporting from satellites can be very useful to confirm PCA events by reporting direct observation of solar protons over the polar regions. In addition, the identification of precipitation of electrons over auroral latitudes confirms the presence of auroral absorption normally associated with geomagnetic storms. Thus, the use of satellite information could prove of value to forecast centers.

We will now return to a discussion of 27-day recurrent storms. These are the gradual commencement storms to which Bartels gave the name M-regions since positive visible solar activity identification had not been made, although the 27-day period of the solar rotation cycle suggested a long-lived solar stream originating from a hypothetical source on the sun.

Pecker and Roberts (1955) using 1952-1953 data suggested the "cone of avoidance" theory. They showed a maximum in the number of quiet days about 3 days after the central meridian passage of active solar centers. This "cone of avoidance" is formed by deflection of the corpuscles over an active region by the action of the magnetic field of the region. Saemundsson (1962) reconfirmed this theory with data from 1919-1954. He found the prolonged M-region emission to occur 30°-90° from the active regions, particularly on the following side of the cone of avoidance. Mustel (1961) on the other hand advocates that M-regions appear to be correlated with active centers on the sun. These are young calcium plage regions above which long coronal rays extend up to the distance of the earth's orbit.

In spite of the great difference in hypotheses, all postulate enhanced beams of solar particles as the cause of recurrent geomagnetic storms. These streams have been detected in recent years by various satellites. Fairfield and Ness (1967) found with the IMP 2 satellite that during October 1964 to April 1965 (solar minimum conditions) the structuring of the interplanetary magnetic field divided into four recurring sectors of approximately equal size. Average fields within each sector were directed either toward or away from the sun near the theoretical spiral angle. High magnitudes and increased geomagnetic activity tended to occur early in the sectors and lower fields and quiet conditions at the end. Thus, if the transitions between sectors could be reported promptly it might assist in the identification of 27-day recurrence sequences.

Shapley (1947) demonstrated the 27-day recurrence tendency by auto-correlation coefficients of Ci indices from 1890 through 1944. Prediction formulas for the daily Ci indices based on the method of least squares for the mean autocorrelation coefficients are:

$$x'_0 = 0.23\,\bar{x} + 0.44x_1 + 0.11x_{26} + 0.12x_{27} + 0.02x_{28} + 0.08x_{54} \quad \text{(strong years)}$$

$$x'_0 = 0.33\,\bar{x} + 0.47x_1 + 0.06x_{26} + 0.07x_{27} + 0.03x_{28} + 0.04x_{54} \quad \text{(weak years)}$$

where the subscripts represent days: 0 for day of prediction, 1 for day before, 26 for 26 days before, etc., and the strong years are those of the descending cycle and minimum and the weaker years those of the ascending cycle and maximum.

Obayashi (1966) states that Mori by using data of meson monitors found residual flow vectors of the amplitude and phase of the diurnal variation of cosmic ray intensity that may indicate additional flows, superposed upon the general modulation effect, due to the outward streaming of the solar wind. Tanaka and Kakinuma (1966) suggest, based upon a study of August 1962 to December 1963, that geomagnetic disturbance preceded the CMP of a solar radio active center at 4000 Mc/s by 1.5 days. Thus identification of radio sources at 4000 Mc/s perhaps could assist in the selection of recurrent storms.

In addition to the study of 27-day recurrence storms attempts have been made to find if geomagnetic storms tend to recur from year to year on the same days. Glushkova (1962) claims such success for forecasts made in 1959 for geomagnetic storms at Voyeykovo, USSR, using data from 1947-1958. Pohrte, Warwick and MacDonald (1960), however, using Ci indices from 1890-1957 were unable to find any singular days for geomagnetic disturbances.

From all the foregoing it can be seen that there have been advances in the prediction of geomagnetic storms in recent years, but even so many unsolved problems remain for future study.

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WORKING GROUP IV-8, MORPHOLOGY OF RAPID VARIATIONS

A. Romaña — Reporter

C'est le continuateur en quelque sorte de l'ancien Comité 10, lequel à l'assemblée de Berkeley a été divisé en deux groupes de travail: celui-ci pour l'étude générale de la morphologie des variations rapides et le groupe pour l'étude plus approfondie des micropulsations.

Il fait partie du Service Permanent des Indices Géomagnétique dépendant du FAGS. Son but est d'obtenir à échelle universelle une image de la distribution dans le temps et dans l'espace des variations rapides et de leurs caractéristiques.

Fonctionnement

En fait l'activité du Groupe de Travail s'est identifiée presque totalement avec son activité comme Service Permanent. Comme plusieurs ne connaissent pas le fonctionnement du service, l'on indique succinctement les pas successifs du travail a accomplir. Les observatoires collabororateurs remplissent chaque mois les formulaires avec le rapport des variations rapides relevées sur leurs enregistrements d'apres les définitions et les normes établies par les symposia de Copenhague (1957) et d'Utrecht (1959) et les assemblées de Toronto (1957), Helsinki (1960) et Berkeley (1963). Ces formulaires sont de deux types: l'un pour les enregistrements à marche normale et l'autre pour les enregistrements à marche rapide.

Avec les formulaires le Centre de Tortosa prépare les listes trimestrielles des phénomènes, publiées et distribuées par le Centre de De Bilt. Une fois publiées les listes du 4ème trimestre de chaque année, l'on distribue aux observatoires les "checking-lists" avec prière de ravoir le cas qu'on leur demande (ssc, si pg, sfc). Avec les reponses on publie les Bulletins definitifs de la serie 12, 2.

Observations sur les Données Publiées

Heure des ssc et des si

L'assemblée de Berkeley pria les observatoires équipés avec enregistreurs rapides de donner l'heure des ssc et des si au dixième de minute près (et, si possible, à la seconde près). Le but était de vérifier si le phénomène se produit simultanément dans tout le globe ou s'il y a un décalage et en quel sens.

On a examiné sur une quarantaine de cas des années 1958-65 la nature des heures publiées dans les bulletins (trimestriels et définitifs). Elles représentent vraiment l'heure la plus probable du phénomène, mais leur précision ne peut dépasser la minute. Des causes comme le développement trop petit de quelques enregistrements, manque de netteté des courbes, degré d'approximation de l'état de l'horloge, influence des cas avec astérisque, etc. ne permettent pas une précision plus grande. La dispersion qui en résulte dépasse parfois les 10 minutes. Examen plus soigné des enregistrements à marche rápide des observatoires ayant suivi la recommendation de Berkeley. Résultat pour le moment négatif. Nombre trop petit de ces observatoires et insuffisance de leur distribution géographique. Leurs données sont affectées pour la plupart d'imprésisions de l'ordre de quelques dixièmes de minute. La comparaison de toutes les données des années 58-65 ne semble pas conduire à un résultat quelconque.

Causes qui pourraient rendre insoluble le problème avec les méthodes actuelles d'enregistrement: a) manque de séourite dû à déficiences inévitables dans le réglage des horloges et aux jeux de rélais nécessairement intercalés entre l'horloge et l'enregistrement; — b) difficulté d'être presque toujours les ssc et les si sur les enregistreurs à marche rapides des "emersiones" et non pas des "impetus" et impossibilité d'obtenir pour le moment une grande sensibilité des enregistrements à cause de la nature même des appareils; — c) subjectivisme inévitable dans l'interprétation des courbes. Dans le cas des si la précision est encore plus difficile à obtenir à cause du mélange des deux classes de phénomènes compris sous ce nom: sauts brusques rappelant les ssc, mais sans orage propre, et mouvements brusques difficiles à classer et baptisés si, faute de meilleure dénomination.

Heures des baies et des pulsations connexes

Leurs listes ont remplacé les anciennes listes des psc. Signification de l'heure qu'on leur attribue, moyenne des heures de commencement du phénomène données par les observatoires. Elle ne peut pas représenter l'heure la plus probable du commencement du phénomène, celui-ci n'étant pas de nature instantanée comme les ssc et les si. Elle n'est qu'une sorte d'heure centrale pondérée, autour de laquelle se groupent les manifestations successives du phénomène. Convenance d'ajouter à cette valeur moyenne les valeurs extrêmes assignées par les divers observatoires au commencement du phénomène.

Heures des pulsations se présentant
sans être accompagnées d'une baie

Si l'on se souvient de la définition primitive des pt (actuellement pi) l'on voit la difficulté de considérer comme heure la plus probable du commencement des pulsations la moyenne des heures données pour leur apparition par les divers observatoires: danger de mêler dans le calcul des heures correspondant à des trains de pulsations différents.

Convénance de donner aussi les heures extrêmes assignées par les observatoires au commencement du phénomène.

Necessité pour leur étude des enregistrements à marche rapide; mais impossibilité pour le moment de laisser de côté les données des enregistrements normaux si l'on veut avoir une image du phénomène à échelle mondiale; mais necessité pour cela de fixer une amplitude minimum dans chaque observatoire des pulsations à rapporter pour avoir des données homogènes.

Remarques sur l'étude des pulsations avec
des enregistrements à marche rapide

Les données sont publiées seulement dans les bulletins trimestriels par des raisons d'ordre économique. Par le même motif on se réduit aussi à la publication des heures du commencement et de la fin des phénomènes, sans ajouter des données sur les periodes et l'amplitude, etc.

pi: On publie tous les cas A et B par ordre chronologique du commencement: si plusieurs commencentà la même heure on les dispose par ordre chronologique de leur terminaison. L'on ne groupe ensemble que ceux dont le commencement diffère tout au plus de 10 minutes et la terminaison de 15. Les case C ne sont publiés que si l'une de leurs parties tout au moins a été qualifiée A ou B. Seulement la qualité A est indiquée expressément. Les morceaux particuliers signalés comme spécialement intéressants dans une longue suite de pulsations sont donnés entre parenthèses a la suite du nom de l'observatoire qui les a signalé.

pc: On les dispose par jours et dans chaque jour par ordre de latitude des observatoires du Nord au Sud. Mêmes remarques que pour les pi sur la qualité des pulsations publiées et les morceaux dignes de mention dans une longue suite de pulsations.

L'on suggèrela publication dans l'avenir de ces données de sorte que l'on puisse les relier ensemble à la fin de l'année comme bulletin définitif (n. 12, 3?), en y ajoutant un fascicule avec les données, toujours nombreuses, arrivées trop tard et peut-être aussi les réponses des observatoires à un certain nombre de cas que l'on pourrait penser à insérer dans les checking-lists.

Pulsations géantes

On a commencé à les mettre sur les checking-lists et à les publier dans les bulletins 12, 2 depuis l'assemblée de Berkeley dans le but d'étudier leur distribution géographique. La plupart de celles que l'on rapporte ne sont pas probablement des veritables pg, dû au manque de précision de leur définition. Si l'on continue à les publier, il faudrait y ajouter toujours leur durée, amplitude et période pour pouvoir décerner s'il s'agit de véritables pg ou tout simplement des pi ou pc à plus forte amplitude.

Solar flare effects

Difficulté de leur étude, faute de forme caractéristique propre. Multiplication des cas rapportés par les observatoires et nécessité de réduire le nombre des insérés dans les checking-lists; suppression à priori de tous ceux qui coincident avec d'autres phénomènes clairement établis ou qui ne sont rapportés que comme douteux ou seulement par des observatoires se trouvant en mauvaise position pour pouvoir les enregistrer. La nature des réponses laisse toujours des doutes sur la solution adoptée. Pour enlever toute incertitude il faudrait pouvoir calculer pour chaque cas le système de courants ionosphériques qui l'ont produit; mais cela exigerait la demande de trop de données aux observatoires. Faute de cela, il n'y qu'à se tenir à la consideration de la distribution géographique des réponses recues et c'est surtout dans ce cas que l'on regrette ne pas recevoir les réponses des observatoires placés dans des régions pauvres en observatoires car leurs réponses peuvent avoir alors une importance très grande. Tendance de quelques observatoires à donner trop de réponses affirmatives, même pour des phénomènes arrivés pendant leur nuit.

Possibilité d'enlever un peu cette imprécision moyennant l'emploi de deux qualifications dans les réponses au checking-lists, l'une pour qualifier le phénomène en soi, l'autre pour juger la qualification de phénomène supposé dans le checking-list.

L'Atlas des Variations Rapides

L'on s'est heurté à beaucoup des difficultés comme suite de la diversité des matériaux recus, ce qui rend le travail beaucoup plus difficile et coûteux qu'on avait cru. Malgré cette difficulté l'on espre pouvoir le publier avant la prochaine assemblée; mais donné le temps écoulé, il faudra bien y ajouter quelques exemples des différentes catégories des pulsations pi et pc, que l'on avait pas prévu an moment de l'Année Géophysique.

Suggestions

Pour améliorer dans l'avenir la composition et l'efficacité du travail du groupe et tout particulièrement pour assurer qu'il n'agisse seulement comme service des variations rapides, mais aussi comme groupe de travail proprement dit.

WORKING GROUP IV-9, MISCROSTRUCTURE OF MAGNETIC DISTURBANCES
V. Troitskaya — Reporter

The new results obtained in the field of micropulsations have shown that many of the usual disturbances of the magnetic field have a definite microstructure.

Investigations of the microstructure of magnetic disturbances, and first of all the magnetic storms, that were begun after the IGY consisted mainly of the analysis of the microstructure of: (1) sudden commencements and sudden impulses; (2) bays and pulsation trains (Pt); (3) first phase of the magnetic storms; (4) main phase of the magnetic storms; and, (5) periods preceding and following the magnetic storms.

Moreover, the application of special frequency time analysis gave the possibility of investigating the microstructure of different kinds of pulsations. It was revealed that frequently pulsations of pc 1 type precede the beginning of the magnetic storms and long-lasting series of these pulsations are usually observed on the 3rd to 7th day following the storm. The ssc has a typical microstructure which depends on the time of occurrence and location of the point of registration. The first phase of the storm in its pure form can be characterized by continuous pulsations of short period. For the main phase, most typical are the intervals of pulsations with diminishing periods. (ipdp). The microstructure of bays and pulsation trains usually consists of a combination of irregular pulsations of pi 1 type and pc 1 pulsations, which in the case of a very intensive bay are transformed into the ipdp.

Investigations of the microstructure of the pulsations themselves, especially in the case of pc 1 and ipdp, presented the possibility of locating the region of their generation and of estimating the energies of particles responsible for their generation. The investigations of the frequency time dependence for the pulsations with longer periods (pc 2-5 and pi 2) was begun only recently by Japanese scientists. They have shown a definite patch-like structure of a series of pc pulsations. There are some indications that the spectra of pi 2 pulsations usually contain two maxima.

The combination of information that can be drawn from the standard records and records of pulsations opens a new possibilities in the investigations of processes occurring in the magnetosphere of the earth. For instance, the value of Δ H which is observed for a sudden impulse and the changing of the period of pc pulsations observed at the same moment can be used to estimate the location of the boundary of the magnetosphere. The combination of the data on the development of Dst, bays, and ipdp give information on the processes developing in the radiation belts.

The physics of the recovery phase of the magnetic storms must take into account the typical occurrence of pulsations of pc 1 type. New data on the correlation between the processes occurring in the magnetosphere and the elements of microstructure of magnetic storms were discovered (ipdp and the changing of the radiation belt intensity and location, the processes in the magnetospheric tail and the pi 2, location of the plasmapause and the properties of pc 1, etc.).

All of these kinds of investigations were conducted rather independently by different scientists in different countries. An attempt to coordinate these investigations by mutual analysis of some definite storm (the storms of February 12 and 20, 1964, were suggested) failed, due to the choice of other intervals for detailed analysis (proton flare projects, special intervals) and due to insufficient activity of this group as a whole.

It seems useful to unite several of the established working groups of Commission IV concerning micropulsations in one group with a definite program of investigations for the next 4 years.

WORKING GROUP IV-10, MICROPULSATIONS, pc 1, pc 2, pi 1, AND pi 2
Y. K. Kato — Reporter (Takao Saito, Collaborator)

Introduction

Since the International Geophysical Year, many types of geomagnetic pulsations have been reported under such various nomenclatures as type A, pc^{v}, LPC, II pc, Pg I, etc. (cf. 43). In order to unify these terms, new classifications were proposed by several researchers (14 and 19). At the Berkeley assembly in 1963, IAGA-IUGG summarized these various notations and established an international classification (35 and 36) as follows:

	Type of Pulsation	Period
Regular oscillation		
	pc 1	0.2 to 5 sec
	pc 2	5 to 10 sec
	pc 3	10 to 45 sec
	pc 4	45 to 150 sec
	pc 5	150 to 600 sec
Irregular oscillation		
	pi 1	1 to 40 sec
	pi 2	40 to 150 sec

At the same time, IAGA organized a working group on short-period pulsations, pc 1, pc 2, and pi 1, on which studies have been rapidly expanded recently. The present report is to summarize the researches on these pulsations, which have been published after the Berkeley assembly, according to the project of the working group. Papers on pi 2 pulsations are also included here, because the spectral boundary between pi 1 and pi 2 is very vague (148 and 150) and because pi 1 and pi 2 were discussed together in most of the pi papers.

The instruments for observing these pulsations are explained in (2, 10, 17, 18, 22, 23, 24, 38, 39, 45, 52, 60, 61, 64, 69, 74, 75, 99, 110, 111, 115, and 118). Power spectra and dynamic spectra covering the whole range of pulsations were studied in (21, 30, 97, 138, and 146). As for whole or limited period range of pulsations, the reader is referred to the review papers (33, 34, 50, 90, 98, 122, and 150).

Research on pc 1 and pc 2

Recent studies on the short-period continuous pulsations can be classified into three classes according to the period range of pulsations:

(1)	pc 1 (including the pearl pulsation)	0.2 to 3 sec
(2)	4-sec band	3 to 5 sec
(3)	pc 2	5 to 10 sec

About half of the papers published during the recent four years are on pc 1.

Frequency analysis of pc 1 has lately been done by many researchers using the sonograph type of spectral analyzers (2, 10, 18, 26, 67, 74, 103, 110, and 137). Patterns of pc 1 signals in the dynamic spectrum could be classified as follows:

- Structured
  - Rising tone
  - Falling tone
  - Complex
- Non-structured

Most structured pc 1's have the rising tone in the frequency versus time display.

Simultaneous observations were carried out at several pairs of magnetically conjugate stations near the auroral zones: Great Whale River, Canada, and Byrd, Antactica; Borok, USSR, and Kerguelen Islands, Indian Ocean; Baie St. Paul, Canada, and Eights, Antarctica; and so on (28, 34, 56, 64, 69, 76, 90, 91, 95, and 131). The structural elements in dynamic spectra showed a displacement in time by one-half the fine structure periodically (or 180° phase shift) at stations in opposite hemispheres.

Spatial properties of pc 1 signals were studied based on the simultaneous observations extended to both low latitudes and polar regions (45, 90, 91, 108, 109, 125, and 139). "A structure doubling" (superposition of structural elements which would exhibit a 180° phase shift when observed in high latitudes at stations in opposite hemispheres) was occasionally observed at middle and low latitude stations (45).

Diurnal variations of pc 1 amplitudes were obtained at many stations distributed from high latitudes to low latitudes (10, 28, 38, 47, 56, 58, 59, 79, and 141). In high latitudes, the pc 1 amplitudes showed a maximum in daytime, in contrast with a nocturnal maximum in low latitudes. Attempts to explain such different diurnal variations, between high and low latitudes, were tried by using an attenuation (51) of hydromagnetic waves in the ionosphere (48, 101, 110, 131, and 141).

The midperiods of pc 1 were, as a rule, shortest in dawn hours (56, 131, and 141). The cause of this diurnal variation in the pc 1 period was interpreted by an eccentric distribution of the region in the magnetosphere, where hydromagnetic waves responsible to the pc 1 were generated (131 and 141).

Amplitude-time display (wave form) of pc 1 exhibited, in simple cases, a regular repetition of fine structure showing a pearl-necklace type envelope. The repetition period was in proportional relations with the midperiod of the pc 1 (10, 38, 56, and 81).

Polarization of the pc 1 wave form was studied in (21, 44, 53, and 64). It was suggested that the superposition of a succession of signals having rising tones could produce apparent reversals in the sense of rotation (42).

Storm sudden commencements (ssc's) observed in middle latitudes were often associated with pc 1 (90 and 147). The midperiods of pc 1 were decreased at the time of ssc's (66). An evident tendency that pc 1 activity on the average was enhanced 3 to 10 days following the large magnetic disturbances was reported (47 and 56). Pearl pulsations were apt to occur on the day when interplanetary magnetic field sector boundary passed the earth. (144). Hydromagnetic waves responsible for pc 1 were reported to be much attenuated in the ionosphere with increasing magnetic activity (131). It was suggested that the average nighttime location of the source of pc 1 excitation in the magnetosphere moves from $L \approx 5$ to $L \approx 3.7$ with increasing magnetic activity (61). Solar cycle variations of amplitude, duration, and frequency of occurrence of pc 1 were studied (78 and 150).

Occurrence models of pc 1 were mentioned more or less in a large number of papers (6, 7, 8, 10, 17, 18, 22, 23, 24, 25, 26, 28, 34, 38, 42, 44, 45, 47, 48, 49, 51, 53, 56, 57, 58, 61, 62, 63, 64, 66, 67, 68, 69, 70, 74, 76, 78, 79, 80, 81, 86, 87, 89, 90, 91, 94, 95, 100, 101, 102, 103, 109, 110, 111, 113, 115, 116, 117, 118, 122, 124, 125, 126, 127, 131, 139, 140, 141, 143, 144, 150, and 151). The alternate pc 1 signals between a pair of conjugate stations were interpreted by whistler mode propagation of hydromagnetic wave packets along the earth's magnetic field-line (37 and 80.) As for the generation mechanisms of the wave packets, the instabilities in the ion cyclotron mode of hydromagnetic waves by a proton stream have been much considered (57, 68, 80, 100, 113, and 126). Propagation of hydromagnetic waves in an ionospheric duct was suggested as an explanation of the low latitude pc 1 (117).

Several researchers found a type of continuous pulsation with a specific period band in the pc 1 range besides the pearl pulsations (38, 67, 92, 107, 110, and 150). This type of pulsation has the following main characteristics:

1. Its period is roughly 3.5 sec (38), 3.3 sec (67 and 110), 1 — 10 sec (92), 3 — 4 sec (107) or 2 — 5 sec (150).
2. Its dynamic spectral pattern is not well structured (92, 107, and 110).
3. Its period is longer in the daytime than at night (38, 90, 107, and 110).
4. It is apt to occur during the nighttime on magnetically active days (92, 107, and 110).

5. The seasonal variation in its intensity shows a pronounced maximum in summer (107).

6. Its amplitude increases with latitude (92).

The occurrence mechanism of the 4-sec band pulsation was explained by:

1. Field-Greifinger's (59) model (107).
2. Jacobs-Watanabe's (15) model (110).
3. Ion-acoustic oscillations in the night ionosphere (133).

In most papers, the continuous pulsations in the pc 2 period range (5 — 10 sec) were regarded to be involved in the pc 3 category (43, 82, 93, 104, 137, and 147). The occurrence of the pulsations in this period range was less frequent in recent years than in the sunspot maximum years (147 and 150).

Research on pi 1 and pi 2

Recent studies of pulsations in the pi category might be classified into the following two main kinds: (1) pi associated with magnetic bay (primarily pt), and (2) pi associated with nuclear detonations.

We have one more kind of short-lived pulsations: the damped type pulsations associated with ssc and si. However, this type of pulsation falls essentially in the pc category because of the probable occurrence mechanism of the pulsations (147).

Spectral patterns of pi associated with bays were discussed based on both electronic (2, 67, 90, and 110) and digital (148) sonographs. A time variation of the magnetic field in the magnetosphere tail suggested a relation with the pi observed on the ground (73). Conjugacy of the wave form was studied on the basis of Great Whale-Byrd observations (69). Relations between this type of pi and other geophysical phenomena, namely, infrasonic pressure waves (3), particle precipitation (119, 130, 145, and 152), aurora (84 and 85), and Es (85) were discussed. Solar cycle variations were studied (148 and 150). Some of the ipdp events (150) seemed to be associated with this kind of pi (142).

Irregular pulsations were observed worldwide at the time of the high-altitude nuclear detonation of July 9, 1962 (1, 4, 9, 12, 16, 27, 29, 70, 71, 120, and 134). This kind of pi was different from all the other kinds of pulsations because of its man-made excitation mechanism, though its wave form was very similar to the wave form of some of the pi's associated with bays (12).

Concluding Remarks

Although studies of pc 1 have been much advanced in these four years, characteristics of pc 2 should be investigated more thoroughly, especially in connection with pc 3. The features of pi pulsations should also be studied more based on dynamic spectral analysis covering both pi 1 and pi 2 ranges.

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WORKING GROUP IV-11, CONJUGATE POINTS
R. Schlich — Reporter

Le groupe de travail "Points Conjugués" de la Commission IV de l'Association Internationale de Géomagnétisme et d'Aéronomie a été constitué après la XIIIe Assemblée Générale de l'U.G.G.I., en 1963. Il compte actuellement onze membres: W. Campbell, T. Nagata, R. W. E. Mc Nicol, J. C. Roederer, R. Schlich (rapporteur pour ce groupe), V. A. Troitskaya, A. M. van Wijk, R. C. Wentworth, E. Wescott, C. S. Wright et V. E. Zelenkov.

Aucune réunion officielle de ce groupe n'a eu lieu entre 1963 et 1967; cependant, de nombreux contacts ont été pris a l'occasion de manifestations internationales telles que les réunions des A.I.S.C. à Madrid, le COSPAR à Vienne, le symposium de Belgrade, etc . . . La plupart des programmes de recherches mis en oeuvre ont été elaborés par des contacts directs entre chercheurs intéressés par des expériences "points conjugués."

Quelques réunions à caractère national ou international ayant pour objet l'étude des phénomènes géophysiques observés entre points conjugués ont été organisées entre 1963 et 1967.

La première s'est tenue à Vancouver (University of British Columbia) les 25 et 26 mars 1965 sous la présidence du Professor J. A. Jacobs; elle avait pour objectif essentiel l'organisation du programme de recherches "points conjugués" enterpris conjointement par des chercheurs américains et canadiens. Elle a réuni une trentaine de délégués.

La deuxième réunion, beaucoup plus importante, a été le symposium de Boulder organisé par le "High Altitude Observatory of NCAR" et le "Institute for Telecommunication Sciences and Aeronomy of ESSA"; les animateurs de cette manifestation étaient W. Campbell et S. Matsushita (13-16 Juin 1967). Plus de 200 délégués, pour la plupart américains ou canadiens (95 pour-cent), ont participé à ce symposium. De nombreuses communications scientifiques, environ 70, couvrant les différents domaines de la géophysique et faisant appel pour une part importante à des observations entre points, ont été présentées. Ces communications seront publiées fin de cette année ou début 1968 dans un numéro spécial de la revue "Radio Science."

