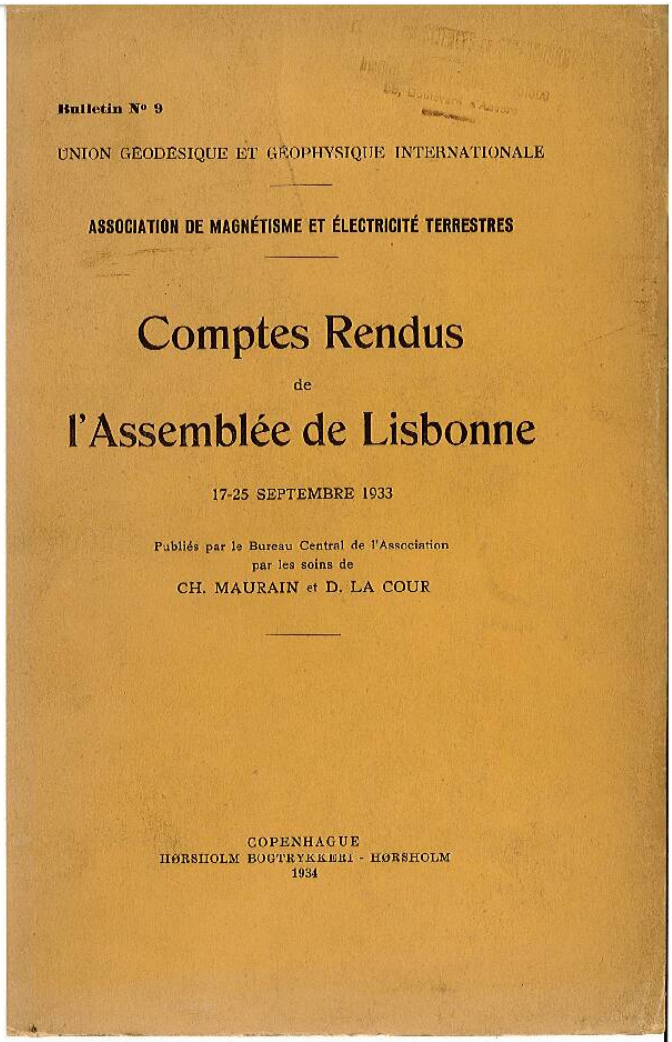

Bulletin N° 9

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ASSOCIATION DE MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES

Comptes Rendus

de

l'Assemblée de Lisbonne

17-25 SEPTEMBRE 1933

Publiés par le Bureau Central de l'Association
par les soins de
CH. MAURAIN et D. LA COUR

COPENHAGUE
HØRSHOLM BOGTRYKKERI - HØRSHOLM
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How to cite:

IAGA (1933). ***IATME Bulletin No. 9, Comptes Rendus de l'Assemblée de Lisbonne, 15-23 septembre 1933.*** **IUGG. https://doi.org/10.25577/6de0-rm38**

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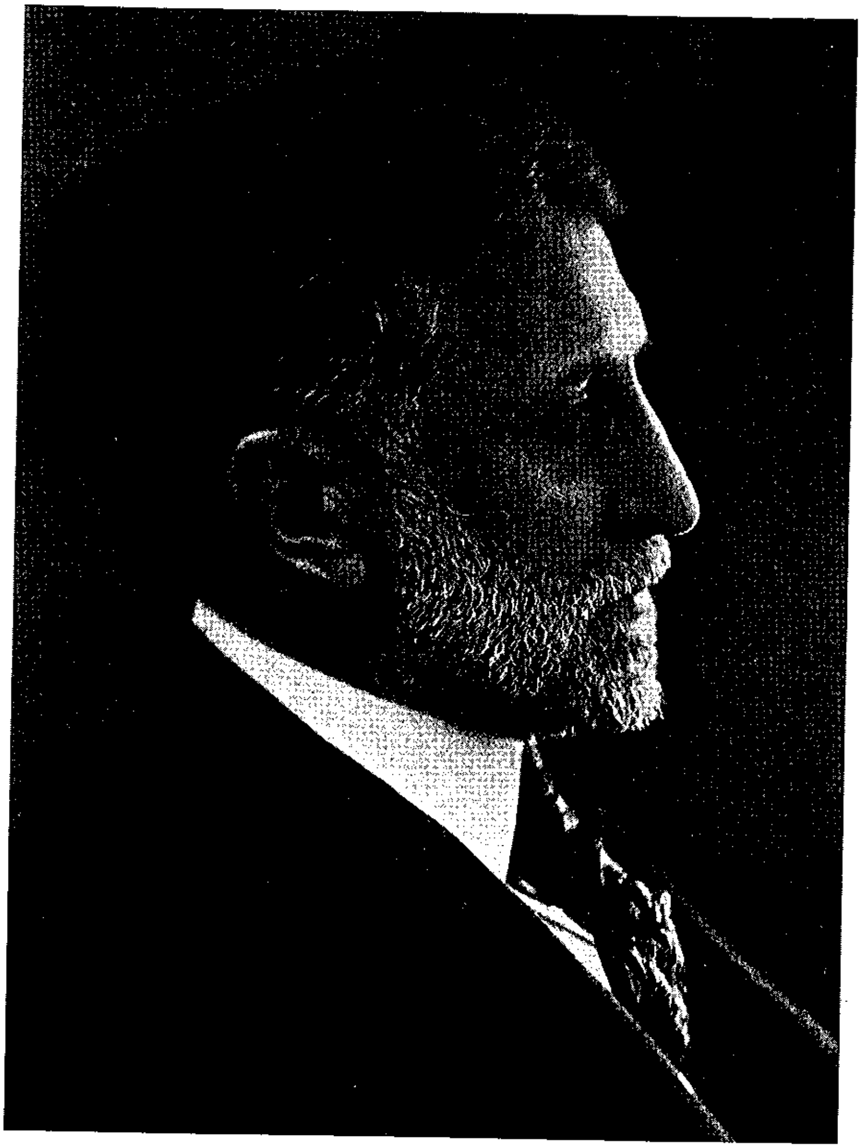

LOUIS AGRICOLA BAUER

Ancien Président de l'Association de Magnétisme et Electricité Terrestres

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TABLE DES MATIÈRES

PREMIÈRE PARTIE

ORDRE DU JOUR ET PROCÈS-VERBAUX

UNION GÉODÉSIQUE & GÉOPHYSIQUE INTERNATIONALE

Assemblée de LISBONNE du 17 *au* 24 *Septembre* 1933

ASSOCIATION INTERNATIONALE DE MAGNÉTISME & ÉLECTRICITÉ TERRESTRES

ORDRE DU JOUR PROVISOIRE

I. Discours du Président. Rapport du Secrétaire. Compte rendu financier. Election du Bureau de l'Association. Généralités. Distribution des Comptes rendus de l'Assemblée de Lisbonne.
II. Rapports des Comités nationaux.
III. Suite donnée à des décisions prises à l'Assemblée de Stockholm (voir ci-dessous le détail).
IV. Année Polaire 1932-1933 (voir ci-dessous le détail).
V. Communications et discussions sur divers sujets (voir ci-dessous le détail).
VI. Nomination de Commissions et désignation de Rapporteurs.
VII. Vœux.

DÉTAIL DES SUJETS POUR LES PARTIES III, IV, et V DE L'ORDRE DU JOUR

III. — *Suite donnée à des décisions prises à l'Assemblée de Stockholm.*

a) Rapport de la Commission sur le choix des emplacements de nouveaux observatoires pour le Magnétisme et l'Electricité terrestres. Vœu pour le maintien de certains observatoires créés pour l'Année Polaire;

b) Rapport de la Sous-Commission sur la répartition des travaux d'observatoires en Europe;

c) Rapport de la Commission sur les dispositions à prendre pour assurer la réoccupation à intervalles réguliers d'un nombre suffisant de stations réparties sur tout le globe, en vue de l'étude des variations séculaires;

d) Rapport de M. Chapman sur le projet d'une collaboration internationale pour avancer l'étude des effets de la Lune sur les phénomènes géophysiques;

e) Discussion sur les études théoriques concernant le magnétisme terrestre. (Il est proposé que cette discussion soit dirigée par MM Cabrera et Chapman, et que les personnes qui désirent y prendre part veuillent bien le leur faire savoir au début du Congrès);

f) Rapport de M. Wait sur les compteurs d'ions. Mode d'emploi et résultats;

g) Rapport de la Commission des aurores polaires;

h) Rapport de M. Tanakadate sur le début brusque des orages magnétiques;

i) Rapport de M. van Dijk sur la publication du caractère magnétique des jours;

j) Rapport de la Commission concernant les relations avec l'Organisation Météorologique Internationale.

IV. — *Année Polaire 1932-1933*

a) Rapport de la Commission de l'Année Polaire sur la collaboration avec l'Organisation Météorologique Internationale pour la réalisation de la seconde Année Polaire;

b) Rapport que M. la Cour sera prié de présenter relativement aux Travaux de la Commission Internationale de l'Année Polaire 1932-1933 de l'Organisation Météorologique Internationale;

c) Discussion des résultats de l'Année Polaire ainsi que des rapports demandés non seulement aux pays qui ont pris part à l'Année Polaire, mais aussi à ceux qui n'ont pas établi de stations spéciales (M. Fleming propose que cette discussion soit dirigée par M. la Cour).

V. — *Communications et discussions sur divers sujets*

a) Comparaison des magnétomètres électromagnétiques des différents pays;

b) Discussion sur l'utilité d'une nouvelle détermination des constantes de Gauss du champ magnétique terrestre en tenant compte des nombreuses déterminations récentes des éléments magnétiques, en particulier de celles de l'Année Polaire (vœu du Comité Britannique) ;

c) Liste provisoire de stations internationales pour l'étude des variations séculaires (communication de M. Heck) ;

d) Discussion sur les orages magnétiques (types, phases des orages polaires et équatoriaux, fréquence) et sur la préparation d'un catalogue d'orages magnétiques (M. Fleming propose que M. Chapman dirige cette discussion) ;

e) Distribution annuelle et diurne des débuts brusques de pertubation magnétiques (communication du P. Rodés) ;

f) Discussion sur l'activité magnétique et la caractérisation magnétique (M. Fleming propose que M. Crichton Mitchell dirige cette discussion). (Communication de M. Egedal) ;

g) Contribution à l'étude des variations périodiques du magnétisme terrestre (communication de M. et Mme Labrouste) ;

h) La géologie profonde de la France d'après le nouveau réseau magnétique et les mesures de pesanteur (communication de M. Jean Jung, présentée par M. Maurain) ;

i) Mesure et méthodes d'observation de l'activité solaire (M. Fleming propose que M. Bartels dirige cette discussion). Réseau mondial de stations munies de spectrohélioscopes (M. George E. Hale a bien voulu promettre une communication à ce sujet) ;

j) Développement des méthodes permettant l'étude des rayons cosmiques et leur enregistrement continu à des stations fixes. Relations possibles avec le magnétisme et l'électricité terrestres (M. Fleming propose que M. Steinke ou M. Regener soient invités à diriger cette discussion) ;

k) Discussion sur la possibilité de faire appel à des amateurs pour l'observation des aurores et sur l'organisation de ces observations (M. Fleming propose que cette discussion soit dirigée par M. Störmer) ;

l) Etude des phénomènes de la haute atmosphère (en particulier de l'ionisation et de la variation diurne des couches conductrices) et de leurs relations avec le magnétisme terrestre (M. Fleming propose que M. Kennelly dirige cette discussion). Le Comité Britannique propose un vœu à ce sujet;

m) Sur la corrélation du champ électrique terrestre et de la conductibilité de l'air atmosphérique (communication de M. Smosarski) :

n) Caractérisation numérique du champ électrique (proposition de M. Salles) ;

o) Etudes sur les orages et sur la foudre (communication de M. Dauzère) ;

p) Influence de la Lune sur la fréquence des tremblements de terre (indiqué par le P. Rodés).

SUPPLÉMENT A L'ORDRE DU JOUR

a) Secular change in the magnetic elements in the United States (communication by N. H. Heck);

b) Sur la caractérisation magnétique (communication de M. Crichton Mitchell). — Séparation des différentes formes d'activité magnétique (communication de M. Eblé). — Sur une caractérisation magnétique (communication de Mme Labrouste);

c) Proposition concerning the publication of the international magnetic catalogue. — Some results on the reliability of polar magnetic charts following from the summary of the magnetic determinations in polar regions. (Communications by B. Weinberg);

d) Levé magnétique de la Pologne (rapport de M. Kalinowski);

e) Le magnétisme terrestre, état actuel de sa théorie (communication de M. F. de Carvalho). — Influences lunaires sur le magnétisme terrestre (communication de M. Dias Pratas présentée par M. F. de Carvalho);

f) Magnétisme des roches (rapport de M. Mercanton);

g) Sur l'étude de l'électricité atmosphérique et des rayons cosmiques (communication de M. R. da Costa);

h) The solar-diurnal and lunar-diurnal variation of the high atmosphère (communication by J. Egedal);

i) Les fluctuations du champ électrique terrestre (communication de MM Duperier et Collado, présentée par M. Maurain);

j) Nouvelles recherches sur la matière fulminante (communication de M. Mathias);

k) Continuous Records of Point-Discharge (communication by F. J. W. Whipple).

Liste des délégués et invités ayant assisté aux séances de l'Association de Magnétisme et Électricité Terrestres, à Lisbonne, du 18 *au* 23 *septembre* 1933.