Enfin, dans le cadre de la prochaine Assemblée Générale de l'U.G.G.I., l'Association de Géomagnétisme et d'Aéronomie a proposé l'organization d'un Symposium sur les Expériences entre Points Conjugués qui se tiendra à Saint-Gall en Suisse du 27 au 30 Septembre 1967. Les animateurs étant Mme V. A. Troitskaya et R. Schlich. Plus de 40 communications dont un certain nombre d'articles de synthèse, traitant exclusivement de phénomènes conjugués, seront présentées a cette occasion. On traitera successivement les phénomenès conjugués associés à des particules énergétiques et les phénomènes non associés à des particules énergétiques. Une discussion générale sur les possibilités offertes par les études géophysiques entre points conjugués cloturera ce symposium.

Dans le but de préciser les différentes expériences "Points Conjugués" actuellement en cours, une lettre circulaire a été adressée aux différents membres du groupe de travail. Les réponses recues sont peu nombreuses malgré plusieurs lettres de rappel; des informations ont été recues du groupe américain/canadien (W. Campbell), du groupe francosovietique (R. Gendrin/V. A. Troitskaya) et du groupe francais/République Sud-Africaine (R. Schlich/A. M. van Wijk).

Activité du Groupe Américain/Canadien

Les expériences entreprises jusqu'à présent se poursuivent essentiellement entre la station canadienne de Great Whale River et la station américaine de Byrd dans l'Antarctique. Le programme des recherches comporte des observations optiques, ionosphériques, magnétiques, radio, etc. . . . Des études plus larges, centrées sur la conjugaison magnétique et faisant appel à des données recueillies par satellites sont également développées.

Activité du Groupe Franco-Sovietique

En 1964, un équipement permettant l'enregistrement des bruits radio-électriques T. B. R. (0.8-10 kHz) et des oscillations hydromagnétiques U. B. F. (0.1 a 3 Hz) d'origine magnétosphérique, était installé aux stations conjuguées de Port-aux-Francais à Kerguelen (coordonnées géographiques: 49° 21'S — 70° 12' E) et de Sogra, U.R.S.S. (coordonnées géographiques: 62° 47' N et 46° 16' E). Trois années d'expériences ont permis à ce groupe d'obtenir un certain nombre de résultats concernant les pulsations régulières du type pc 1, les pulsations irrégulières du type pi 1 et enfin les émissions T.B.F.

Activité du Groupe France-Republique Sud-Africaine

En 1964, la France a ouvert une nouvelle station magnétique (Hurouqué) située près de Villeneuve-de Marsan dans les Landes (coordonnées géographiques: 43° 55' N — 00° 21' W) cette station est approximativement conjugée (à 100 km près) de l'observatoire magnétique d'Hermanus (coordonnées géographiques: 34° 26' S - 19° 14' E). Les études entreprises concernent les variations magnétiques lentes enregistrées sous forme numérique et les variations magnétiques rapides: pulsations pc 4, pc 3, pc 2, pi 2, et micropulsations pc 1, et pi 1 enregistrées sous forme analogique.

Symposium on Conjugate Point Experiments

The main activity of this Working Group was the organizing of the Symposium on Conjugate Point Experiments, Dr. J. A. Jacobs reported on two of the four sessions. The program was as listed in **IAGA Bulletin** No. 24 with exceptions noted below.

Dr. Roederer opened the first session with a general review of conjugate point phenomena. F. R. Bond then presented the paper submitted by P. H. Sulzberger (IV-14) as well as his own. S. Matsushita reviewed the results of the Conjugate Points Symposium (Papers IV - 16 and IV - 17), which was held in Boulder, Colorado, in June 1967. The papers from this symposium have now been published in three volumes and may be obtained upon request.

J. A. Jacobs gave a comprehensive review of conjugate point phenomena associated with reactions in the earth's magnetic field — ranging from slow variations (magnetic storms) down to micropulsations. C. R. Wilson presented his own paper and that of S.-I. Akasofu and C.-I. Meng (IV - 19).

The afternoon session was opened by V. A. Troitskaya with a paper on micropulsation results from polar stations (Thule and Vostok). The results were preliminary, but indicated that pc's at polar stations correlate only on very rare occasions. E. Selzer then spoke on the seasonal variation of pc 3's observed at Chambon-la-Foret, and C. M. Raspopov spoke on the observed behavior of pi 2's at conjugate points.

R. Schlich gave a very interesting account of pc 3, pc 4 and pi 2 as observed at conjugate points in middle latitudes. As the magnetic index Kp increases, correlation was still good for pi's, but poor for pc's. This paper provoked much interesting discussion. Contribution IV - 25 by B. N. Kazak was read by R. Gendvin. The next paper, by M. B. Gokberg, et al., was read by V. A. Troitskaya. The difference between the correlation of pc events depended on whether the period $T > 2.5$ sec. There is also an amplitude variation — probably due to propagation effects in the F2 layer. Paper IV-28, essentially a theoretical investigation, was not given by A. V. Gul'elmy in person. but was read by his colleague. Papers IV-27 and IV-29 were withdrawn. H. B. Liemohn gave an interesting account of what can be deduced about magnetospheric conditions from a study of peals and ipdp events. The sessions closed with a paper by C. S. Wright on the fundamental question of the meaning of conjugacy.

In Session III, paper IV-32 (invited review) was given by Dr. Isaev and an additional paper, "A Note on Conjugate Phenomena Observed by the VLF Experiment on Ariel 3," was presented by K. Bullough, A. R. W. Hughes and T. R. Kaiser. In Session IV G. B. Bukin, N. P. Evzovitch, I. B. Kazenelson, E. V. Sukhorukova, Yu. N. Elizarieva, and Dr. Z. Shatkina presented an additional paper, "Predawn Effect into F2 Variations Caused by the Sunrise at a Magnetically Conjugated Point."

WORKING GROUP IV-12, RELATIONS BETWEEN GROUND AND SATELLITE RAPID VARIATIONS

J. A. Jacobs — Reporter

The reporter has had difficulty in obtaining material for this report. Much data that would seem to be very relevant to the Working Group has not been written up and made available. The long delay between satellite launching and analysis of the observations is perhaps inevitable but at the same time very frustrating.

A considerable advance in the understanding of magnetic variations can be expected if magnetic time variations are monitored reliably in space. To this end a geosynchronous magnetometer satellite, measuring the three directional components of magnetic time variations should be planned. Such a resolution has been made by the International Committee of the Geomagnetism and Aeronomy Section of the American Geophysical Union. Such a resolution should be made at the XIV General Assembly of the IUGG. (See IAGA Resolution No. 15 in a later section of this bulletin.)

It is known that ssc's and si's tend to be worldwide and essentially simultaneous. Nishida and Cahill (1964) have shown from Explorer 12 data that the simultaneity extends throughout the magnetosphere and that positive and negative si's are related, respectively, to compression and expansion of the magnetospheric boundaries. However, few data are available concerning micropulsation measurements by satellites — particularly on their relation to ground observations — although there have been many measurements of the fluctuating field at the magnetopause. Observations of pulsations in the magnetic field inside the magnetosphere were carried out on board Pioneer I and V and Explorer 6 by means of two-component magnetometers (see, e.g., Sonnett et al., 1962; Coleman et al., 1960; Judge and Coleman, 1962). Similar measurements, but with total vector magnetometers were made on board Explorer 12 by Patel and Cahill (1964; see also Patel 1965).

Both transverse mode (Alfven mode, slow mode and mode of left-handed polarization) and longitudinal modes have been observed. Transverse pc pulsations with periods of about 200 sec and longitudinal pulsations with 100-sec period were observed in the magnetosphere by Judge and Coleman (1962). The variations were damped with a time constant of about 500 sec.

Patel and Cahill (1964) observed transverse oscillations (Alfven mode) with periods of 2-3 min simultaneously both in the magnetosphere at a distance of 55,000 km from the earth and on the ground at the end of the magnetic field line. The amplitude of the variations was 6 to 8 gammas in the magnetosphere and slightly less on the earth's surface. The authors state that the wave needed a time of about 1½ min to travel from the satellite to the ground.

At the Sixth Western National Meeting of the American Geophysical Union in September 1966, K. I. Brody et al. gave a short account of the observations of magnetic fluctuations in the spectral range from 0.01 to 1000 cps on the OGO 2 satellite at altitudes from 400 to 1500 km. Large changes in the intensity of magnetic activity (1 to 3 orders of magnitude) were observed in the vicinity of the auroral zones within a spectral range of 0.05 to 5 cps. The enhanced activity, generally located between 67° and 82° geomagnetic latitude, was in the form of bursts occurring within a range of 4°-12° great circle arc. The extent of the range, as well as its position, was found to be related to local time and to the Kp index. The bursts lasted for intervals of 3 to 20 sec, while the satellite was traveling 20-200 km. The beginnings and endings of the intervals were exceedingly sharp with rise and decay time of 1 sec or less. The structure of the signals appears to be similar to hydromagnetic emissions.

Greenstadt et al. (1966) have reported on the structure and pulsations in the magnetosheath using data obtained from Vela 3A. They found that the irregular fluctuations of the magnetosheath occasionally give way to sections of record exhibiting periodicity or near periodicity, sometimes for many minutes. The periods of these quasi-sinusoidal oscillations are consistently confined to certain preferred ranges: 10-15 sec, 20-25 sec, 30-40 sec, and around 1 min; their amplitudes vary from just resolvable, at about 2 gammas peak-to-peak to 50 gammas peak-to-peak. By far the most commonly seen range of periods is that between 10 and 15 sec.

Much work is necessary to establish whether or not a significant correlation exists between the effects observed in the magnetosheath by Vela 3A and the commonly occurring pulsations observed at the surface of the earth, let alone whether they have a physical connection. Many characteristics of pc 2, pc 3, and pc 4, however, support the idea that they may have a common origin with the magnetosheath effects detected by Vela. Additional support has been given by observations of long period (~ 100 sec) hydromagnetic waves, both linearly and elliptically polarized in the magnetosphere. These waves, first reported by Judge and Coleman (1962) from Explorer 6 measurements, were again seen by Explorer 12 and 14 and correlated with surface records by Patel and Cahill (1964) and Patel (1965). The most outstanding distinction between magnetosheath and surface observations lies in the brevity of pulse trains seen by Vela and the corresponding longevity of typical pc events seen on the ground.

Heppner et al. (1967), in an initial study of the OGO-A fluxgate magnetometer measurements, report two classes of field oscillations that are frequently observed at the bow shock front superimposed on the average shock structure: (1) coherent circularly polarized waves with frequencies typically between 0.5 and 1.5 cps in the satellite reference frame, and (2) higher frequency fluctuations (> 3 cps) which are unresolved by the measurements and whose identity is not known. The coherent oscillations are identified as propagating in the whistler mode, existing in the form of wave packets of 4 to 6 cycles and usually show a sharp upper frequency cutoff in power spectra analysis.

Zmuda et al. (1966, 1967) have reported that transverse magnetic disturbances are regularly observed at 1100 km altitude in the auroral oval. The disturbance region exhibits a diurnal variation and during magnetic quiet conditions has, for example, a lower-latitude boundary at $\Lambda = 76^\circ$ at local noon and at $\Lambda = 67^\circ$ at local midnight. The boundary moves southward with increasing magnetic activity. The amplitude of the disturbance characteristically equals about 100 gammas but variations as large as 560 gammas have been observed. Cummings and Dessler (1967) attribute the disturbances to a field-aligned current system of magnitude around 10^5 A. With a few exceptions, disturbances at satellite altitudes correlate temporally with variations at the surface but on the same line of force as the satellite disturbance.

Selzer has reported that direct connections could be found between each "plasma implosion" detected in the tail of the magnetosphere and pc 2 events recorded on rapid run magnetograms at Chambon-La-Foret. He also reported that Mrs. B. de O'Neill has checked all published satellite data against rapid run magnetograms, but unfortunately at the moment no results have been published.

Troitskaya et al. (1966), using data from the satellites Elektron 1 and 2, found that when the boundary of the magnetosphere was about 10 Re, micropulsation records generally showed pulsations of pc 4 type (50-150 sec). When the magnetosphere was compressed, more or less stable short period pulsations, pc 2 and pc 3 (5-40 sec), appeared on the records. Thus the period T of stable pulsations depends on the radius R of magnetosphere (on the day side), the period decreasing as the boundary approaches the earth. Using data from Explorer 12, an empirical power law relation, $T \alpha R^5$,was obtained. Data from Elektron 1 and 2 indicate a similar relationship between T and the outer boundary of the Van Allen belt, i.e., the position of the outer boundary of the Van Allen belt changes synchronously with that of the magnetosphere boundary. Troitskaya et al. also found a relation between ipdp's and the change in electron flux in the radiation belts — the greater the decrease of periods in an ipdp and the lower the minimum period of pulsations, the greater the decrease in the intensity of charged particles in the radiation belts. Lacourly and Grendrin (1967) report that ipdp's appear when the outer boundary of the Van Allen zones approaches the earth. This in turn is related to the change in pattern of magnetic lines of force on the night side of the earth during magnetic storms.

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COMMISSION V
SOLAR-TERRESTRIAL AND COSMIC-TERRESTRIAL RELATIONSHIPS
J. G. Roederer — Chairman

IAGA Commission V on Solar-Terrestrial and Cosmic-Terrestrial Relationships organized four scientific sessions on topics of its specific competence and a symposium on special geophysical events. In addition, two open meetings were held to discuss the reorganization of the Commission, and to analyze proposals for scientific activities during the International Active Sun Years 1968-1970.

SCIENTIFIC SESSIONS

The first scientific session of Commission V was held on the morning of September 26, on "Review of Progress in Solar-Terrestrial and Cosmic-Terrestrial Relationships." Three invited lectures were delivered; the authors had been specifically asked to address the whole IAGA audience, and had been urged to make sure that their talks would enlighten existing, and spark new, interdisciplinary ideas. This difficult task was accomplished very successfully by the speakers: Professor Alexander Dessler (Rice University, Houston, USA) who spoke on "Interaction of the Solar Wind with the Magnetosphere," Dr. Wilmot N. Hess (NASA, Houston, USA) who discussed "The Earth's Radiation Belts," and Professor John J. Quenby (Imperial College, London, Great Britain) who spoke on "Cosmic Ray Modulation."

The second session, chaired by Professor Quenby and held in the afternoon September 26, was on the subject of "Propagation and Modulation of Solar and Galactic Energetic Particles." Two review papers were presented; in this case the speakers had been asked to address the specialists in the subject and to give up-to-date details. They were Dr. Hugh Carmichael (Atomic Energy of Canada, Ltd., Deep River, Canada) who spoke on "Influence of the Atmosphere and of the Undisturbed Geomagnetic Field on Cosmic Radiation," and Professor A. Ehmert (Max Planck Institut, Lindau, Germany) who discussed "High Altitude X-ray Measurements in Polar Regions." Two contributed papers followed: "Mesure du rayonnement cosmique en période de minimum d'activité solaire à l'aide des vols simultanes SPARMO," by Dj. Heristchi, and "Diurnal Variations of Cosmic Rays Underground," by Victor H. Regener and Derek B. Swinson (presented by Prof. Regener).

On September 27 in the morning, the third session, chaired by Dr. Charmichael, was held on the subject of "Solar Energetic Particles, Interplanetary Plasma and Geomagnetic Boundary." The following contributions were presented:

H. H. Sauer: A New Model of the Magnetosphere.

A. J. Masley, J. W. McDonough, and A. D. Goedeke: The Recent Increase in Solar Cosmic Ray Activity (presented by Dr. Masley).

H. K. Sen: The Coronal Exospheric Sheath and the Solar Wind.

D. Venkatesan and S. R. Sreenivasan: The Solar Wind and the Significance of ΣK_p (presented by Dr. Venkatesan).

J. P. Heppner, M. Sugiura, B. G. Ledley, and T. L. Skillman: Magnetic Field Characteristics Near the Magnetopause (presented by Dr. Heppner).

H. R. Lehmann: Interaction Between a Turbulent Velocity Field and the Magnetic Field.

O. C. Allkofer, D. Andresen, W. D. Dau, and H. Funk: Investigation of the Muon and Nucleonic Component of Cosmic Rays during the Atlantic Expedition IQSY 1965 of the Research Vessel **Meteor** (presented by Dr. Allkofer).

The last scientific session of Commission V was held under the title "Physics of the Magnetosphere" on September 29 in the afternoon and was chaired by Dr. Hess.

The two review papers were:

Dr. Norman F. Ness: Observations of the Magnetospheric Tail.

Prof. Juan G. Roederer: Diffusion Processes for Geomagnetically Trapped Particles.

T. L. Aggson, J. P. Heppner, and N. C. Maynard: Electric Field Measurements in Space (presented by Dr. Heppner).

J. W. Freeman, Jr., and J. J. Maguire: Gross Local Time Asymmetries in the Energetic Particle Population of the Magnetosphere as Observed at the Geostationary Orbit (presented by Dr. Freeman).

G. J. Gassmann, J. R. Herman, and C. P. Pike: Observation of Ionospheric Anomalies Related to the Van Allen Belts (presented by Dr. Gassmann).

One serious difficulty arose from the fact that none of the ten papers submitted by Soviet scientists could be presented, due to the absence of the authors. This led to unfortunate last minute changes in the original schedule.

SYMPOSIUM ON SPECIAL EVENTS OF FEBRUARY 1965 AND MARCH 1966

This symposium, held on October 2, morning and afternoon, was devoted to the discussion of the physical processes responsible for, and caused by, a series of solar outbursts that occurred during February 1965 and March 1966. The following papers were presented, under the chairmanship of Dr. J. Aarons:

Virginia Lincoln: Opening Lecture.

A. Lundbak: Solar X-Rays and Related Phenomena.

J. P. Castelli: The Spectra of Some Radio Events in March 1966 (read by J. Aarons).

R. W. Fillius: Penetration of Solar Protons to Five Earth Radii in the Equatorial Plane.

J. Bouska: Electromagnetic Solar-Terrestrial Events Between February 5-9, 1965.

C. O. Bostrom: Solar Protons Observed at 1100 Km During February 1965 and March 1966.

G. C. Reid: Antarctic Polar-Cap Absorption during the Solar-Proton Event of February 1965.

T. A. Potemra, A. J. Zmuda, C. R. Haave, and B. W. Shaw: VLF Phase Perturbations Produced by Solar Protons in the Event of February 1965.

A. J. Masley and A. D. Goedeke: The 5 February 1965 Solar Cosmic Ray Event.

A. J. Masley and A. D. Goedeke: The March 1966 Solar Cosmic Ray Event.

D. E. Hagge: Energetic Particles From the Solar Flare on March 24, 1966.

L. J. Lanzerotti: Outer Zone Electron Fluxes during the February 5, 1965 Solar Proton Event.

J. Aarons and C. Malik: Optical and Radio Observations of the Aurora of February 7, 1965 (presented by Dr. Aarons).

J. Aarons, J. P. Muller, H. M. Silverman, and A. Stenstrup: Auroral Zone Latitudinal Movements of the Scintillation Irregularity Structure and Total Electron Content during March 1966 (presented by Dr. Aarons).

L. A. Sandrucci, G. C. Castagnoli, and M. A. Dodero: The Forbush Decrease of March 1966 Observed Underground (70 m.w.e.) in Torino, Italy (presented by Dr. Castagnoli).

R. A. Langel, S. J. Hendricks, and J. C. Cain: Magnetic Observations of the March 1966 Disturbance by the OGO-C Spacecraft (presented by Dr. Langel).

F. Glangeaud, J. Roquet, and E. Selzer: Microstructures à des Latitudes Moyennes et Équatoriales, et Composition Spéctrale, des Perburbations Magnétiques de Février 1965 et Mars 1966 (presented by Dr. Selzer).

Most of these papers will be published in **Annales de Geophysique.**

OPEN MEETING TO DISCUSS THE REORGANIZATION OF COMMISSION V

On September 27, after the scientific session, an open meeting was held to discuss the reorganization of Commission V. The Commission Chairman presented his personal views about past difficulties with Commission V.

1. Commission V was inserted in 1963 as a new commission into the well-established framework of IAGA. At that time, the subject of solar-terrestrial and cosmic-terrestrial relationships was already being covered very thoroughly in COSPAR and in IUPAP (Cosmic Ray Commission); therefore, Commission V had to compete right from the bgeinning with well-organized structures existing in other ICSU bodies.

2. The initial structure of Commission V was not properly balanced, being heavily oriented towards cosmic radiation, including some topics very weakly, or not at all, related to geophysics.

3. On the other hand, the whole field of physics of the magnetosphere, like the study of radiation belts and magnetospheric plasma, magnetohydrodynamic waves and shocks in the outer magnetosphere, the geomagnetic boundary, the geomagnetic tail, etc., was only weakly represented in Commission V. In addition, this field was not adequately nor comprehensively covered in any other union of ICSU, either.

4. There is an urgent need to make Commission V, and in general the whole of IAGA, more attractive to the new generation of scientists. There seems to be a mistaken feeling among the young, active scientists that the international associations, or unions, are principally interested in politics, and that two important reasons for their existence are to provide ample excuses for scientific tourism, and to award abundant titles of commission chairmanship and membership that may then brighten the beneficiaries' curriculum vitae. The only successful way to overturn this impression is to produce useful work, other than just organizing meetings.

After a long and fruitful discussion, a new structure for Commission V was proposed. Introducing slight changes, the IAGA Executive Committee approved the new organization and officers as shown in a later section of this bulletin. Since the assembly, all of the reporters shown have accepted, except K. I. Grangauz, from whom no word has been received, and I. B. McDiarmid, who has declined.

GENERAL MEETING TO DISCUSS PLANS FOR IASY

This meeting was held Saturday afternoon, September 30. More than 100 participants from all IAGA commissions attended. Dr. Herbert Friedman, Chairman of the Interunion Commission on Solar-Terrestrial Physics (IUCSTP), gave a general review of the work done by this commission, and discussed its polices for setting up an international program for the next period of maximum solar activity.

Several documents, submitted by Drs. Pushkov, Troitskaya and Roederer, containing proposals and recommendations for scientific projects to be conducted during solar maximum, were discussed at length. The general consensus was that a list of limited, well-defined projects should be set up, each one centered on a specific physical problem, involving international cooperation of scientists from various disciplines and the simultaneous use of different observational techniques. It was agreed that IAGA scientists should play a major role in the setup of these scientific projects, and that IUCSTP should keep in close touch with IAGA on this matter.

A recommendation was proposed, which, after a few modifications introduced by the IAGA Executive Committee, was finally adopted by IAGA and IUGG as IUGG Resolution No. 14, given in a later section of this bulletin.

RECOMMENDED PROJECTS FOR THE PERIOD 1968-70 INCLUDING THE YEARS OF THE ACTIVE SUN

The results of the general meeting discussed in the preceding section were conveyed to the IUCSTP, which met in St. Gall on October 5 and 6. Based on the documents discussed at the general meeting, and on the recommendations prepared by the Discipline Representatives, IUCSTP produced a series of projects for the IASY (1968-70), which are described in the sections which follow. These descriptions should be regarded as preliminary since additional planning meetings will be held.

Monitoring of the Solar-Terrestrial Environment.

Systematic monitoring of solar activity and the terrestrial environment is a necessity for further progress in understanding most of the problems in solar-terrestrial physics. The cooperation that was characteristic of the IGY and the IQSY should be continued between the existing ground-based networks in the disciplines of solar activity, ionosphere, geomagnetism, aurora, airglow, and cosmic rays. Data interchange through World Data Centers (WDCs) and through the exchange of publications allows the results of the monitoring program to be used in global and regional studies and in interdisciplinary researches. The detailed plans for the acquisition, processing, and redistribution of data will be modified in the light of recent research experience and of plans for special experiments.

Solar X-ray, ultraviolet, and particle radiations can be monitored directly only from space vehicles. The observations are of basic importance in studies of many ionospheric processes of basic importance in studies of many ionospheric processes and atmospheric effects. Thus, solar monitoring from satellites, preferably at distances beyond the radiation belts, should be improved and made continuous as soon as possible, and the data should be made available to the scientific community for the many special projects that depend on knowing the changes of the solar flux with time.

It will be important also to organize, as soon as practicable, the monitoring, by means of satellites in suitable orbits, of the variations in space and time of the characteristics of the near and distant magnetosphere and the solar wind. It would be advantageous:

(a) to have a number of small, real-time telemetry satellites, operating simultaneously and carrying standard-package instruments; and

(b) to include, in as many spacecraft as possible, standard packages of radiation detectors and magnetic field probes.

Monitored data from simultaneously operating spacecraft with similar or equivalent instrumentation should be made available to all experimenters as promptly as feasible; for example, through Satellite Data Centers. This prompt supply of data would be aided considerably by making on-board data processing a standard procedure in spacecraft.

Proton Flares

Proton flares are one of the most powerful manifestations of solar activity; they inject into interplanetary space streams of atomic particles with energies often ranging up to hundreds and even thousands of MeV. Such castastrophic outbursts constitute one of the most serious hazards to the survival of men in space and they may also be of concern to passengers in future high-flying supersonic aircraft. For the Proton Flare Project, every available tool, both ground-based and space-borne, will be used in the study of all observational aspects of selected flares. Of particular interest are:

1. The spatial structure of local solar magnetic fields at the flare source.
2. The mechanism by which particles are accelerated in and ejected from active regions.
3. The energy spectra and composition of the relativistic particles produced by the flare.
4. The interplanetary plasma clouds and shock waves that propagate from the flare source both in and outside the ecliptic plane.

The project is intended partly to improve our understanding of this most energetic phenomenon originating in the solar atmosphere and partly to develop more successful methods for flare prediction. Routine observations should be accelerated and more sophisticated measurements should be introduced. The choice of periods for such observations should be coordinated with the time schedules of related satellites, space probes, and rocket observations. Certain space projects such as the "Apollo Telescope Mount," which is scheduled for the later portion of IASY, should be supported by the most comprehensive ground-based program of observations that can be organized within that time interval.

Disturbances of the Interplanetary Magnetic Field Configuration

During quiet solar conditions, a continous flow of plasma streams radially away from the sun. This solar wind carries "frozen-in" solar magnetic field lines which, in the ecliptic plane, attain a spiral form due to the sun's rotation, and which appear to be bunched in "sectors" with field vectors pointing either away from the sun or towards it. The basic configuration of the interplanetary magnetic field can be highly perturbed by enhanced plasma emissions from active regions of the sun, and by plasma clouds and shock waves emitted during solar flares. Several processes are of particular importance in relation to interplanetary magnetic field perturbations:

1. Galactic cosmic-ray modulation.
2. Solar energetic particle propagation and diffusion through interplanetary space.
3. Particle acceleration in the neutral regions between sectors or near shock fronts.
4. The structure of the interplanetary medium outside the ecliptic plane.
5. The effects of interacting plasma clouds or shock waves.

Most important for the study of the interplanetary field are in situ measurements of the magnetic field and observations of the flux and anisotropy of solar energetic particles, together with precise directional measurements of cosmic-ray particles by ground-level monitors. These data should be correlated with solar observations throughout the entire electromagnetic frequency range, as well as with observations of magnetic and ionospheric storms and other related terrestrial effects. The network of super-neutron monitors is an essential element of the observational program and should be appropriately enlarged.

Determination of Characteristics of the Magnetosphere

The earth's magnetosphere behaves like an elastic container of plasma and energetic particles enveloping the earth; it is stretched and squeezed by the solar wind, and is capable of transmitting perturbations in the form of waves from one point to another. It follows that many geophysical ground-based observations provide data which are related directly to the actual configuration of the magnetosphere and its temporal variations. For example, some geomagnetic pulsations are manifestations of the response of the magnetosphere to changing conditions in the solar wind; others are generated by plasma resonances due to an interaction between waves and particles. A better physical understanding of such correlations would make it possible to organize a service that could quickly provide much information about important characteristic parameters of the magnetosphere, such as the positions of the boundary, the limit of the closed field lines, the plasmapause and the maxima of the trapped particle fluxes. This project would afford valuable data to complement in situ observations made with rockets and space vehicles.

The immediate goal of the project would be to discover the detailed relationships that must exist between ground-based geophysical observations and the behavior of the fields, plasmas, and energetic particles in the magnetosphere and the interplanetary medium. On the basis of the results obtained and their physical interpretation, the types of surface observations that provide the most useful information about phenomena in space would be recognized and then organized into a continuous service that would be capable of supplying rapidly all available information on certain characteristic parameters of the magnetosphere. The execution of this project would require:

1. The establishment of appropriate observatories to supplement those already in operation and to fill any gaps in the present observatory network, particularly in auroral and subauroral latitudes and on the polar caps.
2. The simultaneous use of satellites to measure magnetic fields, electric field, magnetic pulsations, low-energy plasma and energetic particles along different orbits in space.
3. Effective means of collecting and exchanging ground-based and satellite data.

Conjugate Point Experiments

The effects induced by many magnetospheric processes can be propagated in the form of particles or waves along a geomagnetic field line. If the field line forms a closed loop linking the northern and southern hemispheres, the effects can be detected on the ground almost simultaneously at the conjugate points at which the field line intersects the earth's surface.

A great variety of phenomena such as aurora, VLF emissions, micropulsations, and predawn ionospheric heating, give rise to such conjugate point effects, and they can provide important clues about the primary processes. Whistlers can be used as a means of studying the propagation mechanism along the field line, and the field line geometry can be deduced from observation of the nighttime opening of field lines, diurnal and seasonal variations of conjugacy, and the artificial injection of particles.

Conjugate point experiments must be performed simultaneously in opposite hemispheres; in consequence, they require cooperation between two or more countries. In principle, they involve ground stations located as closely as possible to a pair of conjugate points; however, more sophisticated experiments require one station at one point and a **network** of stations in the conjugate area.

Of particular importance in the field of auroras and energetic particle precipitation are simultaneous high-altitude observations from aircraft flying along conjugate paths or from balloons launched in conjugate areas. Another extremely valuable arrangement would consist of simultaneous observations from a geostationary satellite and from ground stations at the conjugate points joined by the field line on which the satellite is located. Finally, observations by means of an accelerator flown on a rocket or satellite of the effects produced at conjugate points by particles injected along a field line, can yield vital information on field line geometry and electric fields.

Electric Fields in the Magnetosphere

The distribution of plasma and the energetic particle concentration in the magnetosphere are controlled primarily by the magnetic field. However, slowly varying electric fields, associated with cooperation or convection of the plasma and with ionospheric currents, are also present and exert an important influence on the charged particle population. Very little is known at present about these electric fields, but their configuration is extremely important, in general, to particle acceleration and hydromagnetic processes in the magnetosphere. The experimental techniques for the direct measurement of these d.c. electric fields are improving rapidly and could, if applied in a coordinated program, yield information of crucial importance.

A study project should include systematic electric field measurements carried out simultaneously with ion-cloud injections at prefixed locations and altitudes, and with satellite measurements of plasma convection possibly involving direct electric field probes. These investigations would be valuably complemented by ionospheric drift studies. During the initial stage of such a program, combined experiments using two or more methods at the same time would be necessary to calibrate the different methods against each other. In addition, careful studies should be made of the effect of ion-cloud injections on the field to be measured.

Magnetic Storms and Polar Disturbances

Magnetic storms and polar disturbances are manifestations of violent perturbations caused by solar plasma clouds impinging on the earth's magnetosphere. These perturbations are morphologically complex; they involve the whole particle population of the magnetosphere, ranging from the cloud plasma to the most energetic of the trapped particles. In order to make further advances in our understanding of these phenomena, well-coordinated observations are necessary both on the ground and in space. The conduct of the proposed project would require:

1. Improvement of magnetic observations at ground stations.
2. Rapid transmission of microfilmed copies of records and digital data from the stations to the appropriate World Data Centers.
3. Establishment of new stations at locations likely to be most useful for specific problems.

Activity indices intended to represent the physical processes involved should be recorded and made available to scientists working in other related disciplines. Simultaneous high-altitude balloon X-ray measurements, at high latitudes and along geomagnetic parallels and meridians, should be coordinated with auroral observations from the ground, and from aircraft and satellites. Regarding measurements in space, variations in the flux and energy spectrum of trapped particles should be studied, especially in the low-energy range; the behavior of the plasma sheet in the geomagnetic tail should be carefully analyzed. The recently developed techniques of measuring electric fields in the ionosphere and in the magnetosphere by rockets and satellites should be utilized also so as to provide complementary data.

Low-Latitude Auroras

Tropical auroras in which the luminosity exhibits a structure have been observed by the naked eye at times of great geomagnetic storms, but reports of such events are rare. It is very likely, however, that many barely subvisual auroras occur that could be detected with sensitive photoelectric photometers. During the last sunspot cycle, there were five geomagnetic storms of such great intensity that they must almost certainly have been accompanied by subvisual forms at low latitudes. These great geomagnetic storms indicate a gross deformation of the magnetosphere, the nature of which can be revealed by the accompanying mid-latitude and tropical luminosity.

To accomplish the observations, tropical airglow observatories should be equipped with automatic scanning filter photometers. After being alerted by flare-warning systems and by networks of ground-based magnetometers, jet aircraft could fly photometers across wide spans of latitude so as to map the extent of the auroral luminosity. At the same time, rockets in standby readiness could be launched to traverse the disturbed regions. Modern image orthicon cameras are capable of recording detailed pictures of subvisual auroral structures as has already been demonstrated at midlatitudes during a great storm in May, 1967. Ionospheric sounders should be used to make observations of anomalous E-region ionization and these observations should be repeated at the highest practical rates under the alert conditions mentioned above.

Basic Structure of the Upper Atmosphere

The atmosphere "breathes" in and out as a result of the diurnal, seasonal, and solar-cycle variations of the energy input from the sun. In order to clarify the global picture of atmospheric structure, a systematic worldwide survey of composition, temperature, and density is needed.

The air drag on satellites can be measured with high sensitivity up to great altitudes and such measurements provide a simple and precise means of following density variations. At altitudes below 200 km, however, drag forces increase so rapidly that the lifetime of a typical satellite is severely curtailed. Satellites with high mass to cross-section ratios and with restartable rocket power to sustain their lives in low orbit are needed to explore the atmosphere below 200 km. Instrumentation should be included for composition, airglow, and total-density measurements.

The 80-120 km region includes the transition from a mixed atmosphere to one in which eddy and molecular diffusion compete with one another before diffusive equilibrium is attained at still greater altitudes. Furthermore, the photochemical reactions that occur in the 80-120 km region exert a most important influence on the neutral atmosphere at all greater heights.

During IQSY, small rocket techniques were developed to probe the atmospheric structure from the high stratosphere up to the thermosphere. The methods employed included the use of explosive grenades, luminous vapour releases, falling spheres, mass spectrometers, observations of airglow at different heights, and photometry of solar radiation fluxes at various wavelengths. The techniques have only recently attained a high degree of absolute accuracy and their employment thus far has been confined to the vicinities of just a few rocket ranges. For the future, therefore, it is important to apply small rocket methods more widely in conjunction with satellite surveys, so as to establish the large-scale global figure of the mesosphere and thermosphere under basic conditions and to distinguish the distortions caused by micro-, meso-, and macro-scale changes.

Atmospheric Dynamics

Atmospheric dynamics encompasses what is perhaps the most complex system of interacting processes that faces man in the study of his physical environment. These processes have origins that derive in part from the behavior of the meteorological regions beneath, in part from interactions with the solar wind beyond, and in part from effects induced **in situ.** They have consequences that range from simple wind systems, through such diverse phenomena as compositional changes in the neutral gas, anomalous heating, and the modulation of energetic particle precipitation, to the formation of various types of ionization irregularity such as sporadic E, spread F, travelling disturbances, and radio auroras.

Despite the complexity of the processes involved, recent advances indicate that a concerted effort at this time will lead to a greatly improved understanding of individual aspects of these phenomena and of the system as a whole. The project must involve an extension of normal meteorological measurements, improved networks of standard equipment for monitoring the ionosphere, and a judicious use of the more sophisticated (although more expensive) techniques now provided by ground-based meteor scatter and Thomson scatter radar systems and by high-altitude gun and rocket soundings.

Ion Chemistry of D and E Regions

It is generally agreed by ionospheric physicists that their most urgent need is a knowledge of the identity of the positive and negative ions in the D and E regions. Because of the importance of minor constituents in the neutral atmosphere and the complexity of the relevant ionic reactions, it is difficult to deduce the fundamental processes from measurements of electron density alone, except in the most general terms. Rocket and ground-based measurements must be used in combination and at times and places selected carefully so as to yield the maximum amount of scientific information. The experiments should include rocket measurements of the ionized and neutral constituents of the D and E regions, rocket and ground-based measurements of electron density, and measurements of the intensities of solar radiations and energetic particles in approximate energy bands. Among the problems which may be solved by these measurements, if properly coordinated, are:

(a) the role of meteoritic ionization;
(b) sunrise effects;
(c) ion production by midlatitude particle precipitation;

(d) sporadic-E ionization; and
(e) the relation between laboratory measurements of rate coefficients and those observed in the ionosphere.

Sudden Ionospheric Disturbances (SID's)

The coming solar maximum offers the first opportunity to apply several recently developed rocket and satellite experimental techniques to the study of solar flare ionization effects in the D region, commonly known as SID's. It is proposed to organize a project that will include the following subdivisions:

1. The recognition of the onset of a flare (within 15 sec) by means of real-time transmission to a launch site of information from a satellite that can monitor hard X-ray intensity (exceeding 10 keV).

2. Monitoring throughout the flare, with a time resolution of 1 sec or better, of the solar spectrum in the range 0.05-20 A.

3. Rocket (and perhaps gun) soundings of the electron and ion density profiles in the D and E regions between 50 and 150 km. These should start as soon as possible after the flare warning and should be repeated at intervals throughout the duration of the flare; in every case, a control sounding must be made after the end of the flare.

4. Monitoring, with a time resolution of 1 sec or better, of the phase height given by VLF radio signals, and of the ionospheric absorption as measured by pulse, cw, and riometer methods.

This project should reveal the effects at various levels in the ionosphere of the variations with time in the hardness of the flare radiation and it should add greatly to an understanding of the ion chemistry of the lower D region.

COMMISSION VI
AURORA
J. W. Chamberlain — Chairman

Chairman J. W. Chamberlain was unable to attend the assembly. Dr. A. Omholt, who at the end of the assembly was appointed the new Chairman of Commission VI acted as Chairman during this assembly.

THE BIRKELAND SYMPOSIUM

During the Birkeland Symposium on Aurora and Magnetic Storms at Sandefjord, Norway, one session, in the afternoon of September 21, was devoted to reports from the five reporters of the Commission. These reports were in the form of review papers, covering the development within the respective fields during the last 4 years. They will be published as a part of the proceedings from the Birkeland Symposium, which will appear as **IAGA Symposium** No. 6.

BUSINESS MEETINGS OF THE WORKING GROUP ON AURORAL MORPHOLOGY AND OF THE COMMISSION

A Working Group meeting was held on September 26, 17.30h, and the business meeting was held on September 29, 19.00h. The Working Group and Commission discussed the recommendation from the IQSY Working Group on Aurora that the formal requirement for the submission of auroral data to the World Data Centers should be suspended after the IQSY and that an IAGA committee should take over the initiation and coordination of international programs on the aurora in the post-IQSY period. The reporter of the Working Group on Auroral Morphology, F. Jacka, had solicited opinions on the matter, and reported these to the Working Group. This report was discussed, and it was felt that although the requirement for submission of data should be suspended, the resolution should not have a form that would discourage scientists from continuing observations of value to synoptic studies. Also, the WDC's should be kept informed about the observational programs. It was also felt that IAGA Commission VI is, and should be, responsible for initiation and coordination of international programs in its field.

A resolution was forwarded to the IAGA Executive Committee. This resolution was finally adopted as IAGA Resolution No. 16, which is given in a later section of this bulletin.

Observation of Auroras and Airglow in Middle and Low Latitudes

The Working Group and Commission discussed the proposal from the U.K. on the need for observations of middle and low latitude aurora as proposed by S. Chapman and S.-I. Akasofu. A circular had been sent out earlier that resulted in many comments, a few of which are given below.

Akasofu pointed out that tropical auroras, visual and subvisual, occur during geomagnetic storms with a great main phase. Associated with the development of the intense storm time radiation belt are changes in the structure of the upper atmosphere and considerable deformation of the magnetosphere. The study of tropical auroras would be related to these phenomena. He recommended that solar observatories should issue warnings whenever a flare of importance greater than 2 is observed to occur within 20° of the center of the sun. Warnings could also be based on the recordings of the growth of the main phase decrease by a network of magnetometers. The main observations would be made using scanning photometers with appropriate filters at tropical airglow observatories, in jet aircraft, and in rockets. Tropical ionospheric observatories should increase the frequency of their HF records so as to observe the growth of the nighttime E layer, which depends on the magnitude of the main phase decrease.

A. Omholt proposed that the possibility of basing the alert arrangements on satellite observations should be examined. M. S. Rees recommended that the warning system should be based not only on solar observations but also on deep space probe detection of unusual particle fluxes or magnetic perturbations. On the other hand, M. Gadsden, G. M. Weill and M. H. Rees recommended the continuous operation of recording instruments, obviating the need for alerts.

The majority of those who replied to the circular advocated the use of photometers. Weill pointed out that the operation of automatic photometers permanently at night could increase considerably the probability of observing low latitude auroras, for during such events high altitude radiations, particularly 6300 and 5200 A, increase by several orders of magnitude and such enhancements can easily be detected photometrically through the clouds. All suitably airglow and ionospheric stations and also selected magnetic observatories and metrological stations should be equipped with such an instrument.

M. Gadsden proposed the establishment of a minimum network of about 12 all-sky camera stations, spaced at longitude intervals of 60°and ideally in pairs close to one meridian at approximately equal north and south latitudes between $\Phi = \pm 40°$, the stations being chosen on the basis of a high incidence of clear nighttime skies rather than any other factor, such as association with an ionosonde station or the presence of an existing observatory. Lange-Hesse plans to operate 35 mm all-sky cameras combined with a scanning photometer. These cameras, designed and built for special use in subauroral and midauroral latitudes by Stoffregen are controlled by the photometer, which switches on the camera when luminosity exceeds a given threshold value.

Roberts and Firor proposed the Hawaiian Islands as a very suitable site for ground observations, particularly Maui, where nighttime observations of zodiacal light and airglow are proceeding under the direction of Weinberg of the University of Hawaii, which also plans to develop an observing site near the summit of Mauna Kea.

General Planning for the Active Sun Years (ASY)

It was felt that plans for work such as that described above will be particularly important during the sunspot maximum, and the Commission proposed to establish an Auroral and Airglow Committee for the ASY. This Committee should consider, advise on, or aid special projects in the area of optical studies of upper atmospheric phenomena. The Committee should be chaired jointly by the Chairmen of Commission VI (aurora) and VII (airglow) ex officio.

The IAGA Executive Committee finally appointed the following to comprise the IAGA Aurora and Airglow Program Committee for the ASY: A. Omholt and G. Weill, Cochairmen; M. H. Rees, Reporter; K. D. Cole; S. I. Akasofu; B. Hultqvist; M. Huruhata; G. Lange-Hesse; J. Paton; N. N. Shefov; and Yu. L. Truttse.

It was agreed that the Working Group on Auroral Morphology and the Working Group on Radio Aurora should also be concerned with the work that should be undertaken during the active sun years and make recommendations relating thereto. Reports on this should be given to the Commission Chairman who should take further action to coordinate and make the recommendations known.

Internal Resolutions and Recommendations

The following internal resolution was adopted by the Commission for notification of IAGA and all concerned:

In order to ensure comparability and integrability of visual and all-sky camera auroral results into synoptical and worldwide representations those national networks or institutions that have not yet adopted the international nomenclature of auroral morphology are urged to do so, if possible not later than January 1968.

The Commission adopted the following recommendation to the new Working Group on Radio Aurora, upon suggestion from the present reporter, P. A. Forsyth:

In view of the present confusion in radio-auroral nomenclature it is requested that the IAGA Commission VI, Working Group 3, undertake a special study of nomenclature. The Working Group should recommend a classification scheme for radio aurora within 6 months and the scheme should be published in **IAGA News.**

Upon suggestion from the Reporter on Radio Aurora, the Commission adopted the following internal resolution for notification of those concerned:

In view of the probable importance of radio-auroral measurements to an understanding of upper atmospheric and magnetospheric electric fields and motions, it is recommended that during the next 4-year interval a particular effort be made to carry out the following coordinated experiments:

1. Simultaneous radio observations of a small volume of the auroral atmosphere from a number of directions, using Doppler methods and including, whenever possible, optical, riometer and magnetic observations of the same region.

2. Radio-auroral measurements of the kind described in (1) carried out simultaneously with rocket measurements of the electron density and structure of electric fields. These measurements should be carried out at all high latitude rocket launching facilities. The same measurements should be coordinated, where possible, with satellite measurements of precipitating particles.

SCIENTIFIC HIGHLIGHTS

A large fraction of the scientific reports of Commission VI was presented at the Birkeland symposium, the pre-IUGG symposium sponsored by IAGA. This summary therefore includes scientific highlights heard at Sandefjord and St. Gall.

Theoretical papers on the interaction of the solar wind with the earth's magnetosphere were given and the open versus closed model magnetospheres were discussed. Observations relevant to this question were reported, showing detailed conjugacy of auroral forms obtained from simultaneous photography of aurora from aircraft flying conjugate paths in the northern and southern hemisphere. Shell conjugacy, out to $L = 10$, and point conjugacy were obtained while no case of lack of conjugacy was observed.

Many reports on direct measurements of auroral electrons and protons were presented. Several investigators, using rocket-borne instrumentation, reported on detection of energetic electrons exhibiting a narrow energy spectrum; peak energies varied from 3 to 12 keV. Other experiments yielded broad energy spectra. Both isotropic and anisotropic angular spectra were measured. The low energy electrons are accompanied by a much smaller flux of higher energy electrons that show a rapid temporal fluctuation.

Calculations were presented on the interaction of the auroral electrojet with precipitating electrons. The pitch angle distribution is changed and an initially uniform precipitation breaks up into narrow filaments. A motion picture photographed in real time with an image orthicon system was shown; striations nearly always seem to be part of auroral arcs and bands.

Spectra of secondary auroral electrons were reported, showing a continual rise toward low energy.

Measurements of the auroral spectrum in the ultraviolet obtained from OGO-4 were reported. Atomic lines of hydrogen, oxygen and nitrogen were detected, and bands of the Lyman-Brige-Hopfield system of N2 were identified. An unexplained discrepancy between observed fluxes in the u.v. and predicted fluxes was noted.

Ground based measurements of hydrogen Balmer alpha were reported and discussed in terms of hydrogen aurora. A rocket flight into an almost pure proton aurora was reported.

Results of an investigation on the occurrence of very low frequency sound or pressure waves (infrasonic waves) were presented. These waves were shown to be associated with supersonic motion of visible auroral forms.

Perhaps the most significant development centered on the problem of electric fields in aurora. Electrostatic probe measurements were reported, as well as ion cloud drift experiments from which the electric field could be deduced. Radar echo observations likewise may be interpreted by assuming the existence of an electric field. The magnitude of the electric field (normal to the magnetic field) is in the range 10 to 50 mV per meter. Calculations were presented showing that the ion temperature is considerably enhanced in the presence of such an electric field. Electron temperatures are also enhanced in aurora with the energy source provided by the secondary electrons. High electron temperatures were obtained with rocket-borne probes flown into aurora.

The concept of the auroral oval (as distinct from the auroral zone) was firmly established.

Since members of Commission VI were well represented and gave papers at the Birkeland Symposium on Aurora and Magnetic Storms, cosponsored by IAGA, only five papers were given during the St. Gall Meeting. These were the four listed in the program (see **IAGA Bulletin** No. 24) and a paper by Otto Schneider and J. G. Gornez, "Some aspects of auroral morphology in the Wedell Sea regions." Each paper was followed by discussion and comments.

COMMISSION VII
AIRGLOW
F. E. Roach — Chairman

Chairman F. E. Roach was unable to attend the assembly. In his absence M. Gadsden acted as chairman.

Because of other meetings earlier this year, attendance at the Commission VII meetings was relatively small. In the absence of all but one of the working group reporters, no Commission working groups met; there was, however, a meeting of an ad hoc working group jointly with Commission VI to discuss cooperation in studies of low latitude auroras. This discussion led to the formation of a joint Commission VI and Commission VII group to provide informal coordination in such studies. A more complete report on this is given in the preceding section under Commission VI.

Ten contributed papers were presented at two scientific sessions of Commission

VII. The abstracts of those that were received in time appear in **IAGA Bulletin** No. 24.

COMMISSION VIII
UPPER ATMOSPHERE STRUCTURE
H. Friedman — Chairman

During the interval between general assemblies, two symposia of special concern to Commission VIII were held — IAGA Symposium 4 on Aeronomy in the United States in 1965 and IAGA Symposium 5 on Equatorial Aeronomy in Brazil, 1966.

At the assembly in St. Gall, two sessions of contributed papers were sponsored by Commission VIII. The Symposium on Winds, Waves and Drifts in the Ionosphere was organized jointly with Commission III of URSI.

Considerable progress has been made in understanding the general features of the structure of the atmosphere, its diurnal-seasonal and solar-cycle variations, and the fundamental physical processes involved. The picture is still largely qualitative, however, and much attention has to be devoted to absolute quantities and to the delineation of global maps of atmospheric structure.

Some of the noteworthy successes of the past few years have been: the identification of meteretic ion Fe^+, Ca^+, Mg^+ as the major constituents of sporadic E layers, the successful measurements of electric fields from observations of the motions of ion cloud releases, and the development of the Thompson scatter technique for the study of ionospheric profiles all the way from the base of D region through the F Max region to the upper reaches of the exosphere. The utility of the back scatter radar for the study of the scale and drift of ionospheric irregularities has been clearly demonstrated and strongly recommends additional facilities of this type. Finally, the growing recognition of the important influence of gravity waves on the dynamics of the neutral and ionized gas has been a highlight of aeronomical progress in the past few years. The Joint Symposium on Winds, Waves and Drifts at this assembly has demonstrated the remarkable growth of this subject.

It is gratifying to mention successes, but there are also regrettable failures and omissions in the efforts of aeronomists during the past few years. For example, no successful measurements were made of the profile of solar Hα to obtain the hydrogen atom column density between the earth and the sun. Observations of the Lα glow of the geocorona have been very few and rather unreliable so that there has been little advance in our understanding of the structure and dynamics of this vast outer enevelope of the terrestrial atmosphere. Direct measurements by satellite-borne mass spectrometers are at complete divergence with estimates of hydrogen density derived from optical observations. The only substantive studies of the geocorona appear to be Tinsley's ground-based Hα measurements. The problem of the geocorona certainly deserves much more attention than it has received.

During the IQSY, Commission VIII joined with the Panel on Small Rocket Experiments of COSPAR WG-2 in promoting many forms of space observations for aeronomy. These included programs for the study of atmospheric density and composition versus height by means of the techniques of mass spectrometry, falling spheres, grenades, and atmospheric attenuation of solar radiation. Electron and ion density profiles were observed by means of Langmuir probes and ion traps. Upper atmosphere winds were traced with luminous vapor releases.

For the immediate future we may have available a new generation of satellites that promises to provide continuous and spectrally detailed photometry. In combination with ground-based ionospheric profile measurements these refined data should greatly improve our quantitative understanding of ionospheric production and loss processes and the thermal input to the atmosphere. Commission VIII of IAGA should take the opportunity in the coming Years of the Active Sun to assist the IUCSTP in identifying the most important projects for solar-terrestrial research and to play a major role in organizing contacts.

SCIENTIFIC SESSIONS
E. A. Lauter — Reporter

The Scientific Session on Aeronomy was held September 30. The program included the presentation of papers VIII-19,-22,-23, and -26 (see **IAGA Bulletin** No. 24), and an additional paper by Mrs. Shapiro (USSR), read by Dr. Taubenheim, which was concerned with "Ionospheric Temperatures from Ground-Based Measurements."

The main results of the session may be summarized as follows:

1. There is a clear evidence for a change of aeronomical structure with season in the 60-75 km region, as deduced from ionizing effects during sunrise (Wagner et al.).

2. The measurement of X-ray and EUV-absorption on the turbopause region by rockets allows the determination of 0_2 - number density with an extreme accuracy, so that daily variations may be deduced (Grobecker).

3. The luminosity of the geocorona, as deduced from ground-based measurements, appears to be connected with solar activity in the manner to be expected from escape processes (Tinsley).