Nom	Nation	Date				
		18	20	21	22	23
MM.						
J. Agostinho	Portugal	p	—	—	—	—
H. Arctowski	Pologne	p	p	p	p	—
J. Bartels	Allemagne	p	p	p	p	p
M. Bossolasco	Italie	p	p	p	p	p
Melle Bruun de Neergaard	Danemark	p	p	p	p	p
MM. V. Carlheim-Gyllensköld	Suède	p	p	p	p	p
F. de Carvalho	Portugal	—	—	—	p	p
S. Chapman	Grande Bretagne	p	p	p	p	—
Ramos da Costa	Portugal	—	p	p	p	—
S. da Costa Lobo	Portugal	—	p	p	p	—
D. la Cour	Danemark	p	p	p	p	p
C. Dauzére	France	p	p	p	p	—
G. van Dijk	Pays-Bas	p	p	p	—	p
J. A. Fleming	Etats-Unis	p	p	p	p	p
H. Harradon	Etats-Unis	p	p	p	p	p
H. Hubert	France	—	—	—	p	—
H. Spencer Jones	Grande Bretagne	—	p	p	—	—
J. Keränen	Finlande	p	p	p	p	—
H. Labrouste	France	p	—	—	p	p
Mme Labrouste	France	p	p	p	p	p
MM. J. Lugeon	Pologne	p	p	p	—	—
E. Mathias	France	p	p	p	p	—
Ch. Maurain	France	p	p	p	p	p
P. Mercanton	Suisse	p	p	—	p	—
A. Crichton Mitchell	Grande Bretagne	p	p	p	p	p
L. Rodés	Espagne	p	p	—	p	p
S. Shinjo	Japon	p	—	—	—	—
W. Smosarski	Pologne	p	p	p	p	p
F. J. M. Stratton	Grande Bretagne	—	p	p	—	—
A. Tanakadate	Japon	p	—	—	—	—
M. Tenani	Italie	p	p	p	p	—
F. J. W. Whipple	Grande Bretagne	—	—	p	—	—

PROCÈS-VERBAUX DES SÉANCES DE L'ASSOCIATION

Séance du 18 *Septembre* 1933

La séance est ouverte à 11 h. sous la présidence de Mr. Fleming, Président de l'Association.

Mr. le Président prononce le discours d'ouverture.

Le Secrétaire lit son rapport. Il est convenu que le détail du rapport financier sera soumis à la Commission des Finances.

Le Président annonce que Mr. Maurain, très chargé par ses fonctions de Doyen de la Faculté des Sciences de Paris, renonce aux fonctions de Secrétaire de l'Association, et lui adresse des remerciements.

L'Assemblée élit à l'unanimité Mr. Fleming pour représenter l'Association à la Commission Générale de l'Union, et Mr. Chapman comme membre de la Commission mixte s'occupant de la constitution du Globe terrestre.

Le Président propose à l'Assemblée, qui les accepte, la constitution de diverses commissions:

Commission des vœux et résolutions: MM Fleming, Crichton Mitchell et Maurain.

Commission des Statuts: les mêmes.

Le Secrétaire fait remarquer à ce sujet que l'Union n'ayant pas encore adopté de statuts définitifs, la Commission pourrait surseoir à ses travaux jusqu'après la publication des Statuts de l'Union.

Après échange de vues, il en est ainsi décidé.

Comité financier: MM van Dijk, Harradon, Keränen.

Mr. le Président indique ensuite que, Mr. Tanakadate devant quitter Lisbonne ce jour même, il lui donne la parole pour présenter son rapport sur le début brusque des orages magnétiques.

Mr. Tanakadate présente son rapport.

Des remarques sont présentées sur ce rapport par MM la Cour, Chapman et Rodés.

Sur la proposition de Mr. la Cour, il est décidé que le Président désignera quatre personnes pour faire partie de la Commission des Orages à début brusque.

Le P. Rodès fait sa communication sur la distribution annuelle et diurne des débuts brusques des perturbations magnétiques.

MM Bartels et Chapman prennent la parole à ce sujet.

Mr. Fleming mentionne les titres des communications du Department of Terrestrial Magnetism de l'Institution Carnegie se rapportant à ces orages.

Election du Bureau. Sont élus à l'unanimité des votants: Président: Mr. Fleming, Vice-présidents: MM Carlheim-Gyllensköld et Maurain. Secrétaire et Directeur du Bureau Central: Mr. la Cour. Membres du Comité exécutif: MM Agostinho, Chapman, Crichton Mitchell, Störmer, Tanakadate.

Le Secrétaire indique les Rapports nationaux actuellement parvenus.

Il expose ensuite la question de la distribution des Compte-rendus de l'Assemblée. Un échange de vues a lieu à ce sujet. L'Assemblée prendra une décision à une séance ultérieure.

Le Secrétaire prie, de manière générale, les personnes qui prennent part aux discussions de bien vouloir lui faire parvenir une rédaction résumant leur intervention.

Les prochaines séances sont fixées au:

Mercredi 20 septembre, à 9 h.
Jeudi 21 — à 10 h.

La séance est levée à 12 h.45.

Séance du 20 *Septembre* 1933

La séance est ouverte à 9 h. sous la présidence de Mr. Fleming.

Le procès-verbal de la première réunion est adopté.

Mr. Chapman présente son rapport relatif à l'étude des effets de la Lune sur les phénomènes géophysiques. Sur la proposition du Président, il est décidé que ce rapport sera soumis au Comité exécutif. Mr. Chapman est maintenu comme rapporteur.

En l'absence de Mr. Cabrera, qui s'est fait excuser de ne pouvoir assister aux séances, la discussion sur les études théoriques en magnétisme terrestre est reportée à une session ultérieure.

Le Secrétaire présente le rapport de Mr. Störmer sur le supplément à l'atlas des aurores, ainsi qu'une proposition de Mr. Störmer de publier un deuxième supplément. Après échange de vues le Comité exécutif est chargé de prendre une décision à ce sujet, après avoir reçu un rapport du Comité des aurores.

Sur la proposition du Président il est décidé que les Commissions devraient être renouvelées à chaque Assemblée. La nouvelle Commission des aurores comprend: MM Störmer, *Président,* la Cour, Heck, Melander, Stagg.

Le projet de collaboration d'amateurs dans les observations d'aurores sera examiné par ce Comité.

Mr. van Dijk présente son rapport sur la caractérisation magnétique numérique des jours, ainsi que les six volumes déjà publiés. Plusieurs communications relatives à l'agitation magnétique sont ensuite présentées: de Mr. Eblé (résumée par Mr. Maurain), de Mme Labrouste, de l'Institut Carnegie (présentées par Mr. Fleming) et de Mr. Egedal.

L'Assemblée adopte trois résolutions relatives à la publication de la caractérisation numérique et renouvelle pour trois ans le Comité: MM Crichton Mitchell, *Président,* Chapman, van Dijk, van Everdingen, Maurain, Tanakadate.

Le Président donne lecture d'une communication du Secrétaire Général de l'Union relative aux cotisations des pays adhérents et consulte l'Assemblée sur le rapport qu'il doit adresser à ce sujet au Président de l'Union.

MM la Cour et Fleming indiquent les résultats obtenus depuis l'Assemblée de Stockholm relativement à la comparaison des magnétomètres électromagnétiques. L'Association approuve le vœu du Comité britannique à ce sujet.

Relativement à une nouvelle détermination des constantes de Gauss, l'Association adopte le vœu du Comité britannique et exprime le vœu qu'une publication complète des déterminations de Mr. Bauer puisse être faite.

MM Rodés, Chapman, Bartels, Carlheim-Gyllensköld, Costa Lobo et Crichton Mitchell prennent part à une discussion sur les orages magnétiques et sur leurs relations avec l'activité solaire. Mr. Maurain présente une communication sur ce sujet et Mr. Fleming une note de Mr. Hale. Deux vœux sont émis sur les propositions de MM Bartels et Rodés. Une commission comprenant: MM Fleming, Chapman, Bartels, Maurain, est nommée pour l'étude des relations entre l'activité solaire et le magnétisme terrestre.

Différentes communications sont ensuite présentées:

— de l'Institut Carnegie, par Mr. Fleming, et de Mr. Egedal par le Secrétaire, sur les phénomènes électriques de la haute atmosphère;
— de Mr. Lugeon sur les Tables crépusculaires, et
— de l'Institut Carnegie sur les rayons cosmiques.

Des vœux sont émis à propos de ces différentes questions.

Mr. Maurain présente une communication de Mr. Jung sur les relations entre la géologie profonde et le magnétisme terrestre. Mr. Mathias fait des remarques à ce sujet.

Mr. van Dijk lit le rapport du Comité financier, qui est approuvé; le Président s'associe au Comité financier pour adresser au Secrétaire ses remerciements.

Mr. Mathias présente une communication sur la Matière fulminante, qui fait l'objet d'un vœu.

La séance est levée à 13 h.30.

Séance du 21 Septembre 1933

La séance est ouverte à 10 h. sous la présidence de Mr. Fleming.

Les Communications suivantes sont présentées:

— sur les orages et sur la foudre, par Mr. Dauzère;

— sur «Continuous Records of Point-Discharge», par Mr. Whipple;

— sur la caractérisation numérique magnétique des jours, par Mr. Crichton Mitchell. Ce dernier est déjà désigné comme rapporteur pour 3 ans;

— sur la corrélation du champ électrique terrestre et de la conductibilité de l'air, par Mr. Smosarski;

— sur le champ électrique, par Mr. Duperier (présenté par Mr. Maurain).

MM Smosarski et Lugeon font des remarques à ce sujet;

— sur les variations périodiques en magnétisme terrestre, par Mr. et Mme Labrouste. Mr. Maurain signale à ce propos le travail de Mr. Guizonnier sur les variations du gradient de potentiel électrique.

Sur la proposition de Mr. Crichton Mitchell, l'Association émet un vœu relatif à l'établissement de cartes en coordonnées magnétiques.

Un vœu proposé par le P. Rodés concernant l'étude de la variation diurne des débuts brusques d'orages magnétiques est renvoyé au Comité chargé de l'étude de ces orages.

Le Président soumet une demande de subvention adressée par Mr. Wallén, Président de l'Association de Météorologie, en faveur du Bureau international de l'Heure. Après échange de vues l'Assemblée déclare ne pouvoir donner suite à cette demande.

Année Polaire. — Mr. la Cour présente les rapports de MM Störmer et la Cour sur la fabrication et la distribution des appareils photographiques et des spectroscopes pour les aurores. Sur la proposition du Président, l'Assemblée charge le Secrétaire de faire connaître à l'Organisation Météorologique Internationale que la Sous-commission de l'Année Polaire, formée de: MM Störmer, *Président*, Chapman, la Cour, Maurain, Wehrlé, est maintenue sans changement et qu'elle est chargée d'étudier l'emploi ultérieur des instruments dans le même mode que la Commission Internationale de l'Année Polaire.

Mr. la Cour présente son rapport sur l'Année Polaire, ainsi que les trois rapports publiés par la Commission Internationale de l'Année Polaire 1932-1933. Sur sa proposition, l'Association décide d'exprimer ses remerciements à la fondation Rockefeller pour les secours qu'elle a accordés à l'occasion de l'Année Polaire et pour favoriser l'avancement des études en magnétisme terrestre.

Dans un autre vœu l'Association signale la grande importance des résultats de l'Année Polaire et décide de contribuer à leur publication. Le Comité exécutif est chargé de fixer la somme à accorder. L'Association approuve les vœux et résolutions émis par la Commission Internationale de l'Année Polaire à Copenhague relativement au magnétisme terrestre et à la discussion des résultats.

Mr. Carlheim-Gyllensköld indique la contribution de la Suède aux travaux de l'Année Polaire.

Sur la proposition du Secrétaire il est décidé que les rapports préliminaires des différents Pays ne seront pas exposés en détail.

La séance est levée à 13 h.

Séance du 22 *Septembre* 1933

La séance est ouverte à 9 h. sous la présidence de Mr. Fleming.

Le procès-verbal de la séance du 21 est lu et approuvé.

Mr. Fleming expose le rapport de la Commission sur le choix des emplacements de nouveaux observatoires. A ce sujet, Mr. Hubert indique les nouveaux observatoires et les projets de création de stations dans les colonies françaises. Des vœux sont présentés par MM la Cour, au nom du Comité national de l'Année Polaire du Japon, Crichton Mitchell pour les observatoires de l'Inde, et Tenani pour les observatoires italiens. Diverses résolutions sont adoptées par l'Assemblée.

Sur la proposition du Président, le Secrétaire est chargé de faire une enquête en vue de la publication d'un catalogue des observatoires magnétiques. La Commission des observatoires étudiera sous quelle forme cette publication devra être faite et en référera au Comité exécutif.

Mr. la Cour présente le rapport de la sous-commission sur les travaux d'observatoire en Europe.

La Commission sur le choix des emplacements de nouveaux observatoires est renouvelée pour trois ans: MM Fleming, *Président,* Chapman, Maurain, Rodés, la Cour, ainsi que la sous-commission sur les travaux d'observatoires en Europe composée de: MM la Cour, *Président,* Chapman, Maurain.

Le Président résume le rapport de la Commission sur l'Etude des variations séculaires. Trois vœux sont émis à ce sujet et la commission est renouvelée avec la composition suivante: MM

Heck, *Président,* Jolly, Kalinowski, Mathias, Chapman, Fleming, Carlheim-Gyllensköld, Maurain, la Cour.

Mr. Fleming présente:

— le rapport sur les compteurs d'ions par Mr. Wait, qui est maintenu comme rapporteur;

— deux communications de MM Gish et Torreson sur la caractérisation électrique du jour. Un comité comprenant: MM Gish, *Président,* Rodés, Salles, Torreson, Whipple, est chargé de l'étude de cette question.

Mr. Rizzo expose brièvement l'Oeuvre scientifique de Luigi Palazzo.

Il est décidé que la Commission concernant les relations avec l'Organisation Météorologique Internationale et la Commission de Terminologie sont supprimées.

Mr. Arctowski soumet une demande de subvention à l'établissement d'un pavillon magnétique près de Lwów; l'Assemblée ne pouvant y donner suite, le Président propose à M. Arctowski d'en présenter un exposé à la Commission des Vœux dans le but d'obtenir l'appui moral de l'Association sous forme d'un vœu à ce sujet.

Une demande de subvention de Mr. Mercanton est renvoyée au Comité exécutif.

Sur la proposition du Président, une résolution est adoptée relativement à la publication et au mode de distribution des comptes rendus du Congrès.

MM Ramos da Costa, Président de la section magnétique du Comité portugais, et Carvalho rendent hommage à l'ancien Président Mr. Bauer, et apportent leur salut à l'Assemblée et à son nouveau Président. Ils font part de leurs recherches en Electricité et Magnétisme terrestres. Mr. Carvalho invite les membres de l'Assemblée à visiter l'Institut de géophysique et le nouvel observatoire de Coimbre.

Séance du 23 *Septembre* 1933

La séance est ouverte à 15 h. sous la présidence de Mr. Fleming.

Les procès-verbaux de la séance du 22 sont lus et approuvés.

Le Secrétaire lit les vœux et résolutions rédigés par la Commission des vœux; ceux-ci sont approuvés avec de légères modifications proposées pendant la séance.

L'Assemblée exprime au Comité Portugais sa gratitude pour l'hospitalité et les facilités qui lui ont été accordées.

Le Président donne lecture d'une résolution de la Commission Internationale de l'Année Polaire, qui remercie l'Union de sa collaboration à l'Année Polaire.

Mr. F. de Carvalho signale un travail de Mr. A. Dias Pratas relatif aux influences lunaires en magnétisme terrestre.

Le Président exprime ses remerciements au Secrétaire; Mr. la Cour, au nom de l'Assemblée, remercie le Président et le Secrétaire, et Mr. Crichton Mitchell prononce quelques paroles d'accueil à l'occasion du prochain Congrès qui se tiendra à Edimbourg.

La séance est levée à 16 h.

ANNEXES AUX PROCÈS-VERBAUX DES SÉANCES DE L'ASSOCIATION

Allocution du Président)*

We have lost by death since 1930 some eminent investigators. Among these are Louis Agricola Bauer of the United States and Luigi Palazzo of Italy, both of whom took so active part in this Association, Louis Winslow Austin, Robert Lee Faris, and Harlan Wilbur Fisk of the United States, Albert Wigand of Germany, Louis Froc of China, and Ricardo Cirera of Spain, founder of the Ebro Observatory. Let us hope that our deliberations may add worthily to their contributions in terrestrial magnetism and electricity.

Our fields of science have been advanced materially since the Stockholm Assembly in 1930. Outstanding from the observational viewpoint is the realization of the plans for the second International Polar Year 1932-33, an achievement due largely to the tireless energy and enthusiasm of our colleague Dr. la Cour, President of the International Polar Year Commission. Despite serious world-wide economic conditions, a remarkably large number of stations has been especially established both in polar and equatorial regions. The success attending this effort, which has resulted in so great an addition to the treasure of observational data in terrestrial magnetism and electricity, is an excellent example of what may be done in geophysics through world-wide coordination in preparing for development and test of theory. We will be privileged to hear later in these meetings Dr. la Cour's report.

The limitation of our observational data to two dimensions, that is to say, practically to the surface of the Earth, has always presented a serious difficulty in our investigations. The rapid development of effective methods of actually obtaining photographic and continuous records of the ionized regions of the upper atmosphere affords an effective tool to further our understanding of the observed magnetic and electric phenomena at

*) présentée à la première séance de l'Association, 18 septembre 1933.

the Earth's surface. It is important that our Association use its influence to forward systematic work of this kind at widely distributed stations.

Study of accumulated data as regards secular variations has emphasized the great importance of maintaining magnetic-survey operations on land and sea if we are to realize the fullest value of the material already obtained. It is to be hoped that the Association will take action to effect this in its consideration of reports of our special committee offering a coordinated scheme of secular-variation stations for future surveys.

On the theoretical side, the literature of the three years since our meeting at Stockholm affords ample evidence of persistent attack upon the complex problems of terrestrial magnetism and electricity. The communications to be presented later before this Association will give opportunity to estimate their real significance.

The rapid developments in atomic and nuclear physics have suggested further laboratory methods of attack as differentiated from what may be called the statistical approach through the discussion of accumulated and well-distributed observational data over the surface of the Earth. These developments will permit further speculations on the origin and changes of the Earth's magnetic field which must materially advance fundamental conceptions of the nature and constitution of matter.

Rapport du Secrétaire de l'Association, Directeur du Bureau Central, pour la période 1930-1933

MESSIEURS,

Voici, brièvement résumée, l'activité de l'Association depuis l'Assemblée de Stockholm en 1930.

Publications. — Un volume, constituant le Bulletin n° 8, de 479 pages, contenant les Comptes Rendus de l'Assemblée de Stockholm, a paru en 1931. Il a été imprimé à Paris par les Presses Universitaires.

Suite donnée aux décisions et vœux émis à l'Assemblée de Stockholm.

1°. **Atlas des Aurores Polaires.** M. Störmer a préparé un ouvrage: «Supplement to the photographic Atlas of auroral forms», qui a paru à Oslo en 1932. Un rapport de M. Störmer à ce sujet sera présenté à l'Association. (voir: p. 148).

2°. **Caractérisation numérique des jours au point de vue magnétique.** Le Caractère magnétique numérique adopté par la Section à Stockholm a été établi par un certain nombre d'observatoires, et les résultats ont été réunis et publiés par les soins de l'Institut Météorologique Royal des Pays-Bas (Tome I, paru en janvier 1932, tome II, avril 1932, tome III, septembre 1932, tome IV, mars 1933).

3°. **Année Polaire 1932-1933.** L'Assemblée générale de l'Union Géodésique et Géophysique a décidé à Stockholm, sur la proposition de la Section de Magnétisme et Electricité terrestres, de coopérer avec l'Organisation Météorologique Internationale à l'organisation et à la réalisation de l'Année Polaire 1932-33, et a nommé à cet effet une Commission présidée par M. Störmer et comprenant parmi ses membres M. la Cour, président de la Commission Internationale de l'Année Polaire. Ces messieurs, et les autres membres de la Commission, ont pris une part active à l'organisation générale de l'Année Polaire. Il appartient à M. la Cour, qui a été l'âme de cette organisation, de vous en entretenir. J'indiquerai seulement ici l'usage qui a été fait des crédits affectés par notre Association à la construction et à la répartition d'appareils destinés à l'observation des aurores polaires.

Un crédit de 15.000 francs or avait été prévu pour des appareils photographiques et des spectroscopes. M. Störmer a bien voulu se charger de tout ce qui concernait les appareils photographiques, et M. la Cour des spectroscopes. Chacun de ces Messieurs a fait un rapport à ce sujet; ces deux rapports sont données en annexe au présent rapport (voir: p. 163 et 164).

Travaux relatifs au Magnétisme et à l'Electricité terrestres. Les travaux relatifs aux observations, aux Réseaux magnétiques et aux Recherches Scientifiques seront exposés dans les Rapports des Comités Nationaux et dans les communications qui vont être présentées à l'Assemblée. Je signalerai particulièrement les Observations qui ont été faites à l'occasion de l'Année Polaire 1932-33, non seulement dans les Stations organisées spécialement à cette occasion, mais aussi dans un grand nombre d'observatoires sur la Terre entière. De nombreuses stations et observatoires ont été munis d'appareils magnétiques enregistreurs à déroulement rapide, du type étudié par M. la Cour, de manière à ce qu'on puisse réunir des graphiques bien comparables. Ces observations, poursuivies en principe jusqu'au 31 août 1933 pour l'hémisphère Nord et jusqu'au 31 janvier 1934 pour l'hémisphère Sud, seront continuées plus longtemps dans un certain nombre de Stations et d'Observatoires. On peut en espérer un précieux accroissement des connaissances.

Personnel. Les modifications apportées aux listes des Comités nationaux et les pertes subies par l'Association seront exposées dans les Rapports des Comités Nationaux. Qu'on me permette seulement ici de saluer la mémoire de Louis A. Bauer, qui a été longtemps Secrétaire, puis Président de la Section Internationale, maintenant Association, de Magnétisme et Electricité terrestres, enlevé à la science et à notre affection le 12 avril 1932. Un numéro spécial du grand Périodique qu'il avait fondé et longtemps dirigé, le «Terrestrial Magnetism and Atmospheric Electricity», a été en Septembre 1932 consacré à sa mémoire, et plusieurs de nos collègues ont, dans ce fascicule, exposé pieusement les titres de Louis A. Bauer à notre admiration et à notre reconnaissance.

Il me reste, en terminant, à vous exposer la situation financière de l'Association et à vous donner le détail des recettes et des dépenses. Bien que l'Association n'ait pas touché de l'Union Géodésique et Géophysique le total des sommes prévues à l'Assemblée de Stockholm, la situation financière est assez favorable, l'Association ayant en Caisse actuellement une somme de 190.152,85 francs français.

Voici comment se groupent les dépenses relatives à divers sujets:

	frs. fr.
Sommes versées à M. Störmer pour l'Atlas des Aurores polaires	35.183,20
Sommes versées pour les Cartes célestes et le supplément à l'Atlas	32.783,00
Dépenses relatives aux appareils photographiques et aux spectroscopes destinés à l'étude des aurores	75.210,30

(Dans sa séance du 22 août 1930, la Section avait décidé qu'une somme de 15.000 francs or serait affectée aux dépenses relatives à ces appareils; les dépenses se sont élevées à 75.210,30 francs français, dont 59.727,10 versés à M. Störmer pour les appareils photographiques et 15.483,20 à M. la Cour pour les spectroscopes).

Sommes versées pour la publication de la caractérisation magnétique	36.247,45

(Dans sa séance du 19 août 1930, la Section a décidé de remettre une subvention annuelle n'excédent pas 100 £ à l'Observatoire de De Bilt pour le travail et l'impression relatifs à la caractérisation magnétique. Des subventions correspondant chacune à 100 £ ont été remises en florins hollandais en deux fois à M. van Dijk, le 3 novembre 1931 pour les années 1930 et 1931, soit 18.850,00 francs français, et le 1er février 1933 pour les années 1932 et 1933, soit 17.397,45 francs français, soit au total 36.247,45 francs français).

Rapport de la Commission des Finances

La Commission désire exprimer son grand hommage à M. le Secrétaire de l'Association et Directeur du Bureau Central pour son administration excellente; tout a été trouvé en règle.

Relevé des comptes:

Recettes:[1])

Dépenses:[1])

Solde:[1])

Les *Dépenses estimées* pour les 3 années suivantes sont:

Impression des Comptes Rendus de l'Assemblée de Lisbonne, dépenses de bureau, circulaires etc. en chiffre rond	60.000,00 frs. fr.
Publication du «Caractère magnétique numérique des jours» 1934-1936	30.000,00 » »
Subventions aux travaux de l'Année Polaire 1932-1933	

A la réunion de la Commission Internationale de l'Année Polaire à Copenhague en mai 1933, la Commission a exprimé son avis sur sa propre activité dans l'avenir. Le programme de la Commission contient entr'autre le projet de faire des copies photographiques des enregistrements magnétiques et électriques effectués pendant l'Année Polaire, d'organiser et de faciliter autant que possible les études des phénomènes sur ces domaines. La dite Commission a formulé le vœu que des fonds soient mis à sa disposition pour ce but. Il est fort désirable que l'Association contribue autant que possible à la réalisation de ce vœu.

Le montant de ces dépenses ne peut pas encore être évalué, sans doute il sera assez grand. Cependant, il est fort désirable que l'Association y contribue dans la mesure que ses moyens le lui permettent. D'autre part, étant donné le désir de l'Union de réduire les subventions aux Associations aux ¾ des subventions antérieures, et que l'avoir en banque de l'Association se monte encore à 190.152,85 francs français, la Commission recommande de demander à l'Union une subvention de 200.000,— frs. fr. pour les trois années suivantes.

Lisbonne, le 20 septembre 1933.

G. van DIJK. J. KERÄNEN.
H. HARRADON.

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1) Voir p. 17 le relevé des comptes dans la forme proposée par le Secrétaire Général de l'Union.