The common feature of most papers in the session on the ionsphere was that they dealt with interdisciplinany or morphological problems involving data from different groups. While all papers contained important points for specialists on the subject, the highlights included correlated changes in D-region electron density and mesospheric wind systems during stratwarm phenomena and distortions of the E and F 1 layers associated with dynamo currents.

IAGA-URSI SYMPOSIUM ON UPPER ATMOSPHERIC WINDS, WAVES AND IONOSPHERIC DRIFTS

Dr. C. O. Hines — Chairman

The primary objective of this symposium was an improvement in our understanding of the physical significance of ionospheric drifts in terms of upper atmospheric winds or waves, or other processes. Strong empirical evidence was presented to the effect that drift measurements low in the E region and in the D region give a realistic determination of true neutral gas winds, insofar as prevailing and tidal components are concerned, and even on shorter time scales at least on occasion. Strong evidence was also presented to the effect that "traveling ionospheric disturbances" (TID's), and very likely other drift measurements in the F region, are caused by atmospheric gravity waves. The latter evidence was extrapolated into the E region by virtue of TID-associated sporadic-E patches, and there were explicit and implicit indications that the corresponding waves would make some contribution to the drift observations low in the E region.

It was apparent that different techniques tend to select different components of the total dynamical systems, but no explicit identification of the various tendencies was defined. It was also apparent that techniques of drift-data analysis more sophisticated than those currently in common use will be required if the major remaining ambiguities are to be resolved.

WORKING GROUP VIII-3, METEORS
T. R. Kaiser — Reporter

To begin this survey, it may be useful to define, as the reporter sees it, those aspects of meteor science that are relevant to IAGA. On one hand, meteors provide tracers for upper atmospheric studies, and, on the other, they are a part of the total atmospheric phenomenon, and hence we are concerned with the interaction of meteoric dust with the upper atmosphere and its physical implications.

In reporting on the development in this subject area since the Berkeley assembly, it is appropriate first to draw attention to the expansion of the radio-meteor methods for studying winds in the meteor zone. A number of groups are now active, but all are situated in middle latitudes. It is therefore appropriate to point to the importance of encouraging the extension of this field of work to equatorial and polar regions. Several papers on recent work concerning meteor winds will be presented in this assembly.

Observations of enduring luminous meteor trains offer an opportunity to study detailed aspects of the wind structure in the meteor zone, similar in this respect to rocket release experiments. It appears also that the luminosity in the trains results from mutual neutralization of positive and negative ions yielding neutrals in excited states. Thus, measures of the decay of the luminosity yields information about the rate of negative ion formation, which is of considerable importance for the understanding of the equilibrium of the D region of the ionosphere. In this respect, photoelectric and image orthicon techniques for meteor studies are likely to be worthy of development. In recent years, the study of luminous meteor trains by various techniques has been an important aspect of the meteor program in the USSR.

In the field of meteor physics, there are several recent developments to which attention should be drawn. Recent progress in the understanding of the meteor ablation process has important implications in aeronomy. It is now realized that the inclusion of the thermal radiation term leads to a height ceiling in the ablation of small meteoroids and of large meteoroids that fragment into small particles before the onset of ablation. The resulting predictions of rates of collisional ionization and of deposition of meteor atoms have important implications both as regards the E region and the airglow.

The exponential decay of radio echoes from underdense meteor trains gives a measure of the ambipolar diffusion coefficient, which is relevant to many processes involving ionization in this height region (80-110 km). Although it has long been realized that above altitudes of about 95 km the earth's magnetic field may have a controlling effect (mainly through the electrons), only recently has it been predicted that this will only be significant for meteor trains aligned within somewhat less than one degree from the geomagnetic field direction. This prediction has been confirmed from UHF radio-echo experiments, which reveal a pronounced magnetic aspect sensitivity in the observed meteor rates.

Effects of meteors on the ionosphere have also become apparent in changes in the phase variations of VLF signals at sunrise and sunset during periods of enhanced meteoric activity.

Electron attachment in meteor trains, referred to above in connection with their luminosity, has also been studied by the radio-echo technique. The results for attachment rates are in good agreement and confirm that the process is a three-body one, at least below about 95 km altitude. Recent radio meteor observations have also revealed the effect of photo detachment in increasing the lifetime of the ionized trains during the daytime.

Finally, it is important to note that an anomalous increase in the radio-meteor rate in 1963 was reported by workers in New Zealand and Canada. As it has been suggested that this might be due to atmospheric changes during the sunspot cycle, it will be important to continue regular meteor counts during the coming years.

WORKING GROUP VIII-4, GEOCORONA AND MAGNETOSPHERE

F. S. Johnson — Reporter

During the past few years, one of the most interesting developments concerning the exosphere or geocorona has been the detection of a winter density bulge by Keating and Prior (1967a). They identified the bulge as being due to anomalously high helium concentrations (Keating and Prior, 1967b).

Helium was first recognized as an important constituent of the upper atmosphere (Nicolet, 1961) because of its effects on satellite drag. In an atmospheric region in which helium is the principal constituent, the relative magnitudes of perturbations of satellite drag — for example with geomagnetic activity — are less than at altitudes where a heavier constituent, such as atomic oxygen, predominates. Near solar minimum, the region dominated by helium lies near the base of the exosphere, and it is rather thin, extending roughly over the region from about 600 to 1000 km. If the helium concentrations were increased by some mechanism, the density of this atmospheric region would be increased without significantly affecting regions much lower or higher than this region of helium dominance.

The question that arises then is what conditions can cause the helium concentration to change over the winter polar region. Colegrove et al. (1966) have shown how eddy mixing near the turbopause controls the helium distribution there and at higher levels. As the rate of eddy mixing decreases, the helium concentration in the thermosphere and exosphere increases, and the degree of oxygen dissociation should also increase, the atomic oxygen concentrations increasing and the molecular concentrations decreasing. The oxygen concentrations over the winter polar region where the dissociating sunlight has been cut off are not known very well, and the lower latitude distributions probably provide as good an approximation to the winter concentrations as can be provided at this time. The helium concentrations can be increased by a factor of 5 by decreasing the eddy mixing coefficient by a factor of 10; argon concentrations decrease by about a factor of 2 under these conditions. This therefore provides an explanation of how helium enrichment of the upper atmosphere over the winter polar regions might be brought about. However, outflow in the exosphere will counteract this effect. McAfee (1967) has computed lateral transport associated with temperature differences. His calculations are not entirely relevant to the case under discussion, but they suggest that outflow in the exosphere associated with a 50 percent increase in helium abundance might require a vertical upward flux of 4×10^8 atoms/ cm^2-s in the polar region to balance it. This is very large compared to the average escape rate, approximately 10^6 atoms/cm^2-s. It is also almost an order of magnitude greater than the escape flux of helium from the homosphere that can be maintained in a region where the scale height is 7 km and the molecular diffusion coefficient 5×10^5 cm^2/s. Therefore outflow in the exosphere would limit the helium buildup associated with a decrease in eddy mixing in the winter polar region to a value much less than a 50 percent increase — much less than the observed increase.

A more powerful means of concentrating helium in the winter polar region is lateral flow toward the polar region at the turbopause and higher altitudes. The fact that the high-latitude upper atmosphere remains warm even when the solar heating has been cut off in winter indicates that there is downward flow there. The magnitude of these currents can be approximated from the magnitude of the solar heat source that is present at low latitudes but is missing over the winter polar region, since the atmosphere there is approximately as warm as at low latitudes. The rate of heat release per unit volume by the downward motion of the gas is

$$w\, C_p\, \rho\, \frac{dT}{dZ} + w\, g\, \rho\ ,$$

where w is the downward velocity, Cp, the specific heat at constant pressure, ρ the density, g the acceleration of gravity, and $\frac{dT}{dZ}$ the temperature gradient. This can be equated to the average rate of input of solar energy at low latitudes and solved for w, the vertical downward velocity, and the result is shown in figure 1.

The poleward horizontal velocities at 60° latitude required to compensate for the vertical motion are approximately

$$v = \frac{R}{4H}\, w,$$

where R is the distance to the center of the earth and H is the scale height. The required horizontal velocities are also shown in figure 1; these are the values that would be required if the inflow into the polar region were symmetrical with regard to longitude, but the actual inflow is apt to be greater on the daytime side and less (probably negative) on the nighttime side, averaging to the values indicated here.

The horizontal flow above the turbopause is relatively more efficient in the transportation of helium than of heavier atmospheric constituents, in proportion to the scale height. The transport across the 60° latitude circle is

$$\pi R v H_i n_i \text{ atoms/sec,}$$

where n_i and H_i are the concentrations and scale heights for the various atmospheric constituents. The downward flow is

$$\frac{\pi R^2}{4} \; w \, n_i \, ;$$

it does not involve the scale height. The data given in figure 1 indicate a helium inflow, averaged over the whole polar region above 60° latitude, of about 10^9 atoms/cm^2 -s. The loss downward is about 1.4×10^8, leaving an excess for loss by lateral flow in the exosphere near 10^9 . McAfee's results which appear to indicate an outflow of 4×10^8 for a 50 percent increase in helium concentration would therefore be consistent with an increase by a factor of about two for a source of this strength.

The increase in helium abundance in the upper atmosphere over the winter polar region appears to have been confirmed by airflow observations by Tinsley (1967a) and by rocket measurements at Ft. Churchill by Hartmann et al. (1967). Hedin and Nier (1966) have also observed increased helium concentrations at White Sands in winter.

Tinsley has also obtained evidence from Balmer alpha airglow measurements of a variation in the hydrogen concentrations in the upper thermosphere and exosphere (Tinsley, 1967b). For hydrogen, the exospheric concentrations are apparently dominated by the sunspot cycle, the maximum concentrations occurring near sunspot minimum when exospheric temperature and escape rates are relatively low. The solar-cycle control of exospheric hydrogen abundance was predicted by Johnson (1961) and Kocharts and Nicolet (1962), but Tinsley's observation is one of the first experimental confirmations of the effect.

The outstanding development of the past few years with regard to the magnetosphere has been Ness's observation of the elongated open tail (1965). This observation was anticipated, first of all by Piddington (1960) on theoretical grounds. Piddington's model involved the concept of pulling the geomagnetic field lines outward by the solar wind. Later Dessler (1964) arrived at a somewhat different model on the basis that the tail would be blown open by the action of hydromagnetic waves. Ness's observations are summarized in figure 2. The reason for the elongated open tail is still in some doubt, but it appears that it is best explained by the penetration of solar plasma that divides it and produces the neutral sheet (Fejer, 1965).

The most recent observations of magnetospheric interest have been the observations by Ness et al. (1967) and by Colburn et al. (1967) that there is no shock wave in the solar wind in front of the moon and no significant long magnetospheric tail behind the moon, contrary to predictions by Gold (1966). This can be understood in terms of a moon of very poor conductivity, as suggested by Ness, or in terms of a core of high conductivity provided there is an insulating surface layer, as indicated in figure 3 (Johnson and Midgley, 1968). For the case of poor conductivity, the magnetic field lines pass through the moon readily. For the case shown in figure 3, the field lines are excluded from the high conducting core by currents on its surface. The field lines slip around within the insulating layer from the front side to the back side of the moon, as seen from the sun. Currents at the boundary of the solar wind plasma prevent the field perturbations in the boundary layer or in the tail from being seen within the plasma; the insulating layer at the lunar surface must be thick enough (approximately 5 percent of the lunar radius) to provide space for the magnetic field entering the front half of the moon without building up the field strength to a value sufficient to turn back the solar wind, otherwise a shock wave would develop. The length of the tail depends upon the temperature of the plasma, and for the accepted solar wind parameters ($T \approx 10^5$ °/K), the length of the tail should be about 10 lunar radii. The tail is characterized by the lack of plasma in it, and the magnetic field is perturbed very little except very close to the moon.

The plasma flow behind a perfectly insulating moon is shown in figure 4. The flow of the plasma into the plasma shadow gives rise to a rarefaction wave in which the magnetic field is reduced to as little as half its undisturbed value (Colburn et al.,

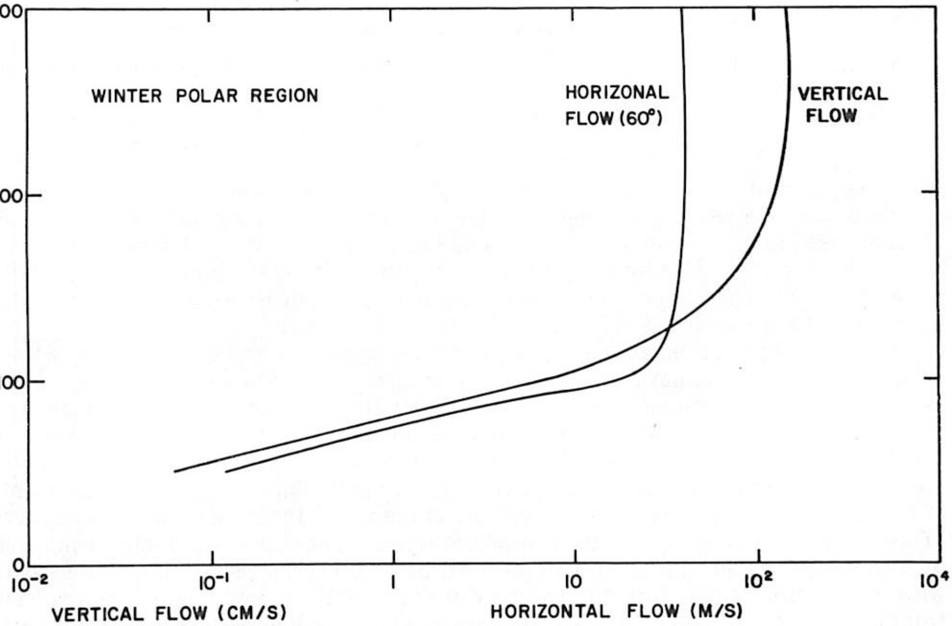

Figure 1. Vertical downward velocities over the winter polar region and horizontal flow velocities at 60° latitude.

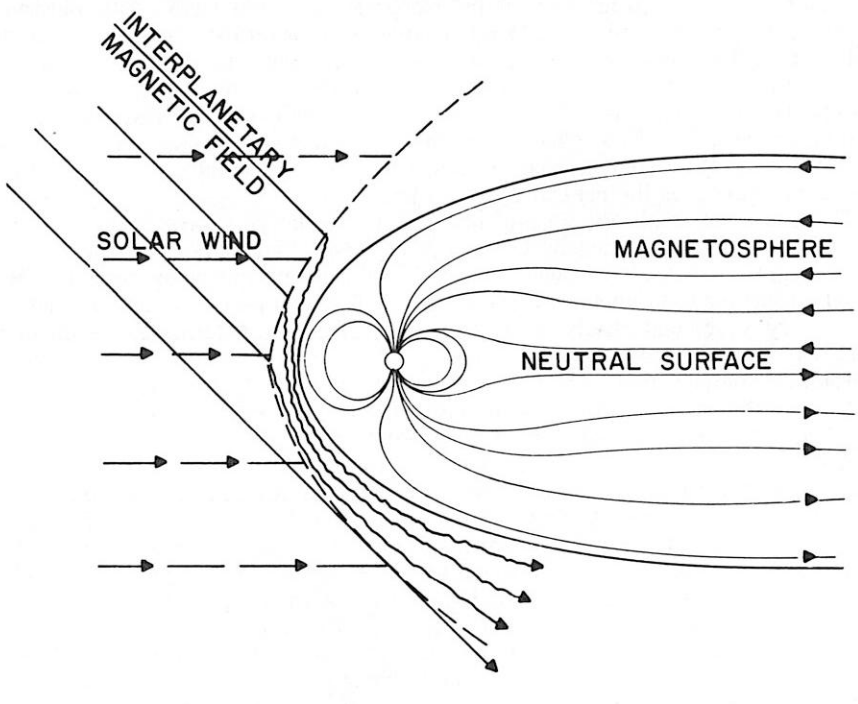

Figure 2 The tail of the magnetosphere as observed by Ness (1965).

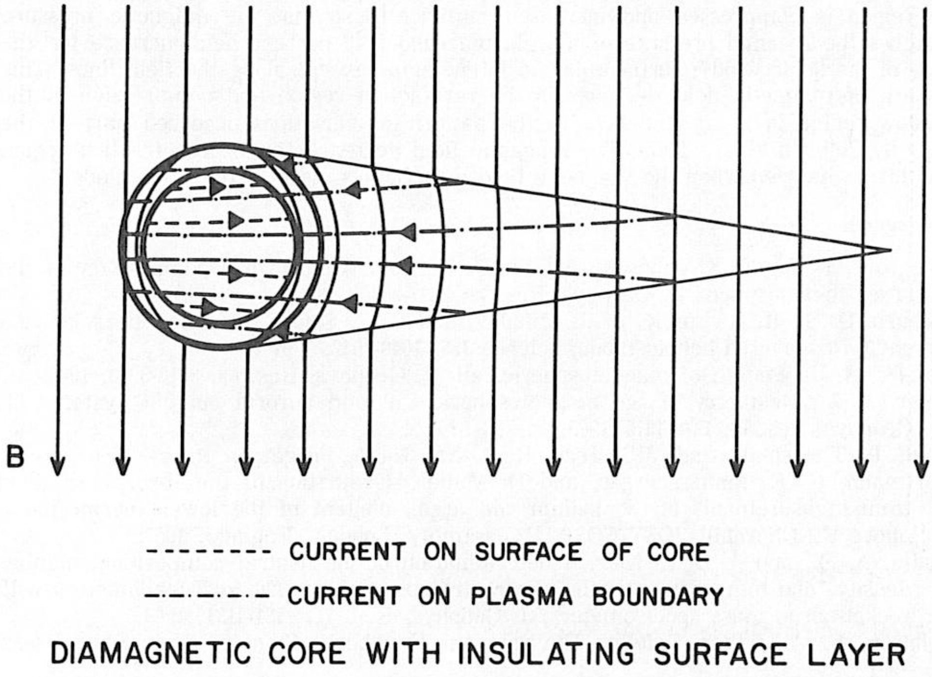

Figure 3 The magnetosphere of the moon.

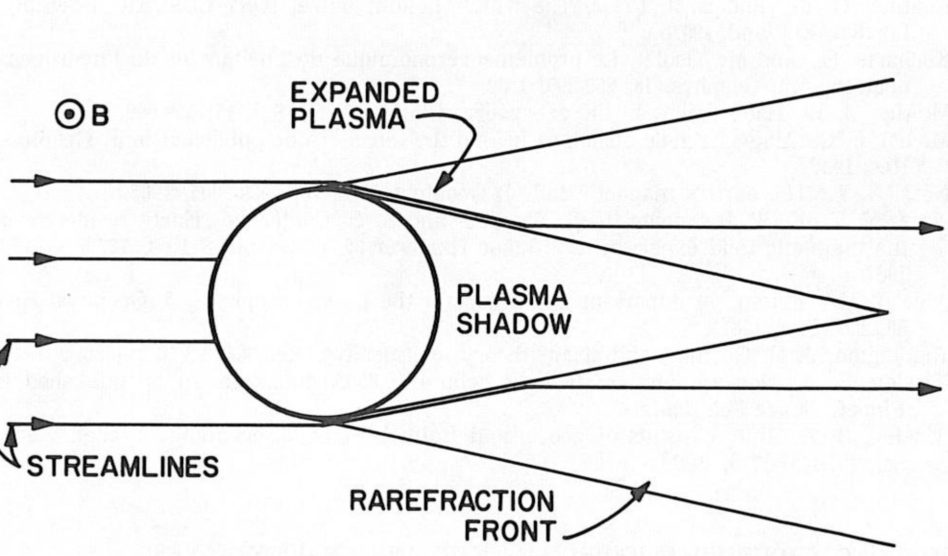

Figure 4 The plasma flow behind a perfectly insulating moon.

1967; Johnson and Midgley, 1968; Michel, 1968). The magnetic field in the plasma shadow region is compressed and increased sufficiently so that the magnetic pressure matches the thermal pressure of the plasma (about 40 percent field increase for the case of the solar wind); further plasma inflow stops except along the field lines. This pattern of magnetic field decrease in the rarefaction region and compression in the shadow region is in agreement with the pattern of variations observed part of the time by Colburn et al. (1967). The magnetic field decreases in the rarefraction region should not be seen when the magnetic field direction is close to the orbit plane.

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WORKING GROUP VIII-6, HYDROMAGNETIC AND GRAVITY WAVES
M. Sugiura — Reporter

Much work has been done in this area since the time of the last general assembly in 1963. As a part of the activity of this Working Group, a list of publications concerning hydromagnetic and gravity waves in the earth's environment is being prepared. Though still very incomplete such a list is presented at this meeting. The following is a brief review of some of the developments that have taken place in this field in the past 4 years.

Large Scale Hydromagnetic Disturbances

Large scale disturbances in the magnetic fields and plasmas in the magnetosphere are generally hydromagnetic in nature. An axially asymmetric inflation of the magnetosphere by a partial ring current, the existence of which was originally suggested by Akasofu and Chapman (1964) from their study of ground magnetic observations, has actually been observed by a satellite-borne magnetometer by Cahill (1966), and has been investigated by Parker (1966), Cummings (1966), Akasofu (1966), and others. How the circuit of the partial ring current is closed is not yet definitiely known and hence its effect at the earth is still not clear. However, the recent observation by OGO-2 (POGO-1) satellite indicates no or little return current in the ionosphere (Langel and Cain, 1967).

Heppner et al. (1967) have shown evidence that β (the ratio of the plasma energy density to the magnetic energy density) is often nearly 1 or greater just inside the magnetosphere boundary around the dawn and dusk meridians and within dipole latitudes of $\pm$ 15°. They have suggested that the hydromagnetic pressure balance at the magnetosphere boundary in these regions may be of different nature from that on the day side of the magnetosphere, and that instabilities may take place resulting in entry of solar wind plasmas into the magnetosphere from these regions.

Electrodynamics of the magnetosphere and the geomagnetic tail during magnetic storms has been studied by many workers (e. g., Axford, 1965; Dungey, 1966; Akasofu, 1966). The exact nature of the interaction between the solar wind and the magnetosphere and what role the geomagnetic tail plays in magnetic disturbances still remains an outstanding unresolved problem.

Hydromagnetic Waves

Hydromagnetic waves of periods of one to a few minutes have been detected in the magnetosphere by satellite measurements, and transverse and longitudinal waves have been identified (e.g., Patel and Cahill, 1964; Patel, 1965). Some of these waves propagate to the earth along lines of magnetic force and are observed at magnetically conjugate areas as magnetic pulsations (Nagata et al., 1963). However, attempts to explain these waves by resonant oscillation of the lines of force of the earth's magnetic field have not been successful (Radoski, 1967), and a model involving a current along lines of force has been proposed (Cummings and Dessler, 1967). It appears that waves in the magnetic field and the plasma must be treated in a self-consistent manner, including currents along the lines of force and those in the ionosphere.

Hydromagnetic waves of periods of a few minutes are often observed just inside the magnetosphere boundary (e.g., Heppner, 1965; Heppner et al., 1967). It seems that waves of this nature are likely to be observed more frequently on the dawn and dusk sectors, though this feature has not been established statistically.

Hydromagnetic discontinuities have been observed in the solar wind; a sudden change in ion flux coincident with a sudden magnetic field change characterize these discontinuities (Sonett et al., 1964; Gosling et al., 1967a, 1967b). Colburn and Sonett (1966) have shown that a discontinuity in the solar wind could be either a shock or a tangential discontinuity without a shock structure. Both shocks and tangential discontinuities could produce SC's or SI's on the earth. Examples of tangential discontinuities that produced an SC or SI have been reported (Gosling, 1967b). SI's have been observed inside the magnetosphere, confirming the idea that SI's are responses of the magnetosphere to sudden changes in the solar wind pressure exerted on it (Nishida and Cahill, 1964).

Much observational data have accumulated concerning a class of hydromagnetic waves of frequency from 0.2 to 5 cps, which are called by various names, such as hydromagnetic emission, hydromagnetic whistlers, pearl-type micropulsations, or pc 1 pulsations. These waves have characteristic repetition patterns and a dispersive property (e.g., Troitskaya, 1961; Tepley, 1966; Kenney and Knaflich, 1967). The generation of these waves has been studied theoretically by many authors (e.g., Obayashi, 1965; Cornwall, 1965; Jacobs and Watanabe, 1965; Hultqvist, 1965; Liemohn, 1967; Cocke and Cornwall, 1967). These waves can be generated by energy exchange between waves and nonthermal charged particles. The mechanism involved is the cyclotron resonance that occurs when Doppler-shifted wave frequency (as seen by streaming particles) matches the proton cyclotron frequency. The problem is that of enhanced diffusion in velocity space by waves and is of importance in determining particle behaviors in the radiation belt (Trakhtengerts, 1963, 1965; Andronov and Trakhtengerts, 1964; Cornwall, 1966; Kennel and Petschek, 1966). Plasma densities in the magnetosphere can be inferred from the observations of these hydromagnetic waves and the results are found to be in good agreement with electron densities deduced from whistler observations (Wentworth, 1966; Watanabe, 1965).

Gravity Waves

The role of internal gravity waves in transmitting energy from the lower levels of the atmosphere to ionospheric heights has drawn considerable attention. Detailed theoretical investigations of gravity waves have been made by many workers (Hines, 1963, 1965a, 1965b; Tolstoy, 1963; Pierce, 1965, 1966; Friedman, 1966; Midgley and Liemohn, 1966; Daniels, 1967). Viscous damping (Pitteway and Hines, 1963), reflection and ducting (Pitteway and Hines, 1965), the effect of wind shear (Hines and Reddy, 1967), heat conduction (Volland, 1967) and the possibility of generating turbulence by gravity waves (Hodges, 1967) have been investigated.

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COMMISSION IX
HISTORY OF GEOMAGNETISM AND AERONOMY
N. Pushkov — Chairman

This commission was formed at the IAGA assembly in Toronto in 1957. At that time it had only seven members from five countries. By the time of the first meeting of the Commission in 1960 in Helsinki, there were 35 members, recommended by national correspondents of IAGA. Fourteen scientific reports were submitted, of which only one, "The History of Magnetic Investigations in Finland," by Professor Keranen, was presented; the others were reported by title only. All the reports were duplicated and distributed among the members of the Commission. It was decided at the Helsinki meeting to concentrate on the history of geomagnetism and aeronomy in separate countries and on the biographies of outstanding scientists.