RECETTES

		Francs français
Actif au 18 Juillet 1930		218.953,57
Reçu du Secrétaire Général:		
1930/31 & 1931/32 allocations	100.000,00	
1931/32 allocations	50.154,59	
1932/33 allocations	42.724,10	
id.	15.277,50	
		208.156,19
Agio (différence entre le revenu du compte au Crédit lyonnais et les impôts, taxes...) au 31 Déc. 1932		911,34
		428.021,10

PAIEMENTS

	Francs français
Pour l'Atlas des Aurores polaires	35.183,20
Pour les Cartes célestes et le Supplément de l'Atlas	32.738,00
Dépenses relatives aux appareils photographiques et aux spectroscopes destinés à l'étude des Aurores	75.210,30
Pour la publication du Caractère magnétique numérique des jours 1930-1933	36.247,45
Impression des Comptes Rendus de l'Assemblée de Stockholm, etc.	45.345.20
Autres dépenses (dépenses de bureau, frais de banque, etc.)	13.144,10
Actif au 11 Septembre 1933	190.152,85
	428.021,10

DEUXIÈME PARTIE

RAPPORTS NATIONAUX

BELGIQUE

Par E. LAGRANGE, *Président de la Commission belge de l'Année Polaire*

La Commission belge de l'Année Polaire, constituée en septembre 1931 par arrêté ministériel du Ministre des Sciences et des Arts, a, dès sa première réunion, fixé le programme de ses travaux en se basant sur la grandeur des moyens financiers mis à sa disposition par le Fonds de la Recherche Scientifique et par l'Etat lui-même.

Il se composait essentiellement de deux parties*) et en premier lieu d'une partie magnétique. Celle-ci comportait d'abord la création en Belgique même d'une station magnétique nouvelle, indépendante de celle de l'Institut Royal météorologique à Bruxelles, et à l'abri des courants «vagabonds»; elle a été installée par les soins de Mr. le professeur Dehalu, sur le plateau de Manhay dans l'Ardenne belge à 450 m d'altitude, à l'abri de l'influence des tramways électriques. Elle est munie des appareils nouveaux, de Mr. le Directeur la Cour, à prismes multiples à petite et à grande vitesse de déroulement; ceux-ci spécialement destinés à l'étude si importante de la propagation des orages magnétiques.

La station a fonctionné normalement à la date fixée du 1er. Août 1932, dans un abri provisoire à température constante, et l'enregistrement photographique des éléments n'a subi aucun arrêt quelconque depuis cette date; les relevés des diagrammes ont été entrepris dès les premiers jours et leur étude se poursuit d'une manière continue par les soins des élèves du Professeur Dehalu, en même temps que leur contrôle par des observations absolues. La station nouvelle est actuellement achevée; elle est

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*) *Note de la Rédaction:* La partie sur les observations météorologiques a été omise dans ce volume.

conçue dans un double but: celui de recevoir les nouveaux appareils en septembre 1933 pour constituer une station permanente destinée à remplacer celle de Bruxelles et en outre, de constituer un laboratoire spécial d'études magnétiques pour la prospection du sous-sol.

La Commission avait décidé également la création au Congo belge, autant que possible dans la région équatoriale, d'une station magnétique identique à la précédente; elle remplissait ainsi, en même temps un desideratum important de la Commission Internationale de l'Année Polaire, et donnait satisfaction aux desiderata scientifiques de nos géophysiciens. La station placée sous la direction de M. Molle, élève de Mr. le Professeur Dehalu, a été établie à Elisabethville (Katanga) par 11° 45′ de latitude sud; suivant les rapports reçus, elle a fonctionné normalement, dans des conditions parfaites et à la date demandée par la Commission Internationale; la documentation qu'elle a fournie est déjà à l'étude, comme celle de la station belge de Manhay.

Convaincu de l'intérêt considérable que présentait pour la science en général, et même au point de vue utilitaire et pratique pour des exploitations et des recherches minières en général, le maintien de la station magnétique d'Elisabethville, j'ai demandé au Fonds de la Recherche Scientifique les moyens financiers nécessaires à cet objet pour l'exercice annuel du 1er. août 1933 au 1er. août 1934.

Ma requête ayant été approuvée par le Conseil et son Président Mr. Francqui, le service de la station est assuré jusqu'au 1er. août 1934. Le personnel y attaché, à côté des observations journalières, aura en outre à jeter les bases d'une carte magnétique générale de notre Colonie, pour laquelle rien de semblable n'a encore été fait jusqu'à aujourd'hui; le service géodésique du Congo, dirigé par Mr. le Professeur Maury, s'est beaucoup intéressé à ce programme et le Comité du Katanga lui prêtera un appui des plus sérieux.

La station magnétique d'Elisabethville deviendrait ainsi, suivant notre programme, une installation scientifique permanente dont le but élargi embrasserait les études d'ordre géophysique en général.

Dès cette année d'ailleurs, M. Herman, assistant à l'Institut astrophysique de Liége, qui en aura la charge, y abordera en plus de ses travaux magnétiques des recherches sur le rayonnement cosmique, sous la direction de Mr. le Professeur Dehalu.

Note relative au maintien de la Station magnétique d'Elisabethville (Lat. sud.: 11° 45′*)*

Par E. LAGRANGE

Président de la Commission belge de l'Année polaire 1932-1933

J'ai présenté en mars 1933 au Conseil du Fonds de la Recherche Scientifique, en mon nom personnel et appuyé par l'Institut Royal Colonial, la Commission belge de l'Année Polaire et le Comité de géophysique nommé par l'Académie, un projet intitulé: *Projet relatif à la continuation et au développement des études géophysiques et spécialement magnétiques effectuées au Congo belge pendant l'Année Polaire* 1932-1933.

Il avait pour but premier le maintien pour un an de la station d'Elisabethville pour la continuation des observations magnétiques; mais dans ma pensée il est destiné à servir de point de départ à l'institution permanente dans notre colonie d'un centre d'études géophysiques. Le premier acte posé sera la mise sur pied de la carte magnétique du Congo.

Disons de suite que le fonds de la Recherche Scientifique en ratifiant ce programme nous a mis à même de le mettre à exécution pour l'exercice 1933/1934, pour lequel il nous a voté les fonds nécessaires.

Nous avons l'honneur de soumettre notre programme à la Commission qui a été nommée pour examiner les vœux de maintien de stations créées à l'occasion de l'Année Polaire, nous sollicitons son adhésion aux idées que nous y avons émises, adhésion qui nous serait certes un précieux appui dans l'avenir.

Monsieur Maurain a bien voulu nous dire que le maintien de la station d'Elisabethville serait d'ailleurs fort utile à l'établissement de la cartographie magnétique des régions équatoriales africaines qui est dans ce domaine «terra incognita» et nous nous permettons d'user ici de la haute autorité de son nom, auprès de la Commission dont nous avons l'honneur de solliciter l'approbation à notre programme.

CANADA

REPORT ON MAGNETIC WORK ACCOMPLISHED BY THE DOMINION OBSERVATORY IN CANADA

BY C. A. FRENCH

The progress of the general magnetic survey of the Dominion of Canada, which was inaugurated in 1907, has been reported to the various meetings of the Union.

During the period 1929-32, the work was carried out with instrumental equipment consisting of a combined magnetometer - dip circle and a combined magnetometer - earth inductor, both of which are Carnegie Institution types. It was found that the needles of the dip circle were somewhat erratic in their behaviour and, as a result, a Dover dip circle has been used as a substitute, for inclinations, since 1924. Mention might be made of a minor defect in the collimating system of the long magnet belonging to the magnetometer - earth conductor. As a result slightly different values of declination are obtained with the magnet at different heights, necessitating a little extra care in adjusting the height of the magnet during observation. In other respects both instruments have given exellent satisfaction throughout.

Observations are reduced to International Magnetic Standard by comparison of the field instruments with standards. Prior to 1930 the standardization was made as a rule at the beginning and end of the season at the Agincourt Magnetic Observatory through the courtesy of the Director of the Meteorological Service of Canada. Between 1930 and 1932 the instruments were compared but twice with recognized standards. In 1930 the usual series was carried out at Agincourt, and in 1931, through the courtesy of Mr. Jno. A. Fleming, Acting Director, an opportunity was afforded of making comparisons at the Department of Terrestrial Magnetism of the Carnegie Institution. In addition to the regular field instruments there was also compared a Cooke magnetometer, which it has been decided to use as a secondary standard for declination and horizontal intensity. The field instruments were compared with this instrument and with a Toepfer earth inductor for inclinations in 1931 and 1932.

Since the preparation of the rapport which was presented at the Stockholm meeting the magnetic work has been, for the most part, restricted to making observations of the three magnetic elements, declination, inclination, and horizontal intensity, at repeat stations. As was stated in that report an observer was then (1929) occupying a series of stations along the Albany river and around James bay, new territory so far as the Dominion Observatory is concerned, though the route had been traversed and stations established by officials of the Carnegie Institution in 1913. In all, ten stations were occupied. Three of these were exact and three approximate C. I. stations.

During 1930 observations were made at repeat stations only. The total number was forty-seven, practically all of which are in the area included between longitudes 75° W. and 116° W., and the U. S. - Canada boundary and latitude 53° N.

The work of the year 1931 was likewise confined to the occupation of repeat stations. Observations were made at thirty-five stations representing thirty-four localities. Twenty-three stations are distributed over the area between longitudes 61° W. and 75° W., and south of 49° N. Of those remaining, which are in Western Canada, nine are along the water route to the Arctic ocean between Chipewyan in lake Athabaska and Arctic Red River on the Mackenzie river.

Except two new stations which were established at the time of the total solar eclipse in August no field work was done in 1932, owing to lack of funds. The completion of the program of occupying the repeat stations over the part of the country thus far covered by the survey is therefore delayed.

DANEMARK

RAPPORT SUR LES TRAVAUX MAGNÉTIQUES DE DANEMARK 1930-1933

Par D. LA COUR

L'Observatoire magnétique de Copenhague (Rude Skov) a continué, régulièrement et sans interruption, ses travaux ordinaires qui sont: des enregistrements de D, H, & Z par deux jeux de variomètres différents et des déterminations absolues de leurs valeurs de base et d'échelle. A côté de ceci, un troisième jeu de variomètres D, H, & Z du nouveau type de l'observatoire et un enregistreur à marche rapide ont été montés au mois de juillet 1932 dans la cave demi-souterraine. Cet enregistreur a fonctionné pendant toute l'Année Polaire et continuera sa fonction aussi au-delà de ladite année.

Monsieur le Docteur *V. H. Ryd,* chef du Service Géophysique de l'Institut Météorologique de Danemark duquel ressort l'observatoire, a pris sa retraite au mois de décembre 1931. En novembre 1932 *M. J. Egedal* a été nommé Météorologue d'Etat et a été chargé du dit service et de la direction de l'observatoire.

En 1930,7 M. Egedal a répété les observations aux «stations séculaires» du Danemark.

Les valeurs trouvées à l'Observatoire de Copenhague sont toujours publiées dans l'Annuaire Magnétique, 1ère Partie: Le Danemark (excepté le Groenland); l'annuaire de 1932 est en préparation et paraîtra avant la fin de l'année courante.

L'annuaire de 1930 contient, outre les données ordinaires, des articles sur: «La marche diurne lunaire de D de 1919-1929» et «Les observations faites aux stations «séculaires» à l'époque 1930,7».

Quant à la série «Communications magnétiques etc.» les publications suivantes ont paru:

No. 10. On tides of the upper atmosphere. By J. Egedal.
No. 11. Le Variomètre de Copenhague. Par D. la Cour et Viggo Laursen.
No. 12. On the scale value and the base value of the H-Variometer. By V. H. Ryd.
No. 13. A theoretical determination of the heights of the stratosphere, the ozone layer and the height of maximum luminosity of the aurora. By Helge-Petersen.

Beaucoup d'expériences ont été faites à l'observatoire afin d'obtenir, à l'aide d'un vieil inducteur Edelmann, des observations de l'inclinaison plus exactes qu'auparavant. Pendant cette expérimentation — comme aussi à plusieurs autres occasions — il a été très avantageux d'avoir à sa disposition de bons variomètres. Le résultat de ces expériences est que l'erreur moyenne d'une seule détermination de l'inclinaison a été réduite à ± 0.'06 dont ± 0.'04 est dû à l'inclinateur même.

Sur la demande de M. le Professeur Nørlund, Directeur de l'Institut Géodésique de Danemark, une détermination de la réparation de la force verticale a été faite dans une région du Jutland. Pour ce but l'observatoire a fait construire deux nouveaux appareils portatifs pour la détermination de la force verticale. Tous les deux appareils sont d'un type portatif comme le «Lokalvariometer», bien connu, de M. le Professeur Ad. Schmidt, mais l'application de l'aimant monade de la Balance de Godhavn, renfermé dans une chambre à air raréfié, a permis de construire des appareils robustes et de constance remarquable qui semblent pouvoir servir non seulement de «Lokalvariometer» mais aussi de magnétomètre. L'un de ces appareils, nommé LMZ, qui en premier lieu doit son origine à M. Læssøe Müller, sert — comme le Variomètre de M. Adolf Schmidt — à mesurer les variations de l'angle entre le plan horizontal et l'axe magnétique de l'aimant dont la valeur d'échelle est de 25 gammas env. pour 1 minute, tandis que l'autre instrument — la Balance Magnétométrique (ou BM) — contient un aimant bien plus sensible dont l'axe magnétique est artificiellement porté à s'ajuster exactement dans le plan horizontal. Une description de ces appareils sera bientôt publiée. Jusqu'ici l'on en a fait trois, et les expériences ont montré qu'il y a lieu de croire que surtout la Balance Magnétométrique pourra rendre bien des services et pourra servir à comparer, d'une manière exacte et simple, les instruments pour les déterminations nommées absolues des divers observatoires.