The second meeting of the Commission was held in 1963 in Berkeley. By that time two main trends in the work of the Commission had been defined:

1. Elaboration of the question on the history of geomagnetism and aeronomy as it was planned at Helsinki.

2. Compilation of the general report on the development of geomagnetism and aeronomy on the basis of national reports presented to the IAGA assemblies.

The Commission heard four scientific reports and discussed the possibility of bringing the task of the Commission into life. It was recommended that retired persons should be invited to participate in the work of the Commission.

Before the third meeting of the Commission at St. Gall a letter was sent to the members of the Commission with the request to report on their work and about their wish to remain members of the Commission for the next term.

Positive answers to the second question were received from 20 persons from the following countries: Belgium (1), Denmark (1), Finland (1), Great Britain (2), Mexico (1), New Zealand (2), Rumania (2), Japan (3), Hungary (3), USA (2), and USSR (2). The members of the Commission have recently worked on the following:

1. Dr. H. G. Kozber (GDR) published six papers devoted to the history of the Potsdam magnetic observatory and to a description of the old magnetic instruments. He is working at present on the history of discovery of magnetic daily variations. The

history of the Geomagnetic Institute in Potsdam is given in Professor Fanselau's speech at the celebration of the 75th anniversary of the institute.

2. Professor J. Keranen (Finland) wrote a historical review on the activity of the Geophysical Institute in Sodankyla.

3. Professor S. Chapman (U.K.) wrote a biographical report on aurora and airglow for the symposium at Keele University, which will be published later.

4. Dr. J. Jacobs (U.K.) is studying original correspondence of Edward Sabine, stored in the archives of the Meteorological Office.

5. Professor A. Kimparo (Japan) has worked out the history of investigations of atmospherics in Japan and in the near future intends to study the history of investigations of ELF and VLF emissions.

6. Professor S. Matsushita (Japan) has studied the history of the knowledge of magnetism and geomagnetism in ancient Japan.

7. In 1966, the Institut Physique du Globe (France) published a very valuable paper on the history of magnetic telluric investigations.

8. Professor G. Barta (Hungary) has studied the history of geomagnetic investigations in Hungary in connection with the celebration in 1969 of the 100th anniversary of the Hungarian Meteorological Institute.

9. Professor A. Tazczy-Honrock has studied maps of magnetic declination with the aim of obtaining reliable data on secular variation of declination.

10. Professor L. Constantinescu (Rumania) has studied early geomagnetic measurements on the Rumanian territory.

11. Dr. N. C. Gerson (USA) has studied the history of investigations of the sporadic E layer in the western hemisphere.

12. N. E. Malinina (USSR) has studied the history of investigations of the permanent magnetic field of the territory of the USSR.

13. Professor M. Nodia (USSR) has written a history of the Tiflis Magnetometeorological Observatory.

* * *

The third meeting of the Commission was held in St. Gall September 28, 1967. It was attended by 26 persons. The following nine reports were read:

W. J. G. Beynon — Biographical Sketch of Professor E. Appleton.

S. Chapman — Biographical Sketch of Professor J. Bartels.

H. Odishaw — Biographical Sketch of Dr. L. Berkner.

A. Kimpara — The Development of the Study of Atmospheric Whistlers in Japan for the last 41 years.

P. H. Serson — Toronto Magnetic Observatory 1830-1967.

G. Barta — History of Geomagnetic Research in Hungary (presented by Professor L. Constantinescu).

L. Constantinescu — Early Geomagnetic Measurements on the Rumanian Territory.

N. Pushkov — Development of the Magnetic Observatories in the USSR for the last 50 years.

N. Pushkov — Short Report on the Activity of the Commission Since the Berkeley Meeting 1963.

One paper by N. C. Gerson, "A Historical Survey of Radio Wave Propagation to the Antipode," was presented by title.

N. Pushkov was reappointed as Chairman of the Commission for the new term by the Executive Committee.

JOINT IAGA-IAMAP COMMITTEE
ATMOSPHERIC ELECTRICITY
L. Koenigsfeld — Chairman
H. Dolezalek — Secretary

Three business sessions were held in Lucerne, under the direction of Chairman Koenigsfeld and Secretary Dolezalek. Calls for items of discussion were distributed to all members early in 1967, and the agenda for all three sessions were distributed to all members during the summer of 1967.

At the first session, held on September 29, the four-year reports (1963-1967) of the working groups and of the Joint Committee as a whole, as submitted to IAGA and IAMAP earlier this year, were approved by the members of the Joint Committee. A few guidelines for the work of the nine working groups were agreed upon, and then the officers and members of the Joint Committee and its nine working groups were elected, after much discussion. The names of those elected as finally approved by both IAGA and IAMAP are given in a later section of this bulletin.

The second session was held on September 30. The Joint Committee decided to establish closer relationships with some commissions of IAMAP and of IAGA, and some groups outside UGGI. Liaison officers have been appointed. Contacts will be sought by letters written by the Joint Committee to the other bodies, and the liaison officers will be quoted in these letters. A better mutual exchange of information on meetings, working areas, and resolutions and recommendations will be attempted.

Working Group IV was asked to organize a conference on ions, aerosols, and atmospheric radioactivity, to be held about 1970. Working Group VIII was asked to prepare a special conference on atmospheric electric measuring methods and apparatuses and their applications in field experiments, to be held prior to the XVth General Assembly. Several additional tasks were assigned to different working groups, such as an organized exchange of addresses, information on industrially produced instruments for atmospheric electricity, collection of reprints, and dissemination of bibliographies. It was decided that in the future during elections of members and/or officers all who are not members of the Joint Committee will be asked to leave the room.

The third session, held October 3, was dedicated to the discussion of a 10-year program of coordinated and intensified research in atmospheric electricity aimed at the investigation of the atmospheric electric global circuit. A rather voluminous booklet on these problems had been distributed several months ago, and a short paper on it had been presented during the Symposium on the Electrical Phenomena in the Atmosphere and Space on Thursday, September 28, 1967, at St. Gall. Previously, the preparation of such a program had been agreed upon by the business meeting of the Joint Committee in May 1965 in Paris.

The idea of conducting such a program is a rather old one. Lord Kelvin had proposed a similar program in 1858. The atmospheric electric work done by the vessel **Carnegie** between 1909 and 1929 was essentially a similar program though restricted to one of the three main research areas of the present program. These three areas are: (1) the global thunderstorm activity, measured (at least at first) by measuring the global lightning activity by different methods; (2) the potential difference between ground and ionosphere, measured again by different methods simultaneously; (3) the air-earth current density measured at globally representative stations in many parts of the world, again simultaneously. An additional area of research can be carried out at all atmospheric electricity stations, namely the investigation of relations between atmospheric electric parameters and fair-weather meteorology. This latter goal can be approached if the potential difference between the ground and ionosphere is known, because only then and during the absence of local generators (i.e., under certain conditions during fair-weather periods) the value actually measured is the columnar resistance that reflects certain meteorological parameters in the atmospheric column above the station. It is planned to intensify and coordinate measurements within all three areas during certain rather short periods within the period of 10 years. The approach is a rather modest and realistic one. It is expected that about 100 stations will participate, but it is assumed that useful results will seldom be obtained from more than 20 stations at a time. Already this is a worthy goal.

The general plan has been discussed with the Secretaries of both IAGA and IAMAP. It is hoped that an agreement with WMO can be obtained since the WMO established a special working group that will have to deal with something like this program. It was decided to draft a brochure which will serve to obtain the collaboration of the 100 or so stations. A special committee was established to prepare the draft and the result will be presented to the members of the Joint Committee during the Fourth International Conference on the Universal Aspects of Atmospheric Electricity in May 1968 in Tokyo.

SYMPOSIUM ON THE ELECTRICAL PHENOMENA IN THE ATMOSPHERES AND SPACE, PART I

S. C. Coroniti — Convenor and Chairman

This session was held September 2, 1967, at St. Gall. The program was essentially the same as that outlined on page 18 of **IAGA Bulletin** No. 24, except that the papers by Yu. A. Gragin (X-1), A. L. Oster and H. Dolezalek (X-5), and H. Dolezalek (X-11) were not given. Paper X-12 was shifted to Part II of the Symposium. Abstracts of two papers not previously published follow.

"Preliminary Balloon Measurement of Negative Small Ion Density" (X-3). Tosio Takeuti, Haruji Ishikawa, and Akira Iwata, Research Institute of Atmospherics, Nagoya Univ., Japan.

Variation with altitude of negative small ion density in the troposphere and stratosphere was measured with a Cerdien condenser suspended from a plastic balloon. The condenser with a microblower producing an air flow of 109 1/min was connected horizontally to the balloon with 1.6-mm nylon cord of 50-m length.

The experiment was originally intended to include a level flight measurement. However, this could not be achieved because of the blower trouble encountered after the balloon went up through the -70°C region of the stratosphere. The measuring system was confirmed to be in a normal operating condition during most of the ascent up to about 20 km. It has been found that the small ion density profile has a maximum in the altitudes from 11 to 16 km and the density in this altitude region amounts roughly to 5×10^9 ions/cm^3.

"Characteristics of Whistlers During IGY and IQSY at Low Latitudes" (X-23). A. Kimpara, Chubu Institute of Technology, Japan.

The characteristics of whistlers are described during IGY and IQSY, in particular the frequency of occurrence and the dispersion correlated to solar and geomagnetic activities. The maximum occurrence was found in February, while the minimum was in June in IGY but in July or August in IQSY. As to the diurnal variation, no definite tendency was found in general, but in February, the most active month in the two periods where there were abundant reliable data, two clear maxima were found, one occurring 1-2 hours before sunrise, and the other in the evening (at sunset in IQSY and 2-3 hours after sunset in IGY).

"The Nature of the Electric Field in Space" (X-9). R. Bostrom, Royal Institute of Technology, Stockholm, Sweden.

In interplanetary space, the degree of ionization is so high that electric and magnetic forces on charged particles are of primary importance for the dynamics of matter. In this case the electric field cannot be discussed as a separate entity as its description is a part of the general treatment of the motion of the plasma. However, the atmosphere of the earth differs from outer space in that motions of neutral matter are not strongly influenced by electric fields. The lower ionosphere serves as a border between these two regions of space and is a natural border between space physics and atmospheric electricity.

The solar wind which sweeps past the earth can set up electric fields in the outer parts of the earth's magnetosphere. These fields extend down into the high-latitude ionosphere. During magnetic storms and auroras they drive currents and produce drift motions of the ionization which may be used to study the electric fields themselves. We may expect considerable potential differences in the high latitude ionosphere. To some extent these may affect the electric field in the lower atmosphere and in this way all regions of space are parts of the same gigantic electric circuit. Simultaneous measurements of the potential differences between the earth and the ionosphere at several points in high latitude regions are highly desirable.

SYMPOSIUM ON THE ELECTRICAL PHENOMENA IN THE ATMOSPHERES AND SPACE, PART II

T. W. Wormell — Chairman; S. C. Coroniti — Convenor

Abstracts of papers presented at this session, held September 28, 1967, in St. Gall, are given below.

"Electric Field Strength Observations with a Probe Ejected from a Rocket." L. Unger and K. Rawer, Ionospharen-Institut, Freiburg, Germany, F. R.

A sensitive, temperature-compensated, measuring device for small potential differences uses detuning of one resonance circuit in a twin oscillator. Both independent oscillations are transposed to higher harmonics, mixed and amplified and emitted as one modulated carrier. The system was applied with two probes ejected at 360 and 300 km from a rocket. From observed changes of the modulation frequency, potential differences up to 1 mV have been deduced.

"A New Technique for Measuring Electric Fields in the Ionosphere." Wolfgang Pfister, Air Force Cambridge Research Laboratories (OAR), Bedford, Massachusetts 01730, USA.

Retarding potential analyzers with plane parallel grids are used consistently in the positive ion mode for the measurement of vehicle potential. During an auroral rocket flight a spin modulation of the vehicle potential was observed with a detector mounted on an arm and looking in the direction of the flight. Since the aperture of the detector is at rocket potential, the modulation is interpreted as due to an electric field component perpendicular to the rocket axis. In addition, the collection efficiency of the retarded potential analyzer in the electron mode is sensitive to the amplitude and direction of the electric field. Therefore, the spin modulation of the electron current can also be used to measure the perpendicular component of the electric field. Preliminary inspection of the data for several auroral flights revealed that the electric field usually is below 100 mV/m but may reach a value as high as 2 V/m.

"A Cesium Ion Beam Electric Field Meter for Space Research." S. H. Levine and S. R. Harrison, Northrop Corporation Laboratories, Hawthorne, California, USA.

The deflection of a cesium ion beam can be used to measure small electric fields in space with the same sensitivity as electrons, provided the beam energy is the same. In addition, the cesium ion beam can operate in magnetic fields 500 times greater than the electron beam device.

The feasibility of employing a cesium ion beam electric field meter has been investigated experimentally in the laboratory using two types of cesium ion sources. The first source used radiant heating, the other electron bombardment heating. Excellent results were obtained with these sources, attaining a sensitivity for measuring electric fields of 0.03 V/m. Methods for attaining sensitivities of the order of 0.01 V/m are possible. This device can be employed at the surface of a vehicle moving through the ionosphere so that it measures the electric field both inside and outside the plasma sheath. Under these conditions, the potential sensitivity of this instrument is much greater.

ADDITIONAL MEETINGS HELD BY THE JOINT IAGA-IAMAP COMMITTEE ON ATMOSPHERIC ELECTRICITY

The Joint Committee held the following five symposia in Lucerne, Switzerland, during the assembly:

1. Electrical Phenomena in the Atmosphere and Space, September 29; S. C. Coroniti, Convenor; H. Israël, Chairman.
2. Nature of Lightning, October 3; S. C. Coroniti, Convenor; L. B. Loeb, Chairman.
3. Fair and Disturbed Weather Electricity, October 4; S. C. Coroniti, Convenor; R. Mühleisen, Chairman.
4. Atmospheric Ions and Aerosols, October 5; J. Bricard, Convenor; R. Siksna, Chairman.
5. Atmospheric Radioactivity and Aerosols, October 5; J. Bricard, Convenor; H. Israël, Chairman.

The program for these symposia are listed in **IAGA Bulletin** No. 24, but the abstracts were not available when the bulletin was published. These abstracts are not included here as they will appear in the **Report of Proceedings of the International Association of Meteorolgy and Atmospheric Physics,** Toronto, 1968, which is now in preparation. Short reports of two discussions that were not on the original program are given below.

Discussion on the Mobility of Atmospheric Ions
J. Bricard — Convenor; H. Dolezalek — Chairman

During the XIV General Assembly of the Union Géodésique et Géophysique Internationale (UGGI) a special discussion on the mobility of atmospheric ions was conducted on October 2, 1967, in Lucerne. All scientists working in this particular field in all countries and known to the Joint Committee on Atmospheric Electricity had been invited. Some of them had spent considerable time in preparing this discussion and some preliminary discussions between some of these scientists had been conducted prior to their coming to Lucerne. About 35 scientists attended.

Following the opening words of J. Bricard, Chairman of Working Group IV (Ions, Aerosols, Radioactivity) of the Joint Committee on Atmospheric Electricity, papers were presented by K. G. Vohra (India), G. Madeleine (France), L. B. Loeb (USA), V. Mohnen (USA), and R. Siksna (Sweden). After these papers, which will be published elsewhere, particular questions were formulated by the Chairman and answered one by one.

The results of the discussion were formulated by a committee consisting of J. Bricard (France), H. Dolezalek (USA), L. B. Loeb (USA), V. Mohnen (USA), A. Pedersen (European Space Laboratories), and R. Siksna (Sweden) as follows:

1. In the real free atmosphere we do not expect any positive 0_2 or N_2 ions in the troposphere and somewhat higher up.
2. The problem of the negative ions should be discussed at a future conference.
3. Provided that some reasonable but only partially proven assumptions are true, we expect a mixture of

$$(H_3 0)^+ \quad \text{and } (H_3 0) \quad (H_2 0)^+_x$$

representing the positive ions. This refers to thermal ions of normal atmospheric temperatures.

4. If it would be possible to take an instantaneous picture of the ion mobility spectrum, one would obtain a line or band spectrum. However, since all known measvuring methods involve at least periods of a fraction of a second, one practically measures a

continuous spectrum. This is due to the oscillation between

$(H_3O)^+$ and $(H_3O)(H_2O)^+_x$

5. However, if there are ions which are stable from the beginning and do not change, one will measure a line spectrum.
6. In the "classical concept," ions move in an environment of gaseous molecules only, but this does not hold any more. There are great numbers of neutral nuclei, that have about the same size as the ions defined above.
7. It is observed that charges do not appear on nuclei smaller than 10^{-6} cm radius. The reason for this is probably that the number of nuclei of smaller size and the rate of capture of ions by these is such as to make the appearance of smaller ions — within the range of the large ions — improbable. In addition, the rate of recombination for smaller charged nuclei is such as to reduce their number.
8. The gap between the small ions and the observed large ions is accounted for by the above statement. It is perhaps possible that in this gap there exist neutral very small nuclei.
9. There are specific problems which should be solved:
   (a) The rate constants for the transitions from
   $(H_3O)^+$ and $(H_3O)(H_2O)^+_x$
   and vice versa should be measured.
   (b) The general picture of the nature of atmospheric ions could be established by means of similar synopsis as the one applied in the lower troposphere as indicated above.

It was also stated that a consequence of the facts listed above is the admission that the classical picture of atmospheric ions, as consisting of one charged molecule surrounded by 10 or even 20 neutral molecules, bound to it by Coulomb, dipole, quadrupole forces to form a cluster must be abandoned.

The facts listed above are derived from calculations and experiments concerning the binding forces between gaseous constituents, including the hydrogen bond, on ionization potentials of the different constituents, on the relative abundance of these constituents, and on measured rate constant. The facts hold for any natural atmosphere with a water vapor content of more than 1 percent relative humidity. They also hold, at least in general for an atmosphere that contains trace gases such as Xe or O_3 as well as organic gases. As a consequence of such calculations it could be established than any O_2 or N_2 ion, if formed initially, will lose its charge to other molecules within a time of the order of less than 10^{-7} sec. The stable ions referred to in section 5 above may be, for example, radon ions.

Discussion on the Electrode Effect
R. Mühleisen — Chairman

The Joint Committee on Atmospheric Electricity conducted a special discussion on the electrode effect on October 4, 1967, in Lucerne, during the XIVth General Assembly of UGGI. The agenda for the discussion was:

1. Definition of electrode effect.
2. Summary of experimental results and observed data.
3. Old theories.
4. Presentation of improved concepts.
5. Consequences of atmospheric electric measurements near the ground in the future.

The results of the discussion were formulated by R. Mühleisen (GFR) and H. Dolezalek (USA) as follows:

In the neighborhood of the "electrode" (in our case the surface of the earth) the atmospheric electric parameters are modified by the fact that no ions can penetrate the electrode. Provided that homogenous ionization exists and that there is no motion of the air we speak of the "pure electrode effect." In reality, other factors modify the parameters near the ground, such as variations of the polar conductivities with altitude, presence of aerosol particles, eddy diffusion, and perhaps exhalation of positive and negatives ions. Closely related to the electrode effect is the requirement of a constant air-earth current density with respect to height.

All available data, including many recent observations, show so much controversy that neither an explanation of electrode effect by measurements nor the constancy of current density could be conclusively established. This is due to the impossibility of encountering the "pure electrode effect" in nature. The well-known extreme complexity of atmospheric electric measurements can not be established; but several suggestions have been made on how to investigate the electrode effect with its problems pointed out above.

About 20 persons participated, among them probably all scientists who have published special papers on the electrode effect in the last few years.

JOINT IAGA-IAMAP COMMITTEE LUNAR VARIATIONS

O. Schneider — Chairman
E. J. Chernosky — Secretary (Until Feb. 1967)

INTRODUCTION

The Joint IAGA-IAMAP Committee on Lunar Variations is concerned with lunar influences in geophysics at large, with the exception of the mechanical, gravitational and dynamic aspects of the solid earth and ocean tides. Thus, the subjects that have come within its scope so far comprise lunar variations, or effects, in the following domains: the neutral atmosphere (as a whole, and also specific layers or regions); the geomagnetic field, both quiet and disturbed; telluric and oceanic electricity; and ionospheric parameters and general aeronomic phenomena, including the magnetosphere and several aspects of cosmic radiation.

At a meeting of the Commission on Terrestrial Magnetism and Atmospheric Electricity; of the International Meteorological Committee, held in Copenhagen in September 1929, the convenience of stimulating and coordinating studies on lunar effects was pointed out, and a report by D.La Cour and S. Chapman was thereafter submitted to the Stockholm meeting of the IUGG Section of Terrestrial Magnetism and Electricity (a forerunner of IATME, and this, of IAGA) held in August 1930. This report was published in **Comptes Rendus de l'Assemblée de Stockholm (IAGA Bulletin** No. 8), pp. 330-333, Paris 1931. At this meeting S. Chapman was appointed reporter on the Project of an International Collaboration to Further the Study of Lunar Effects on Geophysical Phenomena (page 466 of Bulletin No. 8).

At Lisbon, in 1933, Professor Chapman reported to IATME on his own work in this field and on the measures suggested to further such studies (Report on International Collaboration to Advance the Study of the Moon's Effect Upon Geophysical Phenomena; **IATME Bulletin** No. 9, **Comptes Rendus de l'Assamblée de Lisbonne**) and was reappointed Reporter for another 3 years (ibid. p. 354). At the Oslo assembly in 1948 he reported again and recommended setting up a committee (**IATME Bulletin** No. 13, **Transactions of the Oslo Meeting,** p. 343), which was appointed there as a Joint Committee of the International Association of Terrestrial Magnetism and Electricity and the International Association of Meteorology, with Professor Chapman as Chairman and 12 others. This Committee has been continuously active ever since.

In addition to Professor Chapman himself, who became Honorary President after giving up his chairmanship at the Helsinki assembly in 1960, three of the original members are still affiliated with the Committee at the present time. The membership is given in a later section of this bulletin.

It was with deep regret that the Committee learned of the death, on March 6, 1964, of Professor Julius Bartels, and on December 19, 1965, of Mr. J. Egedal, both of whom had been members of the Committee since its beginning in 1948. An obituary note on J. Bartels, by S. Chapman, appeared in **Quarterly Journal of the Royal Astronomical Society**, vol. 6, no. 2, 1966, p. 235 and on J. Egedal in **IAGA News** No. 5, November 1966, p. 64.

BERKELEY BUSINESS MEETING (AUGUST 27, 1963)

Since the Berkeley transactions have not yet appeared in print, a few notes on what happened there is included in this report.

In addition to the Chairman's general review delivered at the scientific session on August 24, committee members reported on their research. Some results are summarized in the "Report of the IAGA-IAMAP Committee on Lunar Variations to the 1963 Meeting at Berkeley." (In that report the phase angle λ_2 of the southward tidal wind component at Balboa should be changed from 29° to 209°.)

Although an increasing number of determinations of lunar effects, especially of tidal character or origin, are becoming available from individual stations, there are still relatively few attempts on record at a comprehensive representation of such phenomena and their physical interpretation on a planetary scale, which is the ulterior aim of lunar studies. Only on these grounds can the often painstaking effort of data processing at many single stations be justified. In discussing this situation the Committee recognized that the lack of uniformity of the diverse criteria adopted in selecting, grouping, processing, and reducing the original observations has been an obstacle for a planetary interpretation of some lunar variations. It was decided that a working group should study the possibilities of:

1. Reducing the already existing, largely heterogeneous local results in such a way as to render them suitable for a worldwide treatment.
2. Recommending criteria and standards of procedure in future lunar analyses.

An ad-hoc advisory group (B. Haurwitz, Convenor, W. Kertz, S. Matsushita and K. S. Raja Rao) was set up to assist the editor of **Meteorological and Geoastrophysical Abstracts** in compiling an annotated bibliography of lunar effects.

The Committee considered a proposal by Professor Chapman to endorse efforts aimed at a comprehensive dynamical study, with the use of all suitable observational data and computational tools, of the lunar atmospheric tide, as a background for understanding the associated meteorological effects and as a contribution for interpreting the associated aeronomical and geomagnetic lunar effects. A draft resolution to this end was passed to the parent associations and later adopted by IAGA. This resolution along with two others related to the need of rigorous statistical procedures in the search for supposed lunar effects and the need for a more complete and homogeneous coverage in the determination of lunar geophysical and meteorological variations in the Southern Hemisphere were adopted by IAGA and IAMAP and were published in **IAGA News,** No. 1, December 1963, pp. 28-29.

COMMITTEE ACTIVITIES SINCE THE BERKELEY MEETING

Regular contact was maintained with the Secretaries of IAGA and IAMAP, who were currently kept informed of the essential items of committee business. Notes on the activities of the Committee were published in **IAGA News,** No. 3, February 1965, pp. 36-37, and in **IAMAP Publication** No. 13, 1963, pp. 41-45.

Professor H. R. Byers, IAMAP representative on the IUGG Committee of 14, considering reorganization of IUGG, was informed, at his request, on the views of the Committee on Lunar Variations regarding the plans for reorganizing the IUGG.

A brief account of the Committee's activities was forwarded to the ICSU Abstracting Board. It was published in **Survey of the Activities of the ICSU Scientific Unions, Special and Scientific Committees and Commissions of ICSU in the Field of Scientific Information,** ICSU Abstracting Board, Paris, December 1966, pp. 37-38.

Professor G. Fanselau, Professor B. Haurwitz, and Mr. B. Leaton were invited by the Chairman, and accepted, to serve on the Working Group on Procedures, with Professor Haurwitz as Convenor. The task, which is an essential part of the Committee's objectives, is considerable, and no immediate results can be expected. It is strongly recommended that this work be continued after the St. Gall meeting.

The compilation of titles and summaries of papers on lunar effects that had been suggested by the Committee prior to the Berkeley meeting was completed with the assistance of several Committee members. It appeared under the title "Annotated

Bibliography on Lunar Influences on Atmospheric and Geophysical Phenomena," by W. Nuper and G. Thuronyi, in **Meteorological and Geoastrophysical Abstracts** (published by the American Meteorological Society), vol. 14, No. 12, December 1963, pp. 3958-4019. It contains 313 summaries, covering a considerable part of the literature from the year 1825 till, roughly, September 1963. A bibliographical list of more recent papers on lunar effects that appeared after the Berkeley meeting is given at the end of this report. Also included in the list are some earlier titles not considered in the compilation by Nuper and Thuronyi. The Committee holds a collection of lunar papers, and wishes to express its thanks to the colleagues who have contributed to this collection by sending reprints or other copies of their publications.

The Allotment Subcommittee for the $1000 subsidy to promote further studies on lunar effects, granted by IAGA at Berkeley, was composed of Professor S. Chapman, Professor J. Bartels, and Mrs. E. Chernosky. After the death of Professor Bartels, Professor B. Haurwitz served on the Subcommittee. Preliminary applications for a subsidy were received from two colleagues, but no detailed analysis projects were afterwards submitted when requested by the Subcommittee. The use of this subsidy for publishing new lunar tables was also temporarily considered, but this became unnecessary as the authors found an independent way of publishing them.

Many studies of lunar variations in geophysical phenomena are based on the mean, rather than the apparent, moon. Previous numerical tables of daily values of the lunar age covered only the period 1850 to 1975, and it has long been recognized that there will be a need for continued lunar studies after this period. The Committee was instrumental in helping amalgamate two projects for extending such tables to the year 2050. As a result of this effort the publication "Lunar Phase Numbers ν and ν^1 for Years 1850 to 2050," by M. Sugiura and G. Fanselau (NASA, Goddard Space Flight Center, Publication X-612-66-401, June 1966) is now available. It contains, in table 1, daily values of the age of the mean moon, nu, in hours to 0.01h; abbreviated daily phase figures nu prime, with the period of half a lunation, to the closest hour; and in table 3, the dates of new moon.

GENERAL PROGRESS OF RESEARCH ON LUNAR EFFECTS

There is a body of well-established findings on lunar tidal phenomena proper in the low and higher atmosphere, and secondary electrical and magnetic phenomena (which in a broader sense are sometimes also called "tides"), but a rather controversial situation prevails regarding a large group of other results. Some of these refer mainly to supposed lunar effects on processes in, and properties of, the troposphere, such as rainfall, cloudiness or sunshine, while another group is concerned with a supposed lunar modulation of geomagnetic disturbance. These effects, if real, would call for nontidal mechanisms as a cause.

The principal papers claiming the reality of such unorthodox findings are listed in the appended bibliography, along with those holding opposite views. The bibliography also includes, of course, papers dealing with the determination and interpretation of the classical tidal and tidelike oscillations in the atmosphere, the ionosphere, and the geomagnetic field. In addition, the following studies have come to the attention of the Committee, mostly by personal reports (an asterisk indicates a paper scheduled for the St. Gall meeting; the symbol (p) refers to personal communication):

Haurwitz (1966) communicated a list of annual and seasonal means of the lunar semidiurnal atmospheric tide determined for a widely distributed network of stations (Haurwitz and Cowley*). A. M. van Wijk (p) reported on plans, now under way, for extending the analysis of lunar atmospheric tides at Hermanus, which had been started earlier, to cover the period 1957-1966. Gouin (1967) determined the solar and lunar barometric tides at Addis Ababa. G. Dietze * continued earlier studies on lunar variations of the optical properties of the atmosphere. Concerning the domain of other atmospheric phenomena, Bigg (p) reports on measurements, on a large scale, of the concentration of ice-forming particles in the atmosphere, with a view to demonstrating lunar influences (Bigg and Miles, 1964). Much attention was paid to the statistical pitfalls in the study of geophysical time series (Martyn, 1965; Davidson and Martyn 1964a, 1964b), so important in assessing the significance of supposed lunar effects.

Several reviews of the distribution of the geomagnetic lunar variations and the corresponding ionospheric current system were made by Matsushita (1965a; 1965b; 1965c; 1966b, and 1967) as well as Matsushita and Maeda (1965). Gupta and Chapman * made a spectral analysis of diurnal and subdiurnal lunar and lunisolar periodicities in the geomagnetic variations at 54 widely distributed observatories, separately for low and high solar activity, in an effort to identify new lunar terms. Some of these had not been described earlier. A new determination of the lunar geomagnetic variations at the low-latitude station Moca was made by J. O. Cardus *, and G. Fanselau did the same for Potsdam-Niemegk, obtaining a clear dependence of L on solar activity. Chapman and Fogle reexamined the geomagnetic lunar variations at San Fernando in relation to the location of the focus of the Sq current system on single days. Other studies on L at individual geomagnetic stations were made by Rougerie (1967), who reported (p) on a new determination of L(H) at Val Joyeux, and by D. E. Winch (p), who has begun a rather comprehensive analysis of data from Watheroo, Toolangi, and Macquarie Island, in the three elements D, H, and Z. His studies also bear on several aspects of the methods of analysis, especially concerning the noncyclic change. Maeda and Fujiwara * have studied atmospheric and ionospheric models capable of producing the observed geomagnetic L-variations, assuming specified conditions of solar activity and taking into account an electric linkage between conjugate points.

Maynard (1967), by interpreting rocket measurements of the geomagnetic field and electron number density near the equatorial electrojet, suitably scheduled with respect to the phase of the lunar geomagnetic variation there, concluded that the lunar current system at E-layer heights is most likely a modulation of the solar correlated currents.

The effects of induced currents in the sea, long recognized as a possible source of modification of the geomagnetic tides, was the object of a new experimental and theoretical approach (Larsen 1966; Larsen and Cox, 1966), and was also considered in a new determination of L in the geomagnetic elements as observed in the British Isles (Malin *; Malin; 1967).

As for the various conjectures on a possible interaction of the Moon with the geomagnetosphere, and secondary manifestations in geomagnetic disturbance, a review on such work was given by Schneider (1967), with a bibliography till the end of 1966.

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This bibliography lists mainly papers published after the 1963 Berkeley meeting, but it also includes some earlier titles not considered in the "Annotated Bibliography on Lunar Influences on Atmospheric and Geophysical Phenomena" by W. Nupen and G. Thuronyi (**Meteorological and Geoastrophysical Abstracts, 14,** No. 12, 3958-4019, 1963).

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ST. GALL BUSINESS MEETING

The business meeting held on September 28 was preceded by a review of progress given by the Committee Chairman. A brief account of this review is given earlier in this section under the heading "General Progress of Research on Lunar Effects." The meeting was attended by 21 persons, 11 of whom were Committee members or deputies: Benkova, Cardus, Chapman, Chernosky, Haurwitz, Malin (replacing Leaton), Matsushita, Schneider, Siebert (replacing Kertz), Turajlic and Van Wijk.

The Committee considers that there is a need for homogenizing the criteria adopted in selecting, grouping, processing and reducing observations for lunar studies. This applies both to retrospective attempts at planetary representations of the lunar variations and to guidance in future work. It is, therefore, recommended that the Working Group on Procedures should be continued. Professor Chapman offered to serve on this Working Group, and the Committee Chairman will also collaborate; Mr. Leaton, who has been a member of the group since it was established, suggests he be replaced by his colleague, Mr. Malin, who has been in close touch with the problems involved. The Working Group will thus be composed of S. Chapman, G. Fanselau, B. Haurwitz (Convenor), S. R. Malin, and D. Schneider.

Professor Haurwitz suggested that a new description of the Chapman-Miller method would be of value, and Professor Chapman hopes that he will be able to conduct such work with his collaborators.

The Committee has taken notice, with interest, of the remarks by Dr. J. C. Cain, that appropriate satellite observations could contribute a great deal to the knowledge and interpretation of lunar effects in the upper atmosphere. If two or three polar orbiting satellites would continuously monitor the geomagnetic field at different local times during a long period, valuable information would accrue for lunar studies.

The Committee is of the opinion that important work is still needed to promote lunar studies for securing a better geographical distribution, adequate worldwide representation, and full theoretical interpretation of lunar effects in geophysics. Uniform criteria for data selection grouping, and treatment are required to this end. It believes, therefore, that its work should be continued.

A recommendation was suggested by Dr. J. Cain on the advantages of machine-readable data presentation for lunar studies. After some discussion, a resolution on this topic was drafted, which was later passed as IAGA Resolution No. 24, given in a later section of this bulletin.

The Subcommittee on Standardization made the following recommendations for the analysis of geomagnetic observatory data for lunar effects:

1. Hourly or bi-hourly values should be used, analysed by the Chapman-Miller method or one of its reliable derivatives.
2. No results should be presented without an estimate of their significance, e.g., vector probable error.
3. The division of data according to season should be done by Lloyd's seasons, or by month. Months should only be used where the difference between months are likely to exceed the vector probable error.
4. The division of data according to solar activity should be on a yearly basis based on the Zurich sunspot number. There should be three sets, and years should be allocated to the appropriate set by the Committee on Lunar Variations.
5. The division according to magnetic activity should also be into three sets: (a) the five international quiet days for each month; (b) the fifteen most disturbed days for each month, according to Cp; and (c) the remaining days for each month.
6. The checking of the data is very important. Indication should be given of the steps taken to estimate errors from the data used in the analysis.

ST. GALL SCIENTIFIC COMMUNICATIONS

Two scientific sessions were held on Thursday, September 28, and Monday, October, 2, 1967. In addition to the papers announced in the **Program and Abstracts (IAGA Bulletin** No. 24), p. 21 and p. 29, four late papers were presented, as follows:

R. C. Rastogi and R. P. Sharma — Lunar tidal variations in the electron density at fixed real heights of the ionosphere (XI-10).

R. C. Rastogi — Lunar tidal oscillations in foF2 and H over the magnetic equator (XI-11).

G. M. Brown — Some tidal effects in earth current observations at Oberystwyth (XI-12).

G. M. Brown — Lunar tidal variations in the E-region (XI-13).

Abstracts of two of these papers are given below:

"Lunar tidal variations in the electron density at fixed real heights of the ionosphere" (XI-10).

R. C. Rastogi and R. P. Sharma, Physical Research Laboratory, Ahmedabad 9, India.

The electron density profiles at Ahmedabad, Puerto Rico, and Huancayo for noon hours are used to compute lunar semi-monthly oscillation in electron density at fixed heights. At any of the stations the amplitude is found to increase with height distinctly above 180 km. Below 180 km the amplitudes are small and its variation with height is not the same at different stations and seasons. The phase of tide is constant with height during any of the seasons for all heights at Ahmedabad and for heights above 180 km at Huancayo. The phase at Puerto Rico, however, is found to vary appreciably with height during any of the seasons.

"Lunar tidal oscillations in foF_2 and H over the magnetic equator" (XI-11).

R. G. Rastogi, Physical Research Laboratory, Ahmedabad 9, India.

The lunar daily oscillations at fixed lunar ages (L) and lunar semimonthly oscillations at fixed solar hours (M_2) in foF_2 and H at Huancayo for the period 1951-

1955 are described. The M_2 (H) oscillation starts increasing with the sunrise, is maximum at noon and decreases to low value by sunset, but the M_2 (foF_2) tide starts increasing only 2 hours after sunrise, has a broad maximum between 10 and 16 h and decreases to low value by midnight. The Chapman phase law given for the lunar daily variation of geomagnetic data is found to be valid for foF_2 also. The maximum positive deviation due to M_2 tide occurs at about 08 lunar hour for H and at about 04 lunar hour for foF_2. The tides in both H and foF_2 are strongest during December solsticial and weakest during June solsticial months. It is concluded that the lunar tides in H and foF_2 at the equatorial stations are greatly influenced by the equatorial electrojet.

SUMMARY REPORT GIVEN AT THE FINAL PLENARY MEETING

An increasing interest in lunar-terrestrial relationships has been evident since the Berkeley assembly. This is true even if we take into account that the joint IAGA-IAMAP Committee on Lunar Variations studies only those relationships in which the earth and its environment are the passive partner of the earth-moon system, and, moreover, excludes from its terms of reference the geodetical and oceanographical aspects of lunar effects in geophysics, that is, earth and ocean tides.

The number and diversity of papers bearing on lunar variations that were published between the last two assemblies was greater than ever before, and so was the number of communications presented at this assembly. In addition to the reporter's progress review, 12 scientific communications were read, five of which referred to new determinations of lunar geomagnetic tides at individual stations or extensive networks; two dealt with the determination of lunar variations in ionospheric parameters; another two had as their subject the joint ionospheric and geomagnetic effect of the moon; one referred to earth currents, and the remaining two dealt with lunar effects in the neutral atmosphere. Models of ionospheric wind systems capable of generating the observed geomagnetic tides were proposed; a better geographical distribution is little by little being achieved within the global network of stations for which atmospheric, ionospheric, and geomagnetic tidal determinations have been made. New emphasis is being laid on the influence of ocean currents and tides on the geoelectrical and geomagnetic lunar variations. As regards methods, power spectrum analysis is more widely used now in this field, along with the classical procedures of harmonic analysis.

At its business meeting, the Committee took notice with interest of a remark by Dr. Cain, that appropriate satellite observations might contribute a great deal to the knowledge and interpretation of lunar effects in the upper atmosphere. It also drafted a recommendation on the importance of committing to computer-readable form past and present geomagnetic, aeronomical, and atmospheric parameters.

Future work of the Committee will have to consider, among other questions, two important subjects: solar influences on lunar effects, and worldwide representations of lunar variations. Regarding the first of these points, the forthcoming period of high solar activity will provide new information to this end, but the very complex nature of these relationships calls for a statistical treatment of the data, which requires very extensive records, so that use must be made of the wealth of past observations. Uniform criteria for selecting, grouping, and processing the data are essential; for this purpose, the Committee has a Working Group of five members, and we are fortunate enough to have the great teacher of generations of geophysicists, Professor Chapman, with us in this task.

WORLD MAGNETIC SURVEY

V. Laursen, Chairman

The program for the continuation of the World Magnetic Survey (WMS) project was discussed in three meetings of the WMS Board.

The first meeting was held in conjunction with Commission II of IAGA, at 09.00h, Tuesday morning, September 1967, and was chaired by E. H. Vestine, Chairman of Commission II. In addition to members of Commission II, the following members of the WMS Board were present: V. Laursen, Chairman, WMS Board; N. V. Pushkov and J. O. Cardus, Vice-Chairmen; L. R. Alldredge, General Secretary of IAGA; T. Nagata, member and representative of SCAR; and E. H. Vestine, Secretary General.

V. Laursen in a short report, "Review of WMS Progress," noted that extensive surveys of the geomagnetic field on land, sea, by airplane, and by earth satellites had been undertaken since the time of the Berkeley meeting of IAGA in 1963. More than 50 countries had contributed data for land and observatory stations. The nonmagnetic ship **Zarya** of the USSR had undertaken extensive magnetic surveys over the oceans. Extensive areas of the oceans had also been covered by the airplane surveys of Project Magnet of the U.S. Naval Oceanographie Office, by Japan using airborne magnetometers over that nation and adjacent waters, and by Canada over that nation as well as over Norway, Sweden, Finland, and Denmark. Much of the data has already been placed in World Data Centers. Worldwide coverage by earth satellites below latitude 49° was afforded by Cosmos 26 and 49 of the USSR and in the USA by 1964-83C in 1964 and 1965, and by OGO-2 and OGO-4 in 1965 and 1967, respectively, the latter affording worldwide coverage. Training missions to Africa, South America, and the Middle East had assisted in land magnetic surveys, and were undertaken with financial assistance and sponsorship by UNESCO. Attention of the WMS Board of IAGA was now focused on publication of results, and manuals to this end were developed, as well as for the conduct of land magnetic surveys by observers beginning this work.

Publication of **Instruction Manual on World Magnetic Survey** No. 2, which deals with publication of WMS results, was discussed by E. H. Vestine. This manual, being prepared with the assistance of UNESCO, outlines a plan for the presentation of WMS results in a volume that constitutes the final WMS report and is scheduled for completion in 1969. To be produced are a WMS chart in seven elements, grid point values over the earth, parameters needed to provide data at satellite level, and an IGRF.

A short WMS manual aimed at helping observatories in developing areas was discussed by V. Laursen, who indicated that J. M. Stagg and K. A. Wienert had assisted in developing the general plan for the manuscript.

Proposals to (a) provide mean hourly data of geomagnetic field data elements on magnetic tape, (b) provide magnetic survey field data on tapes for the years 1840-1965 to WDC's, and (c) rework data for improving secular variations for 1900-1965 were introduced by E. H. Vestine. P. Serson indicated that much of the Canadian data for recent years was already in machine-readable form, and C. G. Sucksdorff indicated that data in Finland were available. J. C. Gupta mentioned that he had developed tapes of the IGY period for 100 observatories, and D. J. Stone stated that results for about 70 stations were developed in machine-readable form in connection with studies of the solar magnetic daily magnetic variation. D. Knapp indicated that data since about 1940 were available for some US observatories, and that the data for land magnetic survey stations since about 1900 in machine-readable form were on hand and had been studied extensively by J. C. Cain. It was also mentioned that early data for 1854-1869 for Trevendum and for 1851 for Alibag were maintained in tabular form in the Meteorological Office of India.

Items dealing with future survey needs and permanent bureau services were noted but left for later consideration.

The second meeting of the WMS Board was called to order at 12.00h, October 2, by Chairman Laursen. The following members of the Board were present: V. Laursen, Chairman; N. V. Pushkov, Vice-Chairman; B. R. Leaton; T. Nagata; L. R. Alldredge; and E. H. Vestine. J. H. Nelson was present by invitation. A resolution was passed recommending the convening of a regional meeting in South America, at which arrangements with the object of coordinating magnetic survey activities in the various South American countries could be discussed. (See IAGA resolution No. 25 in a later section of this bulletin.)

The Chairman directed attention to the need for developing more detailed plans for the final volume of WMS results, since the WMS Board would terminate its activities in 1969. A preliminary list of proposed contributors to the volume was drawn up. Primary attention was directed to the final WMS world chart. It was agreed that only one chart was to be developed jointly by the three principal map making agencies. The meeting adjourned at 13.10h and it was agreed to continue the discussion at another session.

The third meeting of the WMS Board was called to order by Chairman Laursen at 12.00h, on October 4. Present were: V. Laursen, Chairman; N. V. Pushkov, Vice-Chairman; B. R. Leaton; E. H. Vestine; P. Serson (by invitation); J. H. Nelson (by invitation); and A. J. Zmuda (by invitation); J. O. Cardus, L. R. Alldredge, and T. Nagata, though not present, later indicated essential concurrence with the findings developed.

Chairman Laursen directed the attention of the Board to the final WMS report volume, and after some discussion of topics to be covered in this volume and in order to meet a projected deadline for publication in 1969 it was agreed that:

1. The deadline for the supply of WMS data for use in the final report volume is to be March 31, 1968. Although later data were needed to maintain and continue our knowledge of the main field and its secular change, these latter data would not be included in the WMS report.

2. The deadline for submission of invited and other manuscripts for the WMS volume will be March 31, 1968.

3. The committee of three for the previous Herstmonceux meeting (B. R. Leaton, Chairman, L. R. Alldredge, and V. Orlov) will be requested to provide the world grid point values for the WMS world chart by June 30, 1968, and the corresponding charts in 1969 in time for inclusion in the final printed volume.

4. The Secretariat should edit the material submitted by contributors, to the end that the final volume be available in 1969.

An item relating to future needs for a permanent service, or services, for magnetic surveys of the earth was introduced by N. V. Pushkov and E. H. Vestine. It was agreed that the WMS Board should take steps to initiate such services where technically useful and feasible. To this end, the Secretariat was instructed to write S. E. Forbush to obtain a suitable methodolgy for removing ring current corrections from survey data, and to A. T. Price respecting field departures for the remainder of geomagnetic signals affecting survey data, with the hope of improving estimates of secular change.

The possibility of providing grid point coverage of the earth for secular change to be published on a yearly basis was discussed. B. R. Leaton considered that such activity by a permanent service, with access to a computing facility and a WDC, might first begin by trying to take only the ring current correction to survey data into account, which should result in improved secular change estimates at magnetic observatories.

It was agreed that B. R. Leaton, the Chairman of Commission II of IAGA, be asked to assist the WMS Board in evaluating the feasibility of making useful and worthwhile corrections. If procedures analogous in precision to those developed by Bartels for deriving K indices were found to be available it was suggested that steps might be taken to make available a permanent world service providing annual mean secular change values, and at some later date to provide additional corrections.

Chairman Laursen next directed attention to a proposal that secular change values 1840-1965 be improved, using machine-readable data on observatory and other magnetic survey value since that time. Attention was called to various resolutions that had been submitted by Commission II and other commissions of IAGA urging compilation of magnetic observatory hourly values and survey values in machine-readable form for the period since 1840. The WMS Board recorded its view that this project is highly desirable and that it might possibly be regarded as a deferred item of the WMS Project. The meeting adjourned at 13.00h.

NEW IAGA ORGANIZATION

NEWLY ELECTED OFFICERS

The newly elected officers of the IAGA for the period 1967-1971 are as follows:

EXECUTIVE COMMITTEE

President:	Professor Takesi Nagata Geophysical Institute The University of Tokyo Bunkyo-ku Tokyo, Japan
Vice Presidents:	Dr. V. A. Troitskaya Soviet IGC Committee Molodezhnaya 3 Moscow B-296, USSR Professor E. Thellier 191, rue Saint Jacques Paris V, France
General Secretary:	Dr. Leroy R. Alldredge ESSA, Research Laboratories Boulder, Colorado 80302, USA
Past President:	Professor Marcel Nicolet IRM-CNRE 3 Avenue Circulaire Brussels 18, Belgium
Members:	Rev. J. O. Cardus, S. I., Spain Prof. R. M. Casaverde, Peru Dr. F. S. Johnson, USA Dr. J. G. Roederer, USA Dr. R. Turajlic, Yugoslavia

NEW IAGA ORGANIZATIONAL STRUCTURE AND APPOINTED OFFICERS

IAGA COMMISSION I

Title: Observatories and Instruments

Chairman:	A. P. De Vuyst Centre de Physique du Globe Dourbes Nismes-Prov. de Namur Belgium

Responsibility: Deals with all problems relating to the operation of magnetic observatories and to the carrying out of magnetic measurements. This may include instrumental equipment for observatory and field use, and for use in rockets and satellites, international comparison of geomagnetic standards, form and contents of observatory publications, etc.

Working Groups

Magnetic Observatories — **Reporter:** J. H. Nelson (USA)

J. Cain (USA)
V. N. Bobrov (USSR)
V. Laursen (Denmark)
R. Schlich (France)
O. N. Sipahioglu (Turkey)
L. Prior (Australia)
R. Turajlic (Yug.)
O. F. Fambitakoye (Rep. Central Africa)
K. Yanagihara (Japan)
M. Casaverde (Peru)
E. I. Loomer (Canada)
K. Wienert (W. Germany)

Geomagnetic and Telluric Instrumentation — **Reporter:** P. Serson (Canada)

V. F. Shelting (USSR)
J. P. Heppner (USA)
J. H. Nelson (USA)
J. Meunier (France)
T. Ogati (Japan)
M. Fahin (Egypt)
W. Stuart (Great Britain)
E. K. Lauridsen (Denmark)
O. M. Raspopov (USSR)
A. Van Wijk (South Africa)
R. O. Meyer (W. Germany)
M. Giorgi (Italy)

Comparison of Magnetic Standards — **Reporter:** V. Laursen (Denmark)

B. R. Leaton (U. K.)
E. Le Borgne (France)
J. H. Nelson (USA)
L. S. Prior (Australia)
V. F. Shelting (USSR)
K. Yanagihara (Japan)
R. O. Meyer (W. Germany)
G. Fanselau (E. Germany)

Additional Commission Members not Attached to Working Groups:

K. Svendson (USA)
L. Sucksdorff (Finland)
F. Eleman (Sweden)
W. Hannaford (Canada)
W. Campbell (USA)
J. Veldkamp (Netherlands)
E. Selzer (France)
G. Barta (Hungary)
S. H. Ward (USA)
J. Kalinin (USSR)
R. Riddibough (Ireland)

IAGA COMMISSION II

Title: **Representation of Main Magnetic Fields**
Chairman: B. R. Leaton
Royal Greenwich Observatory
Herstmonceux Castle
Halisham, (Sussex), Great Britain

Responsibility: Works as an advisory group to the WMS Board. Prepares reports and recommendations on methodology, equipment and other technical matters pertaining to land, sea, air, and space surveys. Treats the analysis and presentation of the data both in chart form and in analytic form. Devises data interchange ideas for IAGA disciplines.

Working Groups

Land and Airborne Surveys — **Reporter:** P. H. Serson (Canada)

Ocean Shipborne Surveys — **Reporter:** M. M. Ivanov (USSR)

Rockets and Satellites — **Reporter:** J. C. Cain (USA)

Analysis of Geomagnetic Fields — **Reporter:** A. J. Zmuda (USA)

Planetary Magnetic Fields — **Reporter:** R. Hide (U. K.)

Data Interchange — **Reporter:** M. Ota (Japan)

IAGA COMMISSION III

Title: Magnetism of the Earth's Interior

Chairman: T. Rikitake
Earthquake Research Institute
Tokyo University
Tokyo, Japan

Responsibility: Deals with observations, analyses and theoretical interpretations of all phenomena relating to the magnetism of the earth's interior, including the main geomagnetic field and its secular variation, magnetic induction within the earth, archeomagnetism and palaeomagnetism, etc.

Working Groups

Electro-Dynamics

Reporter: F. J. Lowes (U. K.)