En outre, on a construit à l'Observatoire un appareil simple et portatif pour la détermination de la force horizontale. Dans cet appareil, peu compliqué, ce sont les qualités remarquables des fils de quartz à deux têtes dont on a fait usage dans le but de construire un magnétomètre qui, sans application d'aimants auxiliaires ou d'autres accessoires, puisse servir partout sur le globe aux déterminations assez exactes de la force horizontale. Une description de cet appareil paraîtra aussi dans peu de temps.

A côté du travail ordinaire de l'observatoire, des recherches étendues et des travaux préparatoires pour l'Année Polaire y ont été exécutés. Non seulement il a été envisagé par ceux-ci de préparer les travaux magnétiques qui seraient faits aux stations danoises de l'Année Polaire, mais il a été possible à l'Institut Météorologique, avec l'autorisation du Ministère de la Marine, de soutenir, d'une manière fort étendue, les préparatifs internationaux aux recherches scientifiques dans ses domaines. Ont pris part à ce travail, outre le signataire de ce rapport et M. Olsen, chef de l'Observatoire Magnétique à Godhavn, en congé à Copenhague pour un an à partir de l'été 1931: MM les météorologues de service, J. Egedal et V. Laursen, ainsi que les assistants: M. A. Groot-Hansen et Mlle E. Schwartz.

Le travail comprenait: construction d'appareils, surveillance de leur construction, exécution de l'ajustage et des épreuves, construction de pavillons et la production d'accessoires; encore: instruction du personnel des stations danoises et assistance à 27 étrangers qui ont fait un séjour plus ou moins long à l'observatoire pour se mettre au courant de l'emploi des appareils, des auxiliaires et des méthodes spéciales de l'Observatoire.

En outre, on a exercé les instructeurs qui sont allés en Amérique du Sud et en Afrique du Sud de la part de la Commission Internationale de l'Année Polaire 1932-1933, et une assistance personnelle au montage des instruments magnétiques a été prêtée en Russie, Finlande, Suède, Islande, France et Espagne. L'observatoire a encore entrepris le remaniement de divers instruments envoyés de l'étranger pour modernisation à Copenhague. Pour mettre en évidence l'étendue de ces travaux, je mentionne que l'on a fait faire et que l'on a ajusté plus de 200 variomètres, 75 appareils enregistreurs dont 44 à marche rapide, et que l'on a procuré pour tout cela presque tous les accessoires dont 9 pavillons non-magnétiques, dont la construction et l'aménagement ont été essayés dans les détails par des montages provisoires à l'observatoire. Plusieurs magnéticiens étrangers ont apportés leurs appareils pour les déterminations absolues afin de les comparer à ceux de Rude Skov.

En construisant ce grand nombre d'instruments et leurs accessoires, l'observatoire a eu le concours excellent de plusieurs côtés. Grâce à M. Ljungdahl, Stockholm, 13 relais de temps ont été fabriqués par M. Wiholm, Stockholm, fabricant d'instruments — décédé plus tard, et grâce à M. Keränen, Helsingfors, 24 relais de temps et quelques pendules à contact simples ont été procurés de la Finlande.

Des fabricants d'instruments danois ont aussi fait un travail excellent; il faut mentionner tout d'abord M. Læssøe Müller, mécanicien de précision, qui a fourni tous les aimants des variomètres pour la force verticale et qui a collaboré, avec zèle et avec habileté, à la construction des appareils d'essai et à la reconstruction de vieux appareils; et la Maison Andersen & Sørensen qui, par un travail intense et avec quelque assistance d'autres ateliers, a fourni la plupart des variomètres, des appareils enregistreurs et des bobines à ajustage. Faute de temps, l'observatoire n'a fait faire que quelques fils de quartz, la plupart ont été fabriqués par M. le Docteur Strömberg, Stockholm.

Le travail ainsi accompli me sert d'occasion pour présenter mes sincères remerciements à tous mes collaborateurs et, étant donné les expériences nombreuses acquises par le travail étendu, aussi pour souligner l'importance d'une coopération étroite entre des magnéticiens pratiques et des fabricants d'instruments intéressés et habiles qui dans leurs domaines respectifs peuvent fournir les meilleurs produits. L'accomplissement de tous ces travaux sera attribué aussi au fait, très important à mon avis, que l'Institut Météorologique a eu l'autorisation générale susmentionnée de faire faire gratuitement tout ce travail étendu à l'observatoire.

Je désire mentionner, en peu de mots, quelques-unes des expériences acquises pendant les nombreux essais faits avec les nouveaux appareils:

1. Si l'on utilise des fils de quartz à deux têtes pour la suspension des aimants de D & H, on pourra sans inconvénient utiliser de petits aimants à oscillation libre de 1 à 2 secondes; il s'ensuit que, dans ce cas, on n'a pas besoin d'employer des amortisseurs et que les variations, même assez brusques du champ terrestre, seront nettement enregistrées.

2. Etant donné la constance de la force de torsion des fils de quartz à deux têtes, on peut sans inconvénient

employer une torsion permanente pour ajuster l'aimant de D (ou de H) dans sa position correcte.

3. Etant donné la constance des fils de quartz et l'invariabilité des aimants monades, les variations — même brusques — de la température ne font pas sauter les constantes des variomètres.

Il s'ensuit des § 2 et 3 qu'il n'est pas absolument nécessaire, pour établir un bon observatoire magnétique, de construire une maison non-magnétique et bien isolée pour les variomètres. Si l'on dispose d'une bobine Helmholtz-Gaugain on pourra toujours et facilement ajuster les aimants des variomètres dans les directions Nord et Est magnétiques pour le pavillon des mesures absolues, sans aucune préoccupation de la présence des champs perturbateurs constants où les variomètres seront montés — c. à. d. qu'on peut monter les variomètres dans des maisons ou dans des caves déjà construites pour d'autres buts.

4. Etant donné qu'il est important que l'axe de rotation de l'aimant reste horizontal dans un variomètre de Z, il est recommandé d'employer dans des balances des couteaux courts et reposant sur des surfaces d'agate planes et horizontales. Des sauts des lignes de base des Balances de Godhavn, quelquefois observés, proviennent certainement du fait que des tremblements accidentels ont un peu déplacé l'axe de rotation de l'aimant dans les affilements concaves dans lesquels reposent les couteaux de l'aimant. Il est à recommander d'échanger les morceaux d'agate contre de nouveaux morceaux donnant à la balance une invariabilité remarquable contre les effets de tremblements. De tels morceaux d'agate, polis en longueur, et à surfaces linéaires, sont en vente à l'Observatoire de Copenhague pour 2 $ la pièce pour échange dans les Balances de Godhavn achetées autrefois.

A l'Observatoire de Godhavn les travaux ont été continués sans interruptions.

Ayant passé 5 ans de suite à Godhavn M. Olsen a fait partie de la VIe expédition THULE sous la dirction de M. le Docteur Knud Rasmussen pour faire des mesures magnétiques sur la côte du Groenland de Julianehaab vers Angmagssalik. Ensuite, il a passé l'hiver 1932-1933 à Copenhague et pendant son absence de Godhavn, M. A. J. Hansen, de Copenhague, a fonctionné comme chef de l'observatoire. M. Olsen a provisoirement repris la direction de l'observatoire pour l'Année Polaire.

Il a été assisté par son successeur désigné: M. Stilling et par Mlle E. Schwartz. L'esquimau Ole Mølgaard, qui a servi d'assistant pendant 7 ans, a été un aide extrêmement solide et de grande valeur.

On a échangé le grand variomètre pour la force horizontale contre un Variomètre de Copenhague. La Balance de Godhavn, appartenant au jeu peu sensible, mais a sensibilité de 7.30 γ/mm, est considéré comme appartenant au jeu principal des variomètres de l'observatoire. Ensuite, on a installé un troisième jeu de variomètres (des nouveaux types) et un enregistreur à marche rapide. Tous les trois jeux fonctionneront aussi après l'Année Polaire.

Selon les rapports reçus, le personnel a fait un travail énorme pendant l'Année Polaire.

Tous les enregistrements (sauf les enregistrements à marche rapide) ont été mesurés et provisoirement et définitivement, et l'on a non seulement rempli les «Listes de contrôle» et les «Listes de Résultats Préliminaires», mais on a aussi établi des listes complètes des valeurs horaires contenant des valeurs réduites. Voici provisoirement les moyennes mensuelles des trois éléments, dépouillées des listes reçues jusqu'ici à Copenhague.

	1932					1933		
	août	sept.	oct.	nov.	déc.	janv.	fév.	mars
D (W) 57° +	0.'5	2.'1	2.'3	2.'4	2,'7	0.'6	-2.'3	-4.'8
H 8200 +	37	32	28	20	18	16	18	18
Z 55500 +	9	23	25	27	33	31	26	16

Tous les mois, des erreurs moyennes sont rapportées par T. S. F. à Copenhague.

Voici l'erreur moyenne des déterminations des valeurs mensuelles de la valeur de base des variomètres nommés les variomètres principaux de l'observatoire:

	1932					1933						
	août	sep.	oct.	nov.	déc.	jan.	fév.	mars	avr.	mai	juin	juil.
D (en sec.)	5	5	5	5	9	9	4	5	8	5	8	8
H (en gam.)	0.8	0.4	0.6	0.3	0.4	0.5	1.1	0.9	0.7	1.2	0.7	0.5
Z (en gam.)	1.3	1.2	0.6	1.1	1.4	1.2	1.2	1.0	0.7	1.5	2.0	1.5

Comme il a été prévu les enregistrements faits à marche rapide à Godhavn montrent de très grandes variations. Ces enregistrements n'ont pas encore été traités parce que l'étude approfondie de ces courbes sera conforme à l'étude des enregistrements pareils d'autres stations.

Pendant l'hiver passé, des observations continues sur les aurores ont été faites à l'Observatoire de Godhavn, et on a réussi dans certains cas de les photographier en même temps que des photographies en ont été prises à d'autres stations du Groenland (à Egedesminde et à Jacobshavn), munies de chambres photographiques et instruites par l'Observatoire de Godhavn et plusieurs des observations visuelles ont été exécutées en accord avec des observations à Ivigtut, Godthaab et Angmagssalik (station néerlandaise) afin de déterminer la position et la hauteur des aurores. On a fait en outre des observations spectroscopiques fréquentes et systématiques surtout dans le but de constater l'occurence des aurores en cas de ciel nuageux.

La publication des annuaires de l'observatoire a été beaucoup retardée, en premier lieu à cause de la communication difficile entre Godhavn et Copenhague. Jusqu'à l'Année Polaire presque tout le dépouillement des enregistrements a été fait à Copenhague, mais à partir de l'Année Polaire le traitement sera fait à Godhavn, ce qui a déjà beaucoup réduit le travail et en même temps accelléré l'accomplissement. Les tableaux des moyennes horaires pour 1927 sont imprimés, et la distribution de l'«annuaire», comprenant 1926 et 1927, sera faite à la fin de l'année courante.

L'échange de quelques-uns des variomètres contre des variomètres modernes a sans doute beaucoup facilité le contrôle des enregistrements à l'Observatoire de Godhavn. Ce renouvellement des instruments sera continué en échangeant aussi les autres variomètres contre des variomètres employés à la station de Thule pendant l'Année Polaire.

La station de l'Année Polaire à Thule (latitude: env. 76°31.'6 N; longitude: env. 68°53.'6 W) dont les coordonnées géomagnétiques sont: $\Phi = 88.°0$, $\Lambda = 0.°7$, $\psi = -0.°6$, fut établie au mois de juillet 1932 sous la direction de M. V. Laursen. M. Laursen a été accompagné de M. Dahlkild, physicien, M. Mortensen, ingénieur, M. Wienstedt, radiotélégraphiste, et M. Hans Bruun, ancien voyageur au Groenland. En outre, beaucoup d'assistance a été prêtée à l'expédition de la part du chef de la colonie de Thule, Monsieur Hans Nielsen, et du médecin danois local; la tenue du ménage a été confiée à une femme esquimau Emilie, autrefois la ménagère du chef de la Colonie.

Ayant établi la station, les deux pavillons magnétiques, la station radio, une station météorologique de montagne voisine etc., M. Hans Bruun a quitté Thule par un petit bateau venu à Thule tout à fait par hasard.

L'observatoire magnétique temporaire à Thule a été muni de trois jeux de variomètres de D, H & Z et de trois enregistreurs dont les deux ont marché à une vitesse de 15 mm par heure pour des enregistrements «sensibles» et «peu sensibles», tandis que le troisième a marché à 180 mm par heure. Pour des déterminations absolues la station a été munie d'un théodolite construit en 1890 par Adam Paulsen, mais remanié avant l'Année Polaire, et d'un équipement complet pour des déterminations électromagnétiques de la force horizontale et de la force verticale séparément. A Thule, où l'inclinaison est de plus de 85 degrés, la détermination directe de la force verticale est fort utile.

Etant donné la communication difficile avec Thule on n'a reçu jusqu'ici que de rares rapports du travail. M. Laursen a communiqué que les pavillons spéciaux apportés de Copenhague se sont bien comportés pendant toute la longue nuit polaire; encore, il a rapporté les erreurs moyennes suivantes d'une seule détermination:

pour D $\pm$ 0.'4 pour H $\pm$ 1.8 γ pour Z $\pm$ 7 γ

Outre ceci, la station de Thule a eu un programme de travail très étendu. A côté des observations météorologiques assez complètes on a fait des observations des aurores (visuelles et photographiques), des observations de la propagation des ondes radio et des observations de la radiation cosmique (appareil de Compton).

A présent l'expédition est en voie de retour. Les pavillons non-magnétiques sont emmagasinés à Thule pour pouvoir servir une autre fois à reprendre des observations magnétiques à cette station située seulement à 2 degrés de l'axe magnétique du Globe.

La station magnétique de l'Année Polaire à Julianehaab (latitude: 60°43'N; longitude: 46°03'W; coordonnées géomagnétiques: $\Phi = 70.°8$ $\Lambda = 35.°5$ $\psi = -13.°7$) a été établie au mois d'août 1932 sous la direction de M. Thiesen, physicien et ancien chef de la station séismique à Scoresbysund. M. Thiesen a été accompagné de M. Ansgar Jensen, physicien, et de M. Poul Jensen, ingénieur. Une femme esquimau leur a servi de ménagère.

L'observatoire magnétique à Julianehaab a été muni — comme Thule et Godhavn — de trois jeux de variomètres dont le premier sensible, le second peu sensible et le troisième pour des enregistrements à marche rapide continus. Les déterminations absolues de D et de H ont été effectuées à l'aide d'un théodolite nommé Vedel construit jadis au Danemark. Faute d'instruments en nombre suffisant on n'a pas pu munir cette station d'appareils à détermination électromagnétique de la force verticale. Pour ces mesures on s'est servi d'un inclinomètre Dover.

Il va sans dire que dans ces conditions les déterminations de la force verticale, dites absolues, ne sont pas exécutées à

Julianehaab avec la même exactitude que celle obtenue à Godhavn et à Thule. Dans cet état de choses le grand avantage de posséder deux (ou mieux trois) bons variomètres s'est nettement montré. Car il est évident qu'il faut seulement tenir compte de la marche relative de tels variomètres par des comparaisons fréquentes afin d'avoir un moyen excellent pour éliminer la plus grande partie de l'incertitude, à savoir les fluctuations observées (mais non réelles) de la valeur de la ligne de base d'un enregistrement. Dans ces conditions il s'agit en premier lieu d'avoir soin que les déterminations «absolues» ne contiennent pas d'erreurs systématiques.

A Julianehaab on a fait (comme à Thule) des expériences fort intéressantes relatives à l'emploi des pavillons «magnétiques» construits pour les expéditions de l'Année Polaire. Ces expériences portent surtout sur les questions des variations de l'humidité et de la température. Puisque les pavillons se sont montrés très pratiques, on rendra compte aussi de ces expériences dans les rapports complets des travaux de ces stations de l'Année Polaire.

A Julianehaab qui est situé presque au milieu de la zone d'aurores, on a fait beaucoup d'observations de ce phénomène. Un grand nombre de photographies ont été prises.
les «Listes de contrôle» et les «Tableaux des Résultats Préliminaires». Voici l'extrait suivant des résultats préliminaires, reçus
A Julianehaab on a mesuré les enregistrements et rempli jusqu'au mois d'août.

Moyennes mensuelles de D(ouest), H et Z à Julianehaab.

	1932					1933			
	août	sept.	oct.	nov.	déc.	janv.	fév.	mars	avril
D (W) 43° +	28.'6	29.'6	30.'1	29.'7	27.'8	27.'1	26.'0	24.'3	22.'9
H 11600 +	12	0	9	12	18	21	7	0	13
Z 52800 +	185	250	121	103	139	71	33	42	110

Il faut ajouter que les moyennes mensuelles de Z données dans ce tableau ne sont pas définitivement réduites.

L'Observatoire de Julianehaab continuera ses travaux pendant l'année 1933-34.

Copenhague, août 1933.

ESPAGNE

LES TRAVAUX MAGNÉTIQUES EN ESPAGNE

Par M. José GALBIS

Pendant les années 1930 à 1933 on a continué à faire des observations sur le territoire espagnol, afin de connaître la distribution des forces magnétiques, et à cet effet nous avons effectué des mesures absolues en 130 stations reparties dans toute l'Espagne, surtout sur les zones où, d'après la dernière carte magnétique, on constatait des anomalies.

Pour contribuer aux études de l'année polaire, on avait établi un Observatoire magnétique dans l'île de Fernando Póo, et en profitant de cet Observatoire, l'Ingénieur-Géographe M. Cifuentes, avec ses appareils de campagne, a fait six stations absolues dans l'île et une dans l'île d'Annobon.

L'Observatoire mentionné est placé sur la montagne Moka $\lambda = 8^\circ 40.'5$ E, $\varphi = 3^\circ 20.'5$ N, $H = 1240$ mètres, complètement isolé, et muni de bons appareils Askania avec enregistreurs de mouvement lent et rapide. Les observations ont commencé le premier jour de septembre et ont fini le 15 août, sous la direction de l'Ingénieur-Géographe M. Bonelli, sans d'autre interruption dans l'enregistrement que 15 jours dans le mois d'avril à cause d'une maladie de l'Ingénieur.

Les projets de l'Institut Géographique d'établir un Observatoire magnétique dans le centre de la péninsule ibérique seront réalisés incessemment.

Nous avons été obligés, à cause de beaucoup de difficultés d'ordre technique et économique, d'écarter l'endroit que nous avions choisi à Alcalá de Henares, et duquel nous parlâmes à l'Assemblée de l'Union Géodésique et Géophysique à Madrid (1924), ainsi que d'autres endroits étudiés à ce sujet. Heureusement, le don d'un terrain de 16 hectares fait à l'Etat par le Comte de Romanones nous a permis de mettre à exécution nos désirs, étendus à d'autres observations géophysiques (séismologiques, d'électricité terrestre et atmosphérique, radiation solaire, etc.). L'emplacement de l'Observatoire a été adopté après l'exécution d'études géologiques et d'essais magnétiques.

La construction des bâtiments est déjà avancée et nous espérons pouvoir commencer les observations séismologiques dans les premiers jours de 1934, les magnétiques pendant l'été, et les autres en 1935.

Le nouvel observatoire s'appellera «Observatorio Central Geofisico de Buenavista (Toledo)».

José GALBIS.

ETATS-UNIS

WORK OF THE SECTION OF TERRESTRIAL MAGNETISM AND ELECTRICITY OF THE AMERICAN GEOPHYSICAL UNION

Terrestrial Magnetism

The United States Coast and Geodetic Survey continued the observations for the determination of the change of the earth's magnetic field with time at a large number of stations throughout the country. Its five magnetic observatories have been in continuous operation. Declination measurements with the compass declinometer were made at many points in Alaska and the Philippine Islands.

The Department of Terrestrial Magnetism of the Carnegie Institution continued the operations of its magnetic observatories at Watheroo, Australia, at Huancayo, Peru, and at Honolulu. It carried on magnetic observations in South America and its cooperation with the magnetic surveys in China, East Africa, and Samoa.

In Mexico the National Astronomical Observatory completed the new edition of isomagnetic charts of Mexico. From these and earlier charts a study of secular variation was begun.

In Canada the permanent magnetic observatories at Agincourt and Meanook continued routine magnetic observations. In connection with the Polar Year Program, a fully equipped magnetic observatory was established at Chesterfield Inlet.

Ozone

The Smithsonian Institution of Washington continued its measurements of the amount of ozone in the high terrestrial atmosphere by means of spectral energy measurements in the yellow portion of the solar spectrum made at Table Mountain. It was concluded that whereas the ozone absorption for the years from 1921 to 1928 increased and decreased with the number of the sun spots, the ozone absorption for the years from 1928 to 1932 showed a lack of correspondence with the sun spot numbers.

Spectra of the night sky

The Flagstaff Observatory at Flagstaff, Arizona, summarized its observations on the spectra of the night sky, the zodiacal light and the aurora using the multiple image spectrograph.

The spectrograph is of powerful light gathering power and yields spectra taken simultaneously from five different portions of the sky. It was found that the yellow-green auroral line was always present in all parts of the sky, that it was more intense in the sky nearest the sun, that it was weakest in the zenith, and that it varied somewhat in intensity. It was not accompanied during the dark of the night by the negative nitrogen bands so typical of auroral display light.

Many new lines were discovered in the night sky spectra which varied in intensity among themselves and in comparison with the yellow-green line. It was found that weak impressions of the typical auroral nitrogen bands could be photographed in the morning and evening skies at the moment when the first, or last, traces of sunlight touched the high atmosphere. These twilight auroral bands were commonly present and more intense in the sky toward the sun. They were never present during the dark of a night except when an aurora was present.

Aurorae

Routine observations of the frequency and character of the aurorae, with some spectroscopic observations, were carried on at Fairbanks, Alaska, and at Chesterfield Inlet, Canada.

Cosmic rays

A worldwide survey of the intensity of the cosmic rays was instituted and carried out by many cooperating agencies. Observations were made at sixty-nine stations distributed at representative points over the earth's surface. At sea level the intensity of the cosmic rays at high latitudes was about fifteen percent greater than at the equator; at two thousand meters elevation, twenty-two percent greater; and at four thousand three hundred and sixty meters, thirty-three percent greater. The variations followed the geomagnetic latitude more closely than the geographic or the local magnetic latitude and was most rapid between geomagnetic latitudes twenty-five and forty degrees.

The results were shown to be in keeping with the idea that about twenty percent of the incoming cosmic rays were charged particles deflected by the magnetic field of the earth. Further experiments indicated that the particles, or some of them, were positively charged.

Some careful measurements of the fluctuations in the intensity of the cosmic rays at a single station indicated that the fluctuations might be attributed to three important causes; (1) variations in the thickness of the atmosphere as given by the barometric pressure, (2) variations in the thickness of water vapor as given by the absolute humidity, and (3) the effect of variations in the magnetic field of the earth, as during magnetic disturbances.

Various laboratory experiments have been carried out to discover the disintegration products which are formed when the cosmic ray is absorbed by matter. One of the products, called the "positron", has a unit positive charge and a mass of the order of that of the electron.

Radio wave propagation and the ionosphere

The experimental investigation of the ionosphere by means of radio waves has been pursued vigorously by many investigators. The two main regions of ionization in the upper atmosphere, one at about 100 km and one at about 200 km above sea level, were observed to change with the day and night, to be affected variously during magnetic storms, etc. The upper layer was found to be complex and sometimes composed of two or more banks of ionization. During the eclipse of August 31, 1932, the ionization was found to change as it does when partial night time conditions set in.

The skip distances of the shorter radio waves, below 50 meters, in length were averaged from radio transmission data of 1927 and 1928. They were consistently less than the average skip distances during 1923 and 1924. From the values of the skip distances it was found that the density of ionization in the bank at about 200 km increased by about fifty percent from the epoch of sun spot minimum (1923-24) to the epoch of sun spot maximum, (1927-28).

Experimental evidence was brought forward which indicated that a certain type of static observed on a wave-length of sixteen meters came from an extra-terrestrial source in the direction of the constellation af Saggitarius.

Investigations were continued on a possible lunar effect and a meteorological (weather) effect on the transmission of radio broadcast waves.

Respectfully submitted by the Executive Committee of the Section of Terrestrial Magnetism and Electricity of American Geophysical Union.

J. A. FLEMING, *Chairman.*
S. B. NICHOLSON, *Vice-Chairman.*
E. O. HULBURT, *Secretary.*
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PROGRESS OF WORK IN TERRESTRIAL MAGNETISM OF THE UNITED STATES COAST AND GEODETIC SURVEY JULY 1, 1930 TO JUNE 30, 1933

Introduction

The magnetic work of the Coast and Geodetic Survey, developed to meet the practical needs of the navigator and the land surveyor, is now in addition supplying data needed for airway navigation, geophysical prospecting by magnetic methods, investigations of radio transmission, earth currents, auroras and other related phenomena.

Magnetic Surveys

The field work in recent years in continental United States has been devoted primarily to the occupation of repeat stations all over the country at intervals of about five years to determine the change of the earth's magnetism with lapse of time. During the past three years observations have been made at about 85 such stations. With the end of 1930 sufficient data had been secured to extend the secular change tables for declination to 1930 and prepare an isogonic chart for that year.

When the systematic magnetic survey of the country was begun in 1900, it was planned to place a marked station at every county seat, where it would be readily accessible to local engineers and surveyors in testing their compasses. The grounds about the court house or public school grounds frequently afforded a suitable location within the city limits. With the growth of urban population and the accompanying industrial developments, the old magnetic stations are being rendered useless at an increasing rate. At the same time the almost universal use of automobiles now makes it possible to select stations more remote from cities, in order to secure better prospects of future availability, without materially sacrificing accessibility.

With the rapid development of the triangulation work of the Coast and Geodetic Survey contemplated in recent legislation it is expected that within 15 years there will be a first or second order triangulation station within 25 miles of any point in the country. At each station the true bearings of a number of well-defined prominent objects will be determined, as a basis for the orientation of local surveys. It is expected that many of these stations will be suitably located for use as magnetic stations, with good prospect of future availability. During the past two years of field work the use of existing triangulation stations for magnetic stations has been tried, and while it was found that many of the stations could not be used for one reason or another, the plan has many advantages and better conditions may be expected in future triangulation where consideration is given to such use in the location of the stations.

In connection with hydrographic and topographic surveys in Alaska, Hawaii and the Philippine Islands and resurveys of portions of the coasts of continental United States, numerous determinations of the magnetic declination have been made at triangulation stations. In 1932 a more detailed investigation was made of the area of marked local attraction near Duke Island, Revillagigedo Channel, Southeastern Alaska. Observations at many places on shore and aboard ship indicate that the disturbance extends for a considerable distance out into the channel from East Island, the place of greatest disturbance.