P. H. Roberts (U. K.)
R. Hide (U. K.)
E. H. Vestine (USA)
T. Rikitake (Japan)
J. D. Kalinin (USSR)

Secular Variation

Reporter: V. P. Orlov (USSR)

L. R. Alldredge (USA)
B. R. Leaton (U. K.)
E. H. Vestine (USA)
G. Barta (Hungary)
O. Lucke (Germany DR)
T. Yukutake (Japan)
H. Kautzleben (Germany DR)

Electromagnetic Induction

Reporter: K. Whitham (Canada)

C. S. Cox (USA)
W. D. Parkinson (Australia)
S. H. Ward (USA)
W. G. Kertz (W. Germany)
A. T. Price (U. K.)
V. Schmucker (W. Germany)
H. Wiese (Germany DR)
T. C. Tozer (U. K.)
B. M. Yanovsky (USSR)
I. Gough (Canada)
T. Rikitake (Japan)

Rock Magnetism

Reporter: C. M. Carmichael (Canada)

T. Nagata (Japan)
D. W. Strangway (USA)
F. D. Stacey (Australia)
D. W. Collinson (U. K.)
E. Thellier (France)
G. N. Petrova (USSR)
V. Bucha (Czech.)
N. Petersen (W. Germany)
F. Frölich (Germany DR)
C. Radharkrishnamurty (India)
D. Stefanovic (Yugoslavia)

Archeomagnetism

Reporter: E. Thellier (France)

M. J. Aitken (U. K.)
V. Bucha (Czech.)
R. L. du Bois (USA)
K. M. Creer (U. K.)
Mme. El Rachich (U.A.R.)
K. Kobayashi (Japan)
N. Kawai (Japan)
G. N. Petrova (USSR)
E. J. Schwarz (Canada)
R. N. Athavale (India)
A. Bammer (Austria)

Paleomagnetism

Reporter: R. R. Doell (USA)

A. N. Khramov (USSR)
A. S. Boljshakov (USSR)
V. Bucha (Czech.)
R. L. Wilson (U. K.)
S. K. Runcorn (U. K.)
A. Larochelle (Canada)
F. Frölich (Germany DR)
A. Roche (France)
P. Goecii (Kenya)
M. Ozima (Japan)
J. Veldkamp (Netherlands)
M. W. McElhinny (Australia)

Geomagnetic Anomalies — **Reporter:** A. Hahn (W. Germany)

M. M. Ivanov (USSR)
B. Ruman
W. Bullerwell (U. K.)
L. W. Morley (Canada)
T. N. Simonenko (USSR)
A. F. de Vuyst (Belgium)
V. Vacquier (USA)
T. Rikitake (Japan)
I. Zietz (USA)
R. Giret (France)
J. Le Mouel (France)

IAGA COMMISSION IV

Title: **Magnetic Variations and Disturbances**
Chairman: J. A. Jacobs
Killam Memorial
University of Alberta
Edmonton
Alberta, Canada

Responsibility: Commission IV is concerned with promoting the study of transient magnetic variations and developing our knowledge of the sources of these variations. These include both the regularly recurring variations, such as the daily variations and the several types of variations associated with magnetic disturbance. It is also concerned with the development and precise definition of the various indices introduced to characterize certain features of magnetic activity. It acts as the advisory board to the Permanent Services on the routine collection of the necessary data, and the calculation and publication of these indices, together with the records of certain rapid variation events.

Working Groups

Morphology and Indices — **Reporter**: D. Van Sabben (Netherlands)

Daily Variations — **Reporter:** D. J. Stone (U. K.)

Equatorial Electrojet — **Reporter:** D. G. Osborne (Tanzania)

M. Casaverde (Peru)
R. G. Rastogi (India)
D. Fambitakoye (Central African Rep.)
C. A. Onwumechilli (Nigeria)
Mme. J. Roquet (France)
D. J. Stone (U. K.)
O. M. Raspopov (USSR)
M. Sugiura (USA)
J. Untiedt (W. Germany)
G. M. Weill (France)
F. N. Glover (Philippines)

Special Disturbance Events — **Reporter:** S.-I. Akasofu (USA)

Micropulsations — **Reporter:** V. Troitskaya (USSR)

Magnetospheric Field Variations — **Reporter:** M. Sugiura (USA)

Conjugate Points — **Reporter:** R. Schlich (France)

Additional Commission Members not Attached to Working Groups:

P. L. Gouin (Ethiopia)
P. N. Mayaud (France)
V. R. S. Hutten (Nigeria)
S. Matsushita (USA)

IAGA COMMISSION V

Title: **Solar-Magnetosphere Relations**
Chairman: J. G. Roederer
Physics Department
University of Denver
University Park
Denver, Colorado, USA

General Responsibilities: To deal with the physical processes occurring in planetary magnetospheres involving particles and magnetic and electric fields, the solar control of these processes and their effects on the general configuration of the planetary environment.

Working Groups

Solar Wind Interaction with the Earth, Moon and Planets — **Reporter:** N. F. Ness (USA)

Bow shock — magnetosheath and magnetopause — instabilities — geomagnetic tail — interaction of the solar wind and the geomagnetic tail with the moon.

Morphology of Radiation Belts — **Reporter:** D. C. Williams (USA)

Energetic particle flux distribution — long term and typical short term time variations — energetic particles in the distant magnetosphere — Jupiter's radiation belt.

Particle — Field Interactions — **Reporter:** I. B. McDiarmid (Canada) (has declined since the meeting)

Charged particle acceleration and diffusion — particle-wave interactions — d.c. electric fields — precipitation mechanisms.

Cold Plasma and Low Energy Particles — **Reporter:** K. I. Gringauz (USSR)

Plasma composition, plasmapause — plasma sheet in the tail — ring current particles — low energy particles in the distant magnetosphere.

Solar Energetic Particles and Cosmic Rays — **Reporter:** T. Obayashi (Japan)

Solar and cosmic ray particle propagation and modulation in interplanetary space and in the magnetosphere — solar energetic particle precipitation.

IAGA COMMISSION VI

Title: **Aurora**

Chairman: A. Omholt
Institute of Theoretical Astrophysics
University of Oslo
Oslo, Norway

Responsibility: The scope of scientific endeavors which Commission VI represents includes those studies of the atmosphere, ionosphere and magnetosphere which bear on the problems of the aurora. Relevant areas include studies of energetic particles and fields which elucidate on the excitation of the aurora, radio studies, and morphological studies. The modes of investigation range from ground-based photography of auroral forms to satellite-based experiments of charged particles, fields, and the auroral spectrum (with intermediates such as airplane-based and rocket-based experiments).

Working Groups

Morphology — **Reporter:** B. Hultquist (Sweden)

S.-I. Akasofu (USA)
Y. I. Feldstein (USSR)
F. Jacka (Australia)
J. Paton (U. K.)
B. P. Sandford (N. Zealand)
D. Schneider (Argentina)

K. Lassen (Denmark)
P. M. Millman (Canada)
W. Stoffregen (Sweden)
A. Vallance Jones (Canada)

Spectroscopy and Excitation

Reporter: G. G. Shepherd (Canada)

A. Dalgarno (U. K.)
R. H. Eather (USA)

Radio Aurora

Reporter: R. S. Unwin (N. Zealand)

H. F. Bates (USA)
P. A. Forsyth (Canada)
M. Gadsden (USA)
P. Glöde (Germany DR)
A. Kavadas (Canada)
T. R. Kaiser (U. K.)
G. Lange-Hesse (W. Germany)
R. Leadabrand (USA)
E. Ponamazev (USSR)
Y. U. Sverdlov (USSR)

Particles and Fields Effects

Reporter: D. S. Evans (USA)

M. H. Rees (USA)
W. Riedler (Sweden)

Additional Commission Members not Attached to Working Groups:

J. Black (Canada)
O. Holt (Norway)
J. Frihagen (Norway)
H. Trefall (Norway)
P. Czechowsky (W. Germany)

IAGA COMMISSION VII

Title: Airglow
Chairman:

G. M. Weill
Institut d'Astrophysique
98 bis Boulevard Arago
Paris-14e
France

Responsibility: To foster and coordinate studies of the upper atmospheres of the earth and other planets by the observation and theoretical interpretation of optical emissions, excluding the aurora. The scope includes emissions arising under day, twilight, and night conditions, observed by a range of photometric and spectroscopic techniques from the ground and from space.

Working Groups

Instruments and Observations

Reporter: M. Gadsden (USA)

J. E. Blamont (France)
A. L. Broadfoot (USA)
W. G. Fastie (USA)
G. J. Hernandes (USA)
A. H. Jarrett (U. K.)
E. Llewellyn (Canada)
J. Noxon (USA)
D. M. Packer (USA)
P. C. Shcheglov (USSR)
G. G. Sheperd (Canada)
Yu.L. Troutse (USSR)

Spectroscopy and Excitation Processes

Reporter: G. I. Galperin (USSR)

K. D. Cole (Australia)
A. Dalgarno (USA)
T. M. Donahue (USA)
J. Dufay (France)
V. I. Krassovsky (USSR)
M. B. McElroy (USA)
V. L. Peterson (USA)
A. T. Stair (USA)
Stuvart (U. K.)
T. Tohmatsu (Japan)

Photometry

Reporter: M. Huruhata (Japan)

M. W. Chiplonkar (India)
J. Christophe (France
B. T. O'Brien (USA)
K. R. Ramanathan (India)

I. S. Gulledge (USA)
G. Lange-Hesse (W. Germany)
E. Morovich (USA)
F. E. Roach (USA)
O. G. Taranova (USSR)
J. L. Weinberg (USA)

Laboratory Data | **Reporter:** H. I. Schiff (Canada)

C. A. Barth (USA)
M. P. Carleton (USA)
M. Dufay (France)
E. E. Ferguson (USA
F. Kaufmann (USA)
L. R. Megill (USA)
R. W. Nicholls (Canada)
B. A. Thrush (U. K.)
R. A. Young (USA)

Additional Commission Members not Attached to Working Groups:

Abbott, W. N. (Greece)
Bates, D. R. (U. K.)
Silverman, S. M. (USA)
Hunten, D. M. (USA)
Markham, T. P. (USA)
Smith, L. L. (USA)
Carman, E. H. (Lesotho)
Steiger, W. R. (USA)
Carlson, H. C. (USA)
Greenspan, J. (USA)
Stewart, (U. K.)
Weill, G. (France)
Doan, N. H. (France)
Pastiels, R. (Belgium)
Vassy, A. (France)
Tousey, R. (USA)
Gregory, F. (Italy)
Gall, R. (Mexico)
Duboin, M. L. (France)
Hennes, J. P. (USA)
Heath, D. F. (USA)
Rees, M. H. (USA)
Rees, E. (USA)
Reed, E. (USA)
Shefov, N. N. (USSR)
Yarin, V. I. (USSR)
Ingham, D. F. (U. K.)
Nicolet, M. (Belgium)
Link, F. (Chec)
Chapman, S. (USA)
Kofsky, I. L. (USA)
Lory, M. L. (France)
Robley, R. (France)
Vallance-Jones, A. (Canada)
Casaverde, R. (Peru)
Torroja, E. (Spain)

IAGA COMMISSION VIII

Title: Upper Atmospheres
Responsibility: Deals with the electro-dynamics involving the aeronomic processes on neutral and ionized particles.
Chairman: A. Dessler
Space Science Department
Rice University
Houston 1, Texas 77001
USA

Working Groups

Composition and Density Variations	**Reporter:** M. Marov (USSR)
Winds Gravity & Infrasonic Waves	**Reporter:** G. V. Groves (U. K.)
Exospheric Problems	**Reporter:** B. A. Tinsley (USA)
Ionization Processes	**Reporter:** A. Omholt (Norway)
Ion-Neutral Atmospheric Interactions	**Reporter:** E. A. Lauter (Germany DR)
Ionospheric Interactions	**Reporter:** G. Haerendel (W. Germany)
Meteors	**Reporter:** T. R. Kaiser (U. K.)
Planetary Atmospheres	**Reporter:** D. Hunten (USA)

IAGA COMMISSION IX

Title: **History**

Responsibility: Deals with the history of geomagnetism and aeronomy involving reports on progress in geomagnetism and aeronomy, obtained from national reports and other sources.

Chairman: N. V. Pushkov
Izmiran
Vatutenki
Moscow, USSR

Working Groups

History of Geomagnetism — **Reporter: —**

History of Aeronomy — **Reporter: —**

Additional Commission Members not Attached to Working Groups:

M. G. Alvarez (USA)
G. Atanasiu (Rumania)
G. Barta (Hungary)
J. W. Beagley (New Zealand)
E. J. Chernosky (USA)
H. Constantinescu (Rumania)
A. H. Cullington (New Zealand)
G. Fanselau (Germany DR)
F. Florian (Hungary)
N. C. Gerson (USA)
J. A. Jacobs (U. K.)
J. Keranen (Finland)
A. Kimpara (Finland)
J. L. Koenigsfeld (Belgium)
H. G. Korber (Germany DR)
A. Lundback (Denmark)
N. E. Malinina (USSR)
S. Matsushita (USA)
M. Z. Nodia (USSR)
E. S. Staus (USA)
A. Tarczy-Hornoch (Hungary)
N. Fukushima (Japan)

WORLD MAGNETIC SURVEY BOARD

Chairman: V. Laursen

Vice Chairmen: J. D. Kalinin (Rep. of COSPAR)
J. O. Cardus

Secretary: E. H. Vestine

Assist. Secretary: E. Dyer

Members: T. Nagata (Pres. of IAGA and Rep. of SCAR)
L. R. Alldredge (Sec. of IAGA)
V. Vacquier (Rep. of SCOR)
M. M. Ivanov
B. R. Leaton
P. H. Serson

JOINT COMMITTEE IAGA-IAMAP

Title: **Atmospheric Electricity**

Honorary Chairman: H. Norinder (Sweden)

Chairman: L. Koenigsfield (Belgium)

Secretary: H. Dolezalek (USA)

Working Groups

International Cooperation	**Chairman:** H. Dolezalek (USA)
Bhartendu (Canada)	E. A. Lauter (Germany DR)
R. Bostrom (Sweden)	A. Mani (India)
G. Freier (USA)	D. E. Olson (USA)
L. Jacobs (U. K.)	J. Podzimek (CSR)
G. Kondo (Japan)	G. Stout (USA)
K. Kreielsheimer (New Zealand)	J. A. Thomas (USA)

one member to be appointed by Hydromet. Service USSR
one member to be appointed by Atmosph. Electr. Data Center Leningrad

Surface Measurements at Land and Sea	**Chairman:** H. Israel (W. Germany)
D. Blanchard (USA)	R. Janiselli (Italy)
Buis (Netherland)	S. Michnowski (Poland)
W. E. Cobb (USA)	M. Misaki (Japan)
W. D. Crozier (USA)	L. Saxer (Switzerland)
Ette (Nigeria)	M. V. Sivaramakrishnan (India
W. C. A. Hutchinson (U. K.)	

Measurements in the Free Atmosphere	**Chairman:** R. Muhleisen (W. Germany)
R. V. Anderson (USA)	G. W. Paltridge (U. K.)
V. D. Hopper (Australia)	G. P. Srivastava (India)
H. Ishikawa (Japan)	E. Ungethum (Sweden)
M. V. Krasnogorskaya (USSR)	

Ions, Aerosols, Radioactivity	**Chairman:** J. Bricard (France)
A. Junod (Switzerland)	G. Schumann (W. Germany)
M. Kawano (Japan)	R. Siksna (Sweden)
G. McGreevy (Ireland)	B. Styro (USSR)
M. J. Megaw (U. K.)	K. G. Vohra (India)
P. J. Nolan (Ireland)	K. T. Whitby (USA)
J. Pradel (France)	M. H. Wilkening (USA)

Thunderstorm-and Precipitation-Electricity	**Chairman:** J. Latham (U. K.)
	C. B. Moore (USA)
M. Brook (USA)	J. D. Sartor (USA)
D. Fitzgerald (USA)	N. S. Shishkin (USSR)
P. V. Hobbs (USA)	Y. Tamura (Japan)
Ch. Magono (Japan)	
B. J. Mason (U. K.)	

Lightning and Sferics	**Chairman: K. Berger (Switzerland)**
F. W. Chapman (U. K.)	E. T. Pierce (USA)
F. Horner (U. K.)	Ch. Polk (USA)
N. Kitagawa (Japan)	S. A. Prentice (Australia)
H. Konig (W. Germany)	L. Salanare (USA)
L. B. Loeb (USA)	V. A. Solovyev (USSR)
D. J. Malan (South Africa)	M. A. Uman (USA)
M. M. Newman (USA)	T. W. Wormell (U. K.)

Global Circuit	**Chairman: H. W. Kasemir (USA)**
H. J. Aufm Kampe (W. Germany)	R. Reiter (W. Germany)
Figueira (Portugal)	Rosser (Brazil)
E. Gherzi (Canada)	J. R. Storey (New Zealand)
B. B. Huddar (India)	K. Uchikawa (Japan)

D. R. Lane-Smith (Sierra Leone)
K. Zonga (USA)
One member from USSR still to be nominated

Units, Methods, Instruments — **Chairman: B. Vonnegut (USA)**

M. Heffernan (Australia)
J. Hughes (USA)
I. M. Imianitov (USSR)
T. Ogawa (Japan)
L. Ruhnke (USA)
T. Takahashi (Japan)
S. P. Venkiteshvaran (India)

Free Space — **Chairman: R. Lust (W. Germany)**

S. C. Coroniti (USA)
C. G. Fälthammar (Sweden)
V. Gringauz (USSR)
R. E. Holzer (USA)
T. Obayashi (Japan)
R. C. Sagalyn (USA)
L. R. O. Storey (France)
A. Kimpara (Japan)

JOINT COMMITTEE IAGA-IAMAP

Title: **Lunar Variations**

Honorary Chairman: S. Chapman (U. K.)

Chairman: O. Schneider (Argentina)

Working Groups

Procedures — **Reporter:** B. Haurwitz (USA)

S. Chapman (U. K.)
G. Fanselau (Germany DR)
O. Schneider (Argentina)
S. R. Malin (U. K.)

Additional Members not Attached to Working Group:

D. F. Martyn (Australia)
S. Matsushita (USA)
P. Rougerie (France)
J. Thomas (Australia)
D. E. Winch (Australia)
A. M. van Wijk (South Africa)
H. Maeda (Japan)
J. C. Gupta (USA)
A. T. Price (U. K.)
O. M. Burkard (Austria)
R. Sawada (Japan)
R. G. Rastogi (India)
E. J. Chernosky (USA)
M. Fatkullin (suggested by Dr. Benkova for replacement) (USSR)
M. Bossolasco (Italy)
J. C. Cain (USA)
J. O. Cardus (Spain)
W. G. Kertz (W. Germany)

NEW IUGG OFFICERS

Although it was not a part of the IAGA assembly, it is reported here that at the final IUGG plenary session held in Zurich on October 7, the following scientists were elected as the new IUGG officers:

President:	Prof. J. Coulomb (France)
Vice-President:	Prof. H. Kuno (Japan)
Treasurer:	Prof. E. Anderson (Denmark)
Members of the Bureau:	Prof. L. Constantinescu (Rumania) Dr. T. F. Malone (USA) Prof. A. M. Oboukhov (USSR)
Finance Committee:	Prof. S. Krynski (Poland) Prof. T. J. Kukkamki (Finland) Dr. J. Stagg (United Kingdom) Mr. E. Walser (Switzerland) Dr. C. A. Whitten (USA)

RESOLUTIONS

IUGG RESOLUTIONS

The following resolutions were passed by the IAGA and were later approved by the IUGG as Union Resolutions at the XIV General Assembly in Zurich, Switzerland 1967: (Resolution numbers refer to IUGG numbers.)

RESOLUTION NO. 11

The International Union of Geodesy and Geophysics **recognizing** the particular geographic situation of the Orcadas Island observatory and its importance within the observatory network of the Southern Hemisphere **appreciates** the efforts made by the Argentine Government during these latest years to complete the facilities and the scientific equipment of this magnetic station, and **expresses** the wish that the aid granted to the Orcadas observatory be continued and increased in order to permit a continuous participation of this observatory in the international cooperation required for the study of magnetic phenomena.

L'Union Géodésique et Géophysique Internationale **considerant** la situation géographique particulière de l' observatoire iles Orcadas et son importance dans le réseau des observatories de l'hémisphére sud, **apprécie** l'effort réalisé ces dernières années par le Gouvernement de l'Argentine pour compléter les installations et l'équipement scientifique de cette station magnétique, et souhaite que l'aide apportée à l'Observatoire iles Orcadas soit maintenue et accrue pour permettre à cet Observatoire de participer d'une manière continue à la coopération internationale requise pour l'étude des phénomènes magnétiques.

RESOLUTION NO. 12

The International Union of Geodesy and Geophysics **recognizing** the value of establishing a permanent geomagnetic observatory on the mainland of Chile: 1) for contributing to the world network of permanent observatories, 2) for providing a base to which Chile's observatory on Easter Island and her surface magnetic survey activities could be referred, **recommends** that the appropriate authorities give all the support necessary to establish and maintain a permanent geomagnetic observatory at Peldehue, or at such other site on the mainland as is considered suitable.

L'Union Géodésique et Géophysique Internationale **reconnaissant** l'intérêt de disposer d'un observatoire géomagnétique permanent dans la partie continentale du Chili: 1) en vu de sa participation au réseau magnétique mondial des observatoires permanents, 2) afin d'assurer une base pour la réduction des valeurs données par l'observatoire chilien de l'Ile de Pâques et celles obtenues lors des campagnes magnétiques, **recommande** que les organismes compétents puissent disposer de tous les moyens nécessaires pour établir et assurer le fonctionnement d'un observatorie permanent à Peldehue ou à tout autre site convenable sur le Continent.

RESOLUTION NO. 13

The International Union of Geodesy and Geophysics **noting with regret** that a high voltage AC power line is planned near the Geophysical Observatory of Huancayo, which will adversely affect the quality of the data obtained, **noting** the fact that the observatory, which is situated in a unique position, has been operating since 1922, and that a heavy loss to international science would result, **urges** the authorities concerned to consider a re-routing of the power line so that the observatory remains undisturbed.

L'Union Géodésique et Géophysique Internationale **notant avec regret** le projet d'installer une ligne de distribution d'énergie électrique à haute tension devant passer dans le voisinage de l'observatoire géophysique de Huancayo, ce qui affecterait considérablement la qualité des données qui sont obtenuse, **notant** le fait que l'observatoire, situé dans une position exceptionnelle, est en service depuis 1922, et qu'un tel changement entraînerait une lourde perte scientifique internationale, **demande** que les autorités compétentes veuillent bien considérer la possibilité d'un déplacement de l'itinéraire prévu pour la ligne de distribution d'énergie de telle sorte que l'observatoire puisse rester à l'abri des perturbations.

RESOLUTION NO. 14

The International Union of Geodesy and Geophysics **considering** the recommendations of the Geophysics Research Board of the U.S. National Academy of Sciences, as transmitted by Dr. H. Friedman, and of the Academy of Sciences of the U.S.S.R., as transmitted by Dr. N. V. Pushkov, and further **considering** the desires of the IAGA Commissions IV, V, VI, VII, and VIII to participate in the formulation and conduct of cooperative international programs for Solar-Terrestrial Physics, **supports** the organization of an international cooperative program for the Active Sun Years, 1968-1970 (IASY), to be organized under the general direction of the Inter-union Commission for Solar-Terrestrial Physics, **urges** the IUCSTP to complete a draft program for the IASY as soon as possible, **offers** the cooperation of its interested Associations in the preparation of the program, and recognizes the need for a general meeting organized by IUCSTP at an early date to permit the appropriate working groups to finalize the details of the IASY projects.

L'Union Géodésique et Géophysique Internationale **considerant** les recommendations du Geophysics Research Board de la U.S. National Academy of Sciences transmises par le Dr. H. Friedman, ainsi que celles de l'Académie des Sciences de l'U.S.S.R., transmises par le Dr. N. V. Pushkov, et, considerant en outre les intentions des Commissions IV, V, VI, VII, et VIII de l'AIGA de participer à la rédaction et à la réalisation de programmes internationaux de coopération dans le domaine de la physique des relations soleil-terre, **appuie** l'etablissement d'un programme de cooperation internationale pour les "Années du Soleil Actif," 1968-1970, (AISA), lequel devrait être organisé sous la direction générale de la Commission Inter-Union de la Physique des Relations Soleil-Terre, **demande** instamment que cette Commission mette au point un programme provisoire pour les "Années du Soleil Actif" le plus rapidement possible, **offre** la coopération de ses Associations intéressées, en ce qui concerne la préparation du programme et **reconnait** qu'il est nécessaire qu' une réunion générale soit organisée par cette commission à une date rapprochée afin de permettre aux Groupes de Travail appropriés de préciser les détails des projets relatifs aux "Années du Soleil Actif."

IAGA RESOLUTIONS

The following Resolutions were approved by the IAGA at the XIV General Assembly of IUGG held at St. Gall, Switzerland, September-October 1967.

RESOLUTION NO. 1

The IAGA **recognizing** the need for highest accuracy in magnetic observations, **recommends** the selection or establishment of a magnetic observatory in South America which will serve as a primary standard of accuracy and assist in the intercomparison of instruments from other observatories.

L'AIGA, **reconnaissant** la nécessité d'atteindre une précision très élevée dans les observations magnétiques, recommande la sélection ou l'établissement en Amérique du Sud d'un observatoire magnétique qui puisse servir de standard fondamental de précision at puisse permettre la comparaison des instruments des autres observatoires.

RESOLUTION NO. 2

The IAGA considering the great value for geomagnetic investigations of the output-data of magnetic observatories and the great advantage that would accrue from having these data in machine-readable form, **recommends** that magnetic observatories should, wherever possible, be modernized, and their read-outs be registered in digital form.

L'AIGA, **considérant** le grand intérêt pour les études géomagnétiques des données provenant des observatoires magnétiques et le grand avantage qui résulterait de la présentation de ces données sous une forme directement utilisable par un ordinateur, **recommande** que les observatoires magnétiques soient modernisés autant qu'il est possible et que leurs données soient enregistrées sous forme digitale.

RESOLUTION NO. 3

The IAGA **considering** that all magnetic survey data are of great value for the compilation of world magnetic charts as well as regional and local charts, and that the organizations listed below customarily engage in the compilation of world magnetic charts:

1. Royal Greenwich Observatory
2. U.S. Coast and Geodetic Survey
3. IZMIRAN, USSR

therefore **urgently requests** that all organizations which have conducted magnetic surveys under the World Magnetic Survey program in recent years, or which will make magnetic surveys in the future, send the survey data to one or more of the World Data Centers and/or to one or more of the three organizations named above. If the data are in the form of magnetic charts it is **recommended** to add, if available, digital data of the survey in question.

L'AIGA, **considérant** que toutes les données relatives à des levés magnétiques, sont d'une grande valeur, aussi bien pour l'établissement des cartes magnétiques mondiales que pour celui des cartes régionales et locales, et que les organismes énumérés ci-après établissent des cartes magnétiques mondiales dans le cadre de leur activité habituelle:

1. Observatoire Royal de Greenwich
2. U.S. Coast and Geodetic Survey
3. IZMIRAN, URSS

demande instamment, en conséquence, que tous les organismes qui, ces dernières années, ont mené à bien des levés magnétiques comme partie d'un programme du levé magnétique mondial, ou qui feront de tels levés à l'avenir, veuillent bien envoyer les données correspondantes à un ou plusieurs des Centres Mondiaux et (ou) à un ou plusieurs des trois organismes indiqués ci-dessus. Si les données sont présentées sous la forme de cartes magnétiques, il est **recommandé** d'ajouter les données digitales des levés, si celles-ci sont disponibles.