Magnetic Observatories

The magnetic observatories at Cheltenham, Maryland, near San Juan, Puerto Rico, near Tucson, Arizona, at Sitka, Alaska and near Honolulu, Hawaii, have continued in operation during the three years, with material improvements in buildings and equipment.

At Cheltenham the old building used for office and absolute observations became unsafe and was replaced by one providing more adequate and convenient space for the above purposes, as well as for carrying on the functions of the station as the standardizing observatory of the United States for international comparisons of instruments and the base station for the standardization of field instruments of the Coast and Geodetic Survey. The temporary test building has been replaced by a small comparison and test building designed to meet the needs of these functions, particularly as related to variation instruments.

The wooden observatory buildings at San Juan suffered considerable damage in the hurricane of September 25, 1932, for the second time in four years, fortunately without injury to instruments or interruption of operation. To guard against future damage from this source the absolute and variation buildings, after being repaired, were encased (in 1933) in concrete reinforced with heavy copper wire. Two Wenner seismometers have been in operation at this observatory since November, 1930.

At Tucson, the registrations of atmospheric electricity have been continued in cooperation with the Carnegie Institution of Washington. Because of its interest in the study of earth currents, the American Telegraph and Telephone Company has placed at the disposal of the Coast and Geodetic Survey two long-distance telephone lines of the Mountain States Telegraph and Telephone Company extending approximately north and east from Tucson. The necessary instruments and equipment for measuring earth currents were provided and installed by the

Department of Terrestrial Magnetism of the Carnegie Institution of Washington and have been in continuous operation since May, 1931. Since August, 1930, the Tucson Observatory has supplied information as to magnetic character of days for the broadcast of cosmic data sent out daily from Washington, D. C. by Science Service in cooperation with the American Section of the International Scientific Radio Union (URSI).

At Sitka, a remodeled set of variation instruments was installed in October, 1931. The intensity variometers are compensated for temperature and operated at reduced sensitivity; this, with the equivalent of two light sources, so that a reserve spot is provided for each variometer, insures a complete record of even large disturbances. Special tests were made of the recorder in order to secure uniform rate of rotation of the drum. Systematic auroral observations have been continued, but the records are meager because of the limited number of clear nights.

A Wood-Anderson seismometer was in operation at Sitka from June, 1929, to December, 1932, to determine to what extent the prevailing microseisms would interfere with the interpretation of earthquake records. In November, 1932, two Wenner seismometers were installed.

The instrumental equipment of the Honolulu Observatory has continued unchanged except that the H variometer has been compensated for temperature. Extensive repairs were made to the variation and absolute buildings in 1933.

College-Fairbanks Polar-Year Station

The appropriation assuring participation by the United States in the Second Polar Year Program did not become available until July, 1932, but detailed plans for the work had been made in advance so that it was possible to begin construction of the buildings on August 1 and to install and adjust the instruments during September, and nearly all parts of the work were in satisfactory operation early in October. The work is being carried on under the direction of the Coast and Geodetic Survey, as provided in the enabling act, but a number of other organizations have contributed in various ways (personnel, instruments, services and funds) to make possible a well-balanced program of observations in terrestrial magnetism and electricity, earth currents, auroras (at College), radio transmission, Kennelly-Heaviside layer and meteorology (at Fairbanks). As indicated above, part of the work is being carried on at Fairbanks and part of it at the Alaska Agricultural College and School of Mines, about three miles west of Fairbanks.

The magnetic observatory is being operated by the Coast and Geodetic Survey. It is equipped with three La Cour magnetographs, each consisting of D, H, and Z variometers and a recorder. One is operated at ordinary sensitivity with drum revolving once a day; one at low sensitivity with drum revolving once a day; the third at ordinary sensitivity with drum revolving once in two hours. Scale values are determined by means of Helmholtz-Gaugain coils. Absolute observations are made with a Coast and Geodetic Survey type magnetometer and an earth inductor of the Carnegie Institution of Washington type. A dip circle is available as a reserve instrument for observations of dip and relative total intensity. Preliminary results indicate that the variometers are stable and nearly compensated for temperature and that the control observations are adequate. The wide range of temperature in the course of the year and the occasional large changes from day to day emphasize the need of accurate determination of temperature coefficients. The vertical intensity inductometer (Mittchell loop) giving a photographic record with time scale of one centimeter a minute will no doubt furnish very useful supplemental data.

Instruments for recording continuously the variations of earth currents, conductivity and potential gradient of atmospheric electricity are being operated by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington with gratifying success.

Instruments

Continued progress has been made in the improvement of the instrumental equipment particularly of the observatories. All of the intensity variometers except one are now compensated for temperature. At all the observatories scale value deflections are being made with a large deflector at a distance sufficient to secure a nearly uniform field at the position of the variometer magnet. With the exception of Cheltenham the deflector is supported outside the instrument room. An extended series of observations was made to compare results obtained in this way with those derived from the old method of deflections with a small magnet mounted on a bar attached to the variometer. These supplied data for further study of the pole distance and distribution coefficients of magnets. In this connection three spheroidal cobalt-steel magnets of different lengths have been constructed, so designed that they may be used with the optical system of the short magnet of a India Survey pattern magnetometer.

Much study has been given to the development of a recorder which may be depended upon to rotate the drum at uniform speed under all conditions. Lack of such uniformity, found in many cases, is believed to be due to lack of uniformity of gear teeth. The latest type of recorder has a spring clock mounted within a cast aluminum drum, the clock rotating with the drum. The new recorders are equipped with electric lamps which are operated from air-cell or storage batteries.

Various methods have been tried of made time marks on the magnetograms. At Tucson and San Juan the marks are made simply by widening the slit of the lamp each hour. The plan devised by the Department of Terrestrial Magnetism appears to be more satisfactory. It consists of making a line across the magnetogram every hour by means of a flash from an independent light source, controlled by the standard pendulum clock. At Sitka the equivalent of two light sources (stellite mirrors set at an angle of 45° on either side of the recorder lamp) provides a reserve spot for each variometer without the usual extra mirrors or prisms inside the variometer.

Publications

The publications of the bureau issued during the past three years on the subject of terrestrial magnetism are listed below with brief descriptions of their contents. There is also a supplemental list of papers prepared by members of the bureau staff but published elsewhere. Because of a drastic cut in the appropriation for printing it was necessary a year ago to postpone further publication of field and observatory results in terrestrial magnetism. The work of preparation for publication is being continued, however, with the expectation that it will be resumed eventually. The computation of the observatory results (excepting San Juan) is practically completed for 1927 and 1928 and well advanced for 1929 and 1930.

List of Publications

Results of Observations made at the United States Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., in 1925 and 1926.
Same for Honolulu, Hawaii in 1925 and 1926.
Same for Sitka, Alaska, in 1923 and 1924.
Same for Sitka, Alaska, in 1925 and 1926.
Same for Tucson, Arizona, in 1923 and 1924.
Same for Vieques, Puerto Rico, in 1923 and 1924.
Results of Magnetic Observations made by the United States Coast and Geodetic Survey in 1929. (The results of field observations during the Calendar Year 1929, together with descriptions of the stations occupied.)
Same for the year 1930.
Magnetic Declination in the United States in 1930.
(This is the latest one of a series of publications issued at intervals of about five years. It contains a map showing the lines of equal magnetic declination and of equal annual change for the year 1930 and tables showing the change of declination with lapse

of time from as early a date as the available observations will warrant down to 1930, together with an estimate of the annual rate of change since 1930, for points all over the country at intervals of 2° of latitude and longitude. This publication is issued primarily for the use of local surveyors.)

Magnetic Declination in North Carolina in 1930.
(A revised edition of one of the series of publications giving for single states or groups of states all available information regarding the magnetic declination.)

Magnetic Declination in the Philippine Islands in 1925.
(Published in Manila in 1930.)

Articles

Construction of Magnetic Charts, W. N. McFarland, T. M. & A. E. Vol. 35, No. 2.

Early Declination Observations, Kamchatka to Bering Strait, W. N. McFarland. T. M. & A. E., Vol. 35, No. 2.

Variation of Horizontal Intensity Scale Value with Temperature, George Hartnell, T. M. & A. E., Vol. 36. No. 1.

Auroral Observations and Magnetic Conditions at the Sitka Observatory, July, 1929 to June, 1930. Franklin P. Ulrich. T. M. & A. E. Vol. 36, No. 3.

Test Deflections for Variometers and Magnetographs, George Hartnell, T. M. & A. E., Vol. 36, No. 4 and Vol. 37, No. 1.

Auroral Observations and Magnetic Conditions at the Sitka Magnetic Observatory, July, 1930, to June, 1931. Franklin P. Ulrich, T. M. & A. E., Vol. 36, No. 4.

Auroral Observations and Magnetic Conditions at the Sitka Magnetic Observatory, July, 1931, to June, 1932, Franklin P. Ulrich, T. M. & A. E., Vol. 37, No. 2.

The Magnetic Survey and Observatory Net of the United States. N. H. Heck, T. M. & A. E., Vol. 37, No. 3.

Secular Change of the Earth's Magnetism, Daniel L. Hazard. T. M. & A. E., Vol. 37, No. 3.

Earthquakes recorded by Magnetographs. Daniel L. Hazard, T. M. & A. E., Vol. 37, No. 3.

Improvements in Magnetic Instruments and Methods adopted by the Coast and Geodetic Survey. H. E. McComb. T. M. & A. E., Vol. 37, No. 3.

Secular Variation of the Earth's Magnetism in the United States. Daniel L. Hazard. Transactions of the American Geophysical Union, Eleventh Annual Meeting, 1930.

The Utility of Geophysics-Terrestrial Magnetism and Electricity. Daniel L. Hazard, Transactions of the American Geophysical Union, Eleventh Annual Meeting, 1930.

Terrestrial Magnetism. Daniel L. Hazard. American Year Book for years 1930 and 1931.

July 3, 1933.

BIOGRAPHICAL NOTES CONCERNING MEMBERS OF THE AMERICAN GEOPHYSICAL UNION WHO HAVE DIED SINCE 1930

Louis Winslow Austin, chief of the Laboratory for Special Radio Transmission Research at the United States Bureau of Standards, died June 27, 1932, at the age of 64 years. His investigation in the field of radio wave-propagation was recognized throughout the world, and he made many notable contributions to geophysics dealing with the interpretation of radio transmission in relation to terrestrial magnetism and other geophysical phenomena.

Louis Agricola Bauer, founder and director emeritus of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, died April 12, 1932, at the age of 67 years. On the establishment of the Section of Terrestrial Magnetism and Electricity of the International Union of Geodesy and Geophysics in 1919, he was appointed secretary and director of its Central Bureau, an office which he filled with distinction until his election as president of the Section for the period 1927-1930, During his directorship of the Department of Terrestrial Magnetism 1904-1929, he contributed greatly to the advancement of geophysics, particularly by the initiation and conduct of the magnetic survey of the Earth, by land and sea, and in the analysis of the results obtained. He was a potent force in the development of terrestrial-magnetic research during the first quarter of the present century.

Robert Lee Faris, assistant director of the United States Coast and Geodetic Survey, died October 5, 1932, at the age of 64 years. Faris was one of the original members of the American Geophysical Union, and a former chairman of its Section of Geodesy. He was interested in many departments of geophysics and helped to advance scientific knowledge not only by his personal efforts in field and office, but also by the influence he was able to exert through the numerous and important administrative positions held by him during his service of more than 40 years with the Coast and Geodetic Survey.

Harlan Wilbur Fisk, chief of the Section of Land Magnetic Survey, Department of Terrestrial Magnetism of the Carnegie Institution of Washington, died December 26, 1932, aged 63 years. He took a prominent part in the activities of the American Geophysical Union, being secretary of its Section of Terrestrial Magnetism and Electricity during the period 1929-1932. Among his notable contributions to geophysics, mention should be made of his investigation of the secular variation of the Earth's magnetism, based largely on data collected by observers of the Department of Terrestrial Magnetism under his direction, and which led him to infer that in the secular changes observed on the Earth's surface might be reflected changes taking place in the Earth's crust and interior.

John Ripley Freeman, died October 5, 1932, at the age of 77 years. He made many contributions to the science of seismology, especially from the viewpoint of the engineer and the application of seismology to the preservation of life in earthquake regions. His well-known book "Earthquake damage and earthquake insurance" grew out of his experience with the Factory Mutual Fire Insurance Company, studies of Japanese seismological methods, and lectures before the Eastern Section of the Seismological Society of America.

Alfred Judson Henry, principal meteorologist of the United States Weather Bureau, died October 5, 1931, at the age of 73 years. During his long connection with the Weather Bureau, he rendered conspicuous service to geophysics through a series of notable contributions to meteorology, particularly in climatology, forecasting, and the relations between weather and floods.

Albert A. Michelson, distinguished physicist of the University of Chicago, died May 9, 1931, aged 78 years. Michelson was one of America's foremost men of science. In precise measurements relating to the interference of light and the velocity of light, his scientific life was largely spent and in these two fields he was the greatest expert the world has yet seen. A Nobel Prize was awarded him in 1907 — he being the first American to get one in science — and the Copley Medal, the most distinguished honor of the Royal Society of London, was awarded him in the same year.

Franklin G. Tingley, chief of the Marine Division of the United States Weather Bureau, died January 26, 1931, at the age of 59 years. The work in marine meteorology of the Weather Bureau was greatly enlarged under his capable direction and included, among its more recent developments, a comprehensive revision of the wind-roses for the pilot-charts and the beginnings of a far-reaching study of surface-water temperatures.