RESOLUTION NO. 4

The IAGA **urges** all countries having in their archives magnetic survey data from the years 1840-1900 to transmit to the WDC's, in order of preference:

1. The data in machine-readable form or
2. Copies of publications or manuscripts, or
3. Bibliography

L'AIGA **demande instamment** à tous les pays disposant dans leurs archives des valeurs de campagnes magnétiques relatives à la période 1840-1900, de faire parvenir aux Centres Mondiaux, dans l'orde préférentiel suivant:

ou les valeurs correspondant à ces campagnes mises sous une forme se prêtant au calcul automatique,

ou des copies des publications — ou des manuscrits — concernant les valeurs de cette époque,

ou la bibliographie couvrant le sujet.

RESOLUTION NO. 5

The IAGA **recognizing** the recent progress in interpreting observed geomagnetic field anomalies in terms of crustal movement and reversals of the geomagnetic field, and **recognizing** the excellent World Magnetic Survey data gathering facilities in many countries, **recommends** that the effort of national organizations be directed, when possible, towards magnetic surveys in areas (especially marine areas) of geophysical importance, these areas being identified by geophysicists acquainted with the interpretation of anomalies.

L'AIGA, **prenant acte** des progrès obtenus récemment dans l'interprétation des anomalies du champ géomagnétique par les mouvements de la croûte et les renversements du champ principal, et **reconnaissant** les grandes facilités offertes dans de nombreux pays pour l'acheminement des données relatives au levé magnétique mondial, **recommande** que les efforts des organisations nationales soient orientés, dans toute la mesure du possible vers la réalisation de levés magnétiques dans les régions (en particulier les régions oceaniques) présentant un intérêt géophysique, — régions qui auront été choisies par des géophysiciens ayant l'habitude de l'interprétation des anomalies.

RESOLUTION NO. 6

The IAGA **recommends** that to prevent unnecessary repetition of effort in the preparation of data for determinations of the main field, all mean hourly value data of the geomagnetic field elements be made available in a machine-readable form through the World Data Centers.

L'AIGA **recommande** que, afin d'éviter une duplication inutile du travail de préparation des valeurs destinées à la détermination du champ moyen, toutes les valeurs horaires moyennes des éléments géomagnétiques soient rendues disponibles par la voie des Centres mondiaux sous une forme se prêtant au calcul par machines.

RESOLUTION NO. 7

For the improvement of knowledge of secular variation in the regions of the Atlantic, Indian and Pacific Oceans, the IAGA **recommends** to the appropriate agencies the continuation and extension of effort toward secular-change determinations by repeat stations and observatories on islands.

En vue d'atteindre une meilleure connaissance des variations séculaires dans les régions des Océans Atlantique, Indien et Pacifique, l'AIGA **recommande** aux organisations compétentes de poursuivre et d'étendre leurs efforts en vue de la détermination de ces variations séculaires dans les stations de répétition et observatoires insulaires.

RESOLUTION NO. 8

The IAGA considering the growing need for magnetic data in machine-readable form, **recommends** the establishment of several world digital data centers (WDDC) for Geomagnetism (USA, USSR, Great Britain, Japan), to receive, catalog, and file magnetic data. These data shall then be supplied in standard formats on request to suitable institutions for scientific purposes by appropriate arrangements. The IAGA also **encourages** the WDDCs to perform other functions as user demand indicates, so far as they are able. It is further **suggested** that a manual for operation of the WDDCs be prepared.

L'AIGA **considérant** le besoin croissant de données magnétiques sous une forme directement utilisable par un ordinateur, **recommande** l'établissement de plusieurs centres mondiaux de données digitales (WDDC) (USA, USSR, U.K., Japan) pour Géomagnétisme. Ces centres seront chargés de recevoir, cataloguer et classer les données magnétiques. Ces données seront ensuite fournies sous une forme standard, à la demande des institutions compétentes, suivant des dispostions appropriées. L'AIGA **désire** également inviter les centres mondiaux à remplir d'autres fonctions suivant la demande des utilisateurs et leurs possibilités propres. Il est par ailleurs suggéré qu'un manuel d'opération pour les WDDC soit préparé.

RESOLUTION NO. 9

The IAGA **recommends** an investigation of the feasibility of automatically constructing ionospheric current charts for any U. T. epoch, using mean hourly values from a well distributed group of magnetic observatories. After feasibility is proven the IAGA **recommends** that arrangements be made with a suitable agency to construct and publish such charts for 3 or 4 epochs each Greenwich day, as a routine procedure.

L'AIGA **recommande** d'étudier la possibilité d'une construction automatique de cartes de courants ionosphériques pour toute heure T.U., à partir des valeurs moyennes horaires d'un groupe d'observations magnétiques convenablement répartis. Lorsque cette possibilité aura été demonstrée, l'AIGA **recommande** que les dispositions pratiques soient arrêtées avec un organisme compétent en vue de la préparation et de la publication régulière de telles cartes pour 3 cu 4 moments particuliers de chaque journée de Greenwich.

RESOLUTION NO. 10

In view of the great importance of observations of pulsations for the investigation of processes in the magnetosphere, the IAGA **recommends** the recording of pulsations as one of the important tasks of permanent geomagnetic observatories.

Etant donné la grande importance des observations de pulsations pour l'étude du comportement de la magnétosphère, l'AIGA **recommande** que l'enregistrement des pulsations soit l'une des tâches importantes des observatoires géomagnétiques permanents.

RESOLUTION NO. 11

The IAGA **taking into account** the growing necessity of magnetic observations on a dense network of stations in auroral and polar regions as well as at middle latitudes, around conjugate points, **recommends** that selected observatories and geophysical institutes unite their efforts in organizing such international experiments utilizing their equipment in temporary networks of stations.

L'AIGA, **tenant compte** du besoin croissant d'observations magnétiques dans un réseau dense de stations situées tant dans les régions aurorales et polaires qu'aux latitudes moyennes, au voisinage des points conjugués, **recommande** que des observatoires selectionnés et les Instituts de Géophysique unissent leurs efforts pour organiser de telles expériences internationales, faisant appel à leurs équipements pour mettre sur pied des réseaux temporaires de stations.

RESOLUTION NO. 12

The IAGA **considering** the proposal of the Working Group on Magnetic Indices of Commission IV, concerning the elimination of solar flare effects in the computation of the Kp index, **endorses** the principle according to which, beginning January 1, 1968, an index Kp' should be derived from K' indices and published supplementary to the Kp index.

L'AIGA, **considérant** la proposition du Groupe de Travail des Indices Magnétiques de la Commission IV relative à l'élimination des effets des éruptions solaires dans le calcul de l'indice Kp, **adopte** le principe selon lequel, à partir du 1er Janvier 1968, un indice Kp' soit calculé à partir des indices K' et publié en supplement de l'indice Kp.

RESOLUTION NO. 13

The IAGA **considering** the proposal of the Working Group on Magnetic Indices of Commission IV concerning the characterization of the magnetic activity in each hemisphere and on a worldwide scale by the new indices Kn, Ks and Km, **recommends** that the determination of these new indices be started on a trial basis with data beginning 1 January 1964, and **urges** the fullest possible collaboration on the part of the observatories whose K indices will be required for this determination.

L'AIGA **considérant** la proposition du Groupe de Travail des Indices Magnétiques de la Commission IV relative à une caractérisation de l'activité magnétique dans chaque hémisphère et à l'échelle mondiale par de nouveaux indices Kn, Ks et Km, **recommande** que la détermination de ces nouveaux indices soit entreprise à titre d'essai avec des données débutant au 1er Janvier 1964, et **demande instamment** aux observatoires dont les indices K seront requis pour cette détermination d'apporter leur collaboration.

RESOLUTION NO. 14

The IAGA **recognizing** that the study of the geomagnetic field requires comprehensive, and continuous, world-wide measurements and that the practicability of such observations by earth satellite has now been demonstrated, **recommends** that the appropriate agencies be requested to provide measurements by low altitude satellites recording data from absolute magnetometers. IAGA **recommends** at least two satellites at near polar inclinations, with their orbital planes at right angles, and a third spacecraft orbiting near the equator. IAGA further **recommends** that machine-readable data from these orbiting magnetic observatories be made available to the World Data Center system in a timely way.

L'AIGA **reconnaissant** que l'étude des modifications subies par le champ géomagnétique nécessite tout un ensemble de mesures coordonnées et continues faites à une échelle mondiale et que la possibilité de réaliser de telles mesures au moyen de satellites terrestres est maintenant bien reconnue, **recommande** que l'on s'adresse aux organisations compétentes dans le but de réaliser un tel programme au moyen de satellites de basses altitudes équipés de magnétomètres absolus. L'AIGA **recommande** l'usage d'au moins deux satellites placés sur des orbites quasi polaires, dont les plans sont normaux entre-eux, un troisième satellite circulant au voisinage de l'équateur. L'AIGA **recommande** de plus que les valeurs sous forme digitale transmises par ces satellites soient mises à la disposition des Centres Mondiaux sans trop tarder.

RESOLUTION NO. 15

The IAGA **recognizing** the difficulty in understanding the nature of rapid magnetic variations within the magnetosphere from moving satellites and **recognizing** the recent improvements in satellite technology, **recommends** that a suitable geostationary satellite be placed in orbit for studying these magnetic variations. Because of the great significance of this project to geomagneticians in many countries it is further **proposed** that the results be made immediately available to the international scientific community

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L'AIGA, **reconnaissant** la difficulté de comprendre la nature des variations magnétiques rapides observées au sein de la magnétosphère à l'aide de satellites en mouvement at **reconnaissant** les progrès récents de la technologie spatiale, **recommande** qu'un satellite géostationnaire approprié soit mis en orbite an vue de l'étude de ces variations magnétiques. En raison de la signification majeure de ce projet pour les géomagnéticiens de nombreux pays, il est en outre **recommandé** que les résultats soient rendus immédiatement accessibles à la communauté scientifique internationale.

RESOLUTIONS NO. 16

The IAGA **considering** the IQSY recommendations on the creation of a special Working Group on aurora inside the frame of IAGA, and on the formal requirement for the submission of auroral data to the WDCs be suspended after the IQSY, **asserts** that its Commission VI (Aurora) has the responsibility to initiate and coordinate international programmes within its subject and while **agreeing** to the IQSY recommendation on the suspension of the formal requirement for the submission of data, **strongly recommends** that each country continues acquisition of data of value to large scale synoptic studies and that a listing of observations that have been undertaken be submitted annually to the WDCs.

L'AIGA, **considérant** les recommendations AISC sur la création d'un groupe de travail spécial sur les Aurores au sein de l'AIGA et sur la suspension après les AISC, de la demande formelle de transmission des données aurorales aux Centres Mondiaux, affirme que sa Commission VI (Aurores) a la responsabilité de promouvoir et de coordonner les programmes internationaux dans son domaine d'activité, et, tout en **se déclarant** d'accord avec lse recommendations AISC sur la suspension de la demande formelle de transmission des données, **recommande énergiquement,** que chaque pazs, continue à acquérir ces données dont la valeur est grande pour toute étude synoptique à grande échelle, et qu'une liste des observations qui ont été entreprises, soit transmise annuellement aux Centres Mondiaux.

RESOLUTION NO. 17

The IAGA **recommends** that the international effort in airglow observations and in the distribution of information to the WDC's be maintained at a level at least similar to that during the IQSY.

L'AIGA **recommande** que l'effort international qui a été applique aux observations de luminescences atmosphériques et à la transmission des données aux centres mondiaux reste maintenu à un niveau au moins du même ordre que durant les AISC.

RESOLUTION NO. 18

The IAGA **noting** that the geographical coverage of airglow stations is still unsatisfactory, **recommends** that additional stations be established; highest priority should be given to stations in middle Southern latitudes and in the vicinity of the magnetic invariant latitude poles. Cooperation should be developed within meridional chains of stations along four longitudinal sectors: Europe-Africa; Asia-Australia; North-South America; Siberia-India.

L'AIGA **note** que la couverture géographique des stations de luminescene atmosphérique est encore insuffisante, et **recommande** que des stations nouvelles soient implantees; les regions à équiper en priorité sont les latitudes moyennes de l'hémisphère austral, et le voisinage des pôles de latitude magnétique invariante. Il convient de développer la coopération des stations situées au voisinage d'un même meridien dans quatre secteurs de longitude: Europe-Afrique; Asie-Australie; Amérique du Nord-Amérique du Sud; Sibérie-Inde.

RESOLUTION NO. 19

The IAGA **recommends** that during the period of high solar activity, particular attention be paid to the phenomena of mid-latitude red arcs (SAR-arcs) and to the equatorial system of enhanced airglow emissions. Close coordination with radio investigations of the ionosphere, both from the ground and from space, is necessary.

L'AIGA **recommande** que durant la période de grande activité solaire une attention particulière soit apportée au phénomène des arcs rouges des moyennes latitudes (arcs SAR) et au mécanisme équatorial d'amplification des luminescences atmosphériques. Une coordination étroite avec l'exploration de l'ionosphere par sondages radio faits aussi bien à partir du sol que de l'espace, est nécessaire.

RESOLUTION NO. 20

The IAGA **recommends** that an increased effort be made to achieve a satisfactory interpretation of OH, 0_2 and Na emissions in the nightglow.

L'AIGA **recommande** qu'un effort accru soit fait pour arriver à une interprétation satisfaisante des émissions de OH, O_2 et Na dans le ciel nocturne.

RESOLUTION NO. 21

The IAGA **recommends** that increased effort be made on the following observational programs:

1. photometric detection of the 5200 A atomic nitrogen emission ,
2. determination of rapid temperature variations from Doppler broadening of emission lines,
3. rocket-borne determinations of altitude profiles of airglow emission,
4. twilight measurements of atomic helium fluorescence and ionized nitrogen scattering.

L'AIGA **recommande** qu'un effort accru soit axé sur le programme d'observation suivant:

1. détection photométrique de l'émission 5200 A de l'azote atomique,
2. détermination des variations rapides de température par l'élargissement Doppler des raies d'émission,
3. détermination par fusées de la distribution verticale des émissions de la luminescence atmosphérique,
4. mesures crépusculaires de la fluorescene de l'hélium atomique et de la diffusion de l'azote ionisé.

RESOLUTION NO. 22

The IAGA **recommends** that laboratories performing calibrations of airglow photometers take steps for comparison of photometric scales, preferably within the next twelve months.

L'AIGA **recommande** que les laboratoires où se font des étalonnages de photomètres pour la luminescence atmosphérique fassent le nécessaire pour assurer la comparaison des échelles photométriques, ceci si possible avant un délai de douze mois.

RESOLUTION NO. 23

The IAGA **notes with satisfaction** the extended use of radio-meteor techniques for the study of the upper atmosphere. Most exisiting measurements are made at middle latitudes. The IAGA therefore **draws attention** to the importance for synoptic studies of equatorial and high latitude measurements and, where possible, of simultaneous meteor wind, ionospheric drift, rocket release and other appropriate observations.

L'AIGA **exprime sa satisfaction** en constatant l'usage de plus répandu de la technique des radio-météores pour l'étude de la haute atmosphère. La plupart des mesures actuelles ont lieu aux latitudes moyennes. En conséquence, l'AIGA **attire** l'attention sur l'importance des études synoptiques aux latitudes équatoriales et élevées et quand cela est possible, des observations simultanées des vents météoriques, des mouvements ionosphériques, des émissions artificielles par fusées et d'autres observations appropriées.

RESOLUTION NO. 24

The Joint IAGA-IAMAP Committe on Lunar Effects **considering** the lack of statistical significance, obtained so far, on studies of lunar variations in atmospheric, aeronomical and geomagnetic phenomena, and further **considering** that a wealth of past observations in these fields is available for improving such results, **recommends** that all possible measures be taken to commit to computer readable form past and present atmospheric, aeronomical and geomagnetic parameters in such a way as to facilitate the integration and correlation of the data so processed into world-wide computer analysis of lunar effects.

Le Comité mixte AIGA-AIMPA sur les effets lunaires **considérant** le défaut de signification statistique actuelle des études de l'influence lunaire sur les phénomènes atmosphériques, aéronomiques et géomagnétiques et **remarquant de plus** que tout un capital d'anciennes observations dans ces domains de recherche est disponible pour l'amélioration des résultats correspondants, **recommande** que toutes les mesures appropriées soient prises afin de présenter sous une forme se prêtant au calcul digital les données, aussi bien anciennes qu'actuelles, relatives aux paramètres atmosphériques, aéronomiques et géomagnétiques, d'une facon telle qu'elle permette tout échange des données ainsi transcrites et l'intégration de ces dernières dans tout programme mondial relatif à des analyses lunaires sur ordinateurs.

RESOLUTION NO. 25

The IAGA **having noted** from the report of the World Magnetic Survey Mission in 1965 that plans are being considered for convening a regional meeting in South America, at which arrangements with the object of coordinating magnetic survey activities in the various South American countries could be discussed, **expresses its great satisfaction** with this initiative, and **urges** that the meeting be convened at an early date, in order to be of maximum benefit to the World Magnetic Survey and to future magnetic survey projects.

L'AIGA, **ayant relevé** dans le rapport de la Mission du Levé Magnétique Mondial pour 1965 qu'il est question d'organiser une réunion régionale en Amérique du Sud, au cours de laquelle il sera possible d'examiner les conditions à réaliser pour une meilleure coordination des opérations de levés magnétiques dans les divers pays de l'Amérique du Sud, l'AIGA **exprime sa grande satisfaction** d'une telle initiative et **demande instamment** que cette réunion se fasse à une date prochaine afin que le plus grand bénéfice puisse en être retire pour le Levé Magnétique Mondial et pour les projets de levés magnétiques ultérieurs.

RESOLUTION NO. 26

The IAGA **noting with satisfaction** the increased number of magnetic determinations in the Antarctic since the IGY but further **noting** that the number of magnetic stations now existing in the Antarctic cannot provide sufficient data for reducing these determinations to common epochs to be used for preparing Antarctic and world magnetic charts in the future, **recommends** that a network of regular magnetic stations be organized in the Antarctic at a number of especially chosen places where the magnetic field has only small anomalies. The observations at the repeat stations should be repeated each five years. IAGA **requests** the help of SCAR in organizing the repeat stations.

L'AIGA **notant avec satisfaction** le nombre croissant de mesures magnétiques effectuées dans l'Antarctique depuis l'AGI, mais **notant de plus** que le nombre des stations magnétiques existant actuellement dans l'Antarctique ne peut fournir un ensemble de valeurs suffisant pour la réduction de ces mesures à une époque commune de référence, en vue de leur utilisation ultérieure pour la préparation des cartes magnétiques de l'Antarctique et de la carte magnétique mondiale, **recommande** qu'un réseau de stations magnétique de répétition soit organisé dans l'Antarctique en choisissant un certain nombre d'emplacements convenable, là où le champ magnétique présente seulement de faibles anomalies. Les mesures à ces stations de répétition devraient etre faites tous les cinq ans. L'AIAGA **demande** son aide au SCAR pour l'organisation de ces stations de répétition.

RESOLUTION NO. 27

The IAGA **noting** the difficulty and expense of establishing and equipping a good archeomagnetic laboratory, **recommends** that laboratories having good measuring facilities should provide opportunity for the measurement of archaeomagnetic samples collected in countries where such facilities are not available and for training in the techniques of collection and measurement.

L'AIGA **faisant** état de la difficulté matérielle et financière entrainée par l'établissement et l'équipement d'un bon laboratoire d'archéomagnétisme, **recommande** que les organismes bien équipés acceptent de faciliter les mesures concernant des échantillons archéomagnétique prélevés en des pays où de telles possibilités n'existent pas encore, et de participer à l'initiation aux techniques de prélèvement et de mesures.

RELATIONS WITH COSPAR

In the Plenary Sessions Minutes in this bulletin reference was made to a statement by President Nicolet regarding IAGA relations with COSPAR. The statement, which follows, was distributed to all participants at the assembly.

STATEMENT

Representatives of IAU, URSI and IUGG participated in a special meeting of the COSPAR Executive Council, London, July 22, 1967, which was called to discuss the Resolution on COSPAR of the VIth ICSU Executive Committee, Monaco, October 7 and 8, 1966. In preparation for this meeting, the subject had already been discussed by the COSPAR Bureau at its XIIIth Meeting in Paris, October 18, 1966, and had been the subject of extensive correspondence among the Union Representatives and COSPAR. At the conclusion of the COSPAR Meeting in London, the COSPAR (full Committee) accepted a statement of its Executive Council containing several constructive expressions of principle regarding future COSPAR action and a specific Resolution regarding the participation of COSPAR Member Unions in Working Group activities. A copy of this statement is appended herewith:

In our opinion, this COSPAR action offers the possibility for an effective participation of the Scientific Unions in the future work of COSPAR.

In view of this statement and of the good climate for excellent relationship between COSPAR and the Unions which was observed at the London Meeting, it does not seem necessary at present to consider the question of revision of the COSPAR Charter and By-Laws.

For IUGG — M. Nicolet
For URSI — S. Silver
For IAU — L. Gratton

REPORT OF THE EXECUTIVE COUNCIL SPECIAL COMMITTEE

London, July 25, 1967

The following members of the Executive Council met on the afternoon of July 25, 1967, at the instruction of the Council to consider in detail the constructive suggestions which had been set forth by various members of the Council Meeting on July 22, 1967:

Prof. Maurice Roy	Prof. J. Kaplan
Dr. R. W. Porter	Prof. S. Silver
Acad. A. Blagonravov	Prof. L. Gratton

After lengthy deliberation, these Members have agreed to submit to the Council for its further consideration and possible action the following statements:

1. In order to stimulate and encourage more active participation by all Union Members in COSPAR, and especially in the deliberation of its Executive Council, the Council instructs its President to send a personal letter to the representatives of all Union Members urging that they attend a session of the Executive Council during the XIth COSPAR Meeting to be held in Tokyo for the purpose of discussing possible future scientific programs of COSPAR that might be especially interesting to those Unions that have not heretofore been very active in COSPAR, and offering financial assistance if needed. It is also recommended that the President send a personal note

to the President of each Member Union expressing the importance of full Union participation in this session and asking him to encourage correspondence and discussion within his Union on the subject as to how it might best participate in the future work of COSPAR and to make sure that either the regular representative or some other well-informed person will be designated to represent his Union at this session. A financial subvention should be sought from ICSU to help defray additional travel expenses of representatives of Member Unions.

The personal assistance of the President of ICSU should be sought in the form of unofficial encouragement to all Union Members of COSPAR to participate actively in its work and deliberations.

2. In order to make the deliberations of the Executive Council more effective, the Council recommends that its President prepare for each meeting an annotated agenda, with explanatory notes setting forth the background for discussion of each of the main points to be covered. In addition, the Council recommends that each of its Members give careful consideration, well in advance, to matters which, in its opinion, ought to be discussed at a Council Meeting and communicate the results of such consideration to the President of COSPAR to assist in preparing the agenda and, where appropriate, to the representatives of other Members in order that they may have time to consult their colleagues before the meeting.

3. In order to facilitate communication among the various Union Associations and/or Commissions and COSPAR Working Groups, the Executive Council suggests that the representatives of each Member Union, or some other person designated by the Union to assist and advise him, collect from all appropriate Commissions and adhering Associations, if any, of his Union information relating to the subject matter of scientific meetings or symposia planned more or less firmly for the three coming years, relating to research conducted by means of rockets or space vehicles, and that these representatives and advisors of Member Unions in closely related fields (such as IAU, IUGG, URSI, IUPAP, IUPAC, IUTAM and IMU in physical sciences, and IUB, IUBS, IUPS and IUPAB in the life sciences, or any other combination which may be more rational) should meet together informally with appropriate representatives of COSPAR Working Groups or Panels, prior to Executive Council meetings, to exchange information about planned scientific programs and formulate constructive suggestions for COSPAR activity. (A time for such a meeting should be included in the official program of COSPAR).

It is further suggested that one Member Union representative serve as Convenor for each meeting (for example, the IUGG representative for physical sciences and the IUBS representative for life sciences). No formal reports would be expected to result from these informal meetings, but rather a better background of information for their subsequent participation in the Executive Council.

4. In order to provide the Member Unions with means for more effective scientific participation and a more formal voice in the deliberations of the COSPAR Working Groups and Panels, as provided for in Section II of the COSPAR Charter, the following resolution is submitted to the COSPAR Plenary Assembly for consideration:

Resolution: on official Union Members in Working Groups and Panels

COSPAR,

noting the increasing concern in many Unions over the activities of COSPAR Working Groups and Panels and their concern about the communication of these actions to Member Unions,

invites each Member Union to study the constituency of COSPAR Working Groups and Panels and, if it desires to do so, to designate an official representative to any COSPAR Working Group or Panel. These designated representatives may be persons who are already Members of the Working Groups or Panels concerned or they may be additional persons to be named by the Union. The additional responsibilities implied by such designation shall be defined by the designating Union.

5. The Executive Council accepts as a general guide for its future actions the suggestion that, wherever possible, major scientific meetings arranged by COSPAR should be held at contiguous times and places with Union assemblies or symposia and that an attempt should be made to select common or complementary themes for such meetings; however, it recognizes certain difficulties in universal implementation.

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	Caractère Magnétique Numérique des Jours (from 1 January 1930 to 31 December 1939) and Caractère Magnétique Numerique des Jours pendant l'Année Polaire 1932-1933 (in complete sets only)	$ 5.60
	International Auroral Atlas, published for the IUGG, to be obtained from University Press, Edinburgh, 1963	45 sh.
	IAGA Symposium No. 1, Copenhagen, 1960	$ 8.00
	IAGA Symposium No. 2, Berkeley, 1963	$ 5.30
	IAGA Symposium No. 3, Pittsburgh, 1964	$10.00
	IAGA Symposium No. 4, Cambridge, Mass., 1965	$ 7.00
	IAGA Symposium No. 5, San Paulo, Brazil	$ 7.00
	IAGA Symposium No. 6, Birkeland, Aurora and Magnetic Storms, 1967	(in preparation)
	IAGA Symposium No. 7, Upper Atmospheric Winds, Waves and Ionospheric Drifts, 1967	$ 9.00

PUBLICATIONS

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INTERNATIONAL ASSOCIATION OF GEOMAGNETISM AND AERONOMY

To be obtained from the IUGG Publication Office,
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No. 1	Organization, Minutes, and Proceedings of the Brussels Meeting, 1919	Out of print
No. 2	General Report of the Rome Meeting, 1922	Out of print
No. 3	Transactions of the Rome Meeting, 1922	\$ 2.60
No. 4	General Report of the Madrid Meeting, 1924	Out of print
No. 5	Transactions of the Madrid Meeting, 1924	\$ 2.60
No. 6	Preliminary Reports on Subjects of Investigation, 1926	Out of print
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(Continued inside back cover)