Robert DeCourcy Ward, professor of climatology, Harvard University, died November 12, 1931, at the age of 64 years. He was a recognized authority on climatology, and rendered an important service in the advancement of that science in America, both through his inspiring lectures at Harvard and Radcliffe and through his outstanding contributions to the literature of the subject.

Jno A. FLEMING.

LOUIS AGRICOLA BAUER (1865-1929)

BY H. D. HARRADON

In the calendar of the Carnegie Institution of Washington the date of April 12, 1932, marks the passing of one of its foremost investigators and founder of one of its major departments. In the annals of geophysical research, it signifies the termination of the career of one who contributed more perhaps than any other single man to our knowledge of terrestrial magnetism and the remarkable progress of research in that domain during the first quarter of the present century. For to few has come the opportunity of carrying to a successful conclusion so vast and well-conceived a project of scientific research in their chosen field as fell to the lot of Louis Agricola Bauer.

In the course of his studies at the University of Berlin (1892-1895) and during his subsequent work in terrestrial magnetism at the United States Coast and Geodetic Survey (1899-1906), his theoretical investigations had progressed to the point where he was convinced that a satisfactory understanding of the nature of terrestrial magnetism could only be obtained when a much more abundant observational material than existed at that time should be available. Only thus could the fundamental problems of the science be successfully attacked — the question of the physical nature of the Earth's magnetic field and its secular variations. As a first requisite for such research, a systematic magnetic survey of the whole Earth, both on land and sea, would have to be made and, on account of the irregular and incalculable course of the secular variation, be renewed from time to time. To the accomplishment of this huge enterprise, Bauer dedicated his whole energy.

In order to make possible this project of truly international scope, Bauer drew up a plan for an international magnetic bureau whose "purpose would be to investigate such problems of world-wide interest as relate to the magnetic and electric condition of the Earth and its atmosphere, not specifically the subject of inquiry of any one country, but of international concern and benefit." The plan supported by the unanimous approval of the most eminent geophysicists of the time, was submitted to the Carnegie Institution of Washington and from it in the course of time developed the Department of Terrestrial Magnetism of which Bauer was appointed (1904) the first director, a post which he held for nearly a quarter-century until illness compelled his retirement from active service in 1927. The evolution of the scientific research work of this Department may be regarded as the image of Bauer's own scientific activity.

The magnetic survey of the Globe, as conceived by Bauer and initiated and executed by the Institution through its Department of Terrestrial Magnetism, constitutes one of the greatest single achievements in geophysical research ever attempted. Under Bauer's direction nearly 300 expeditions were equipped and sent to all parts of the Earth where magnetic work was not done by the governments — the inhospitable polar regions and tropical countries, across the deserts of inner Australia and Africa, the jungles of South America, and the high plateaus of Central Asia — all these regions being systematically surveyed according to the plans elaborated by him and his colleagues. At the same time the oceans were being surveyed with vessels equipped with specially devised magnetic instruments, first (1905-1908) by the *Galilee* and later (1909-1929) by the unique non-magnetic yacht *Carnegie,* the regrettable destruction of which at Apia, Samoa, in 1929, brought to an abrupt end the oceanographic work in which she had been successfully engaged for so many years.

While directing this magnetic work on land and sea, Bauer was still able to find time to turn his attention to studies bearing on the physical decomposition, theory, and analysis of the origin of the Earth's magnetic field, and to the discussion of the phenomena of the internal and external systems of operating causes and theory of the secular variation facilitated more and more as results from the survey work accumulated. His attention was also given to the possible effects of solar eclipses on the Earth's magnetism and the relationships of solar activity and terrestrial magnetism, as well as to studies bearing upon the cosmical effects on terrestrial magnetism and electricity, possible planetary magnetic effects, similarities in the magnetic fields of the Earth's atmosphere and the Sun, and correlations between solar activity and atmospheric electricity and the annual variation of atmospheric electricity.

In addition to the technical papers in which the results and discussions of these investigations are embodied, he has left a large number of more popular writings which served the useful purpose of communicating to the general public the scope and meaning of magnetic work and of arousing interest in scientific research. In this form of writing he possessed much ability and in some of his printed lectures will be found concise and excellent presentations of the status of research in geophysics at the time of their delivery.

During the closing years of the past century there existed no journal exclusively devoted to the sciences of terrestrial magnetism and atmospheric electricity, papers dealing with these subjects being scattered through a wide range of scientific periodicals and reports. The need for such an organ became apparent to Bauer during his early work. To remedy this deficiency he personally assumed, with his characteristic initiative, the financial and editorial responsibility for the international quarterly "Terrestrial Magnetism" (1896) later known as "Terrestrial Magnetism and Atmospheric Electricity". During the 31 years that he personally conducted this Journal, many papers of fundamental value appeared in its pages and the importance that it, now in the thirty-eighth year of publication, continues to have for the development of these sciences more than justifies the purpose of its founder.

It was to be expected that one so intimately concerned with the international aspects of terrestrial magnetism and electricity should take a keen interest in the foundation of the International Union of Geodesy and Geophysics, and particularly in the creation of its Section (now Association) of Terrestrial Magnetism and Electricity. At its formation in Brussels in 1919 Bauer was appointed the first secretary and director of its central bureau, the duties of which office he discharged with zeal and efficiency until his election to the presidency of the Section in 1927. At the meetings of the Union he made the acquaintance of colleagues from many lands and through these personal contacts did much to improve international understanding in the advancement of geophysics.

In the direction of activities of international scope the cultural advantages arising from extensive travel are an important asset. In connection with his work at the United States Coast and Geodetic Survey (1887-1892 and 1899-1906), especially in the selection of sites for magnetic observatories, in the inspection of the magnetic survey of the Carnegie Institution of Washington which took him to various parts of the world, including two visits to the orient, as well as during his frequent trips to European countries in attendance on international scientific gatherings, Bauer enjoyed most ample opportunity for travel. This broadening influence made itself felt in his intercourse with all with whom he had dealings, and in the entertainment of the many foreign visitors at the Department of Terrestrial Magnetism with whom he was always at ease. Moreover, the first-hand information of men and conditions in various countries thus acquired was of great service in arranging survey-work and comparisons of instruments in foreign lands.

Bauer was the recipient of many honors in recognition of the important services he rendered to science. Among these may be mentioned the Charles Lagrange Prize (Physique du Globe) of Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique (1905), and the Georg Neumayer Gold Medal at Berlin (1913). He was also appointed Halley Lecturer at the University of Oxford in 1913, and was made a corresponding member of several foreign academies and scientific societies. In his own country honorary degrees were conferred upon him by his Alma Mater the University of Cincinnati (1913) and Brown University (1914).

Aside from these important honors that lent encouragement to him in the prosecution of his scientific labors, the greatest and most enduring monument which he has erected for all time will be found in the wealth of available data in the researches of the Department he founded and in the unceasing progress of that Department which continues to promote, through its ever-widening activities, the general cause of geophysics.

August 30, 1933. *Department of Terrestrial Magnetism, Carnegie Institution of Washington.*

FINLANDE

PROGRESS OF WORK IN TERRESTRIAL MAGNETISM AND ELECTRICITY IN 1931-1933

By J. KERÄNEN

Since the Stockholm Meeting in 1930 the Section of Terrestrial Magnetism has lost by death one of its members, – Prof. A. Petrelius, formerly professor of Geodesy at the Technical Institute of Helsinki, died on June 5th, 1928. He was a member of the Finnish Polar Year Expedition to Sodankylä 1882-1884 and worked there as astronomer and observer in geophysical investigations. As a teacher of geodesy at the Technical Institute in Helsinki during 38 years, Prof. Petrelius has done a remarkable work. In the last years of his life he studied the upheaval on the coast of Finland.

Field Work. Because the magnetic surveying of Finland was practically completed in the year 1928, the magnetic observation work has been little. In April 1931, however, I have made a small regional investigation on the ice in the neighbourhood of Turku.

In the summer 1932 I could occupy the repeat stations Signilskär, Viipuri, Petsamo, Sodankylä and Mieslahti.

In the current year two expeditions have visited the repeat stations in Finland, the one under the leadership of Mr. H. Hyyryläinen has measured 30 stations and another under my charge 13 stations. In this manner we shall sacrifice our magnetic field work for the investigations of the Polar Year.

The Magnetic Survey. The field work was projected by the former director of the Central Meteorological Office, Prof. G. Melander and has been carried out by this Office. The first expedition was sent out in the summer 1910 and the regular observations were begun 1911.

We can now present the main result of this extensive mapping work, which contains the figures of 920 different land stations, as report No. 17. of the Earth Magnetic Researches of the Meteorological Head Office: A Magnetic Survey of Finland on July 1, 1930, by J. Keränen. The publication contains the values of elements D, I, H, X, Y, Z, T and in maps: distribution of Magnetic stations and lines of equal D, I, H, Z.

The Work of the Magnetic Observatory at Sodankylä. Mr. E. Sucksdorff has been observer in charge of this observatory, which lies under the patronage of the Finnish Academy of Science. The magnetic work has been carried on without interruption. For the investigations of the Polar Year the programme of the observatory has been enlarged. A magnetic quick-running set of the model la Cour has registrated since the beginning of 1932. The observatory was equipped in the autumn 1932 with apparatuses for measurements of atmospheric electricity and earth currents. All this work will be continued after the Polar Year. The results of the magnetic observations at Sodankylä, "Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Sodankylä", have been published as follows: No. 12 of the year 1925 by H. Hyyryläinen and Nos. 14-16 of 1927-1929 by E. Sucksdorff.

The Temporary Magnetic Observations during the Polar Year. This work has also been originated by the Academy of Science. On the shore of the Arctic Sea at Petsamo (69° 32 N, 31° 13 E) a polar observatory was set up by Mr. M. Tommila and by myself in July 1932 and works under the leadership of the first named scientist. The station is equipped with two sets of magnetic apparatuses, the one for ordinary and the other for quick-running registration. The absolute measurements have been made with the small French Chasselon magnetometer, with the English Dover dip circle and the German Wild-Edelmann Earth Inductor. This observatory will cease by the end of the Polar Year.

A small magnetic station with a quick-running set has been established at Kajaani (64° 13′ N, 27° 46′ E) in November 1932 by the president of the International Polar Year Commission Dr. D. la Cour and myself. The station works under the leadership of Dr. M. Hela. Following the suggestion of the Polar Year Commission this station will continue the magnetic work for at least another year, because "it is situated in the transitory region between the highly disturbed auroral belt and the less disturbed subarctic regions, covered by permanent observatories".

We have had the pleasure to receive from the International Polar Year Commission for our disposal instruments for electric measurements and two sets of variometers with quick-running registrators and appurtenances for these instruments.

Observations of the Polar Lights. Mr. Sucksdorff has continued with the photographic work of the aurora at Sodankylä with an auxiliary station. He has also organized a net of stations for visual observations of aurora, using a simple wooden quadrant for angular measurements of height of quiet arcs.

The meteorological stations also make visual observations of the aurora.

For the occurrence of aurora displays five stations are provided with such small spectroscopes, which are recommended for use by the International Polar Year Commission.

Finnish National Committee for Geodesy and Geophysics
Section for Terrestrial Magnetism and Electricity

Members:

Dr. J. Keränen, chairman, Valtion Meteorologinen Keskuslaitos, Helsinki.
Prof. G. Melander, Etelä-Hesperiankatu 36, Helsinki.
Prof. V. A. Heiskanen, Teknillinen Korkeakoulu, Helsinki.
Mr. E. Sucksdorff, Magneettinen Observatorio, Sodankylä.

J. KERÄNEN.

Helsinki, September 8, 1933.

FRANCE

RAPPORT SUR LES TRAVAUX DE LA SECTION DE MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES DEPUIS LE CONGRÈS DE STOCKHOLM (1930)

par le Secrétaire E. *Mathias*

1° Magnétisme terrestre

Travaux de l'Institut de Physique du Globe de Paris. — Dans le troisième et dernier Mémoire du *Nouveau Réseau magnétique de la France au 1er Janvier* 1924, Ch. Maurain, E. Mathias, L. Eblé et Mlle Homery ont donné une représentation cartographique des anomalies françaises chiffrées dans le deuxième Mémoire. Les erreurs résiduelles des *éléments observés* se reportant, quelquefois en s'ajoutant, dans les *éléments calculés,* on s'est borné à représenter les anomalies de D, I, H, en y ajoutant celles de la composante verticale Z qui a une grosse importance au point de vue de la prospection magnétique.

Le résultat essentiel est celui-ci: *les anomalies magnétiques sont en général des surfaces continues* et non pas seulement des lignes continues ou des points isolés. Les cartes ont été imprimées en deux couleurs: les anomalies positives ont été figurées par des teintes rouges, les négatives par des teintes bleues. Pour ne pas surcharger les cartes, on n'a pas adopté une équidistance constante pour les lignes d'égale anomalie conservées, l'échelle des teintes permet d'apprécier à vue la grandeur de l'anomalie.

Le Mémoire décrit les principales anomalies françaises et les particularités qu'elles présentent suivant l'élément magnétique considéré.

Ch. Maurain, qui avait publié en 1926 un travail relatif *à l'intervalle de temps entre les phénomènes solaires et les perturbations magnétiques* par une méthode statistique, a repris ce travail par la méthode individuelle en cherchant l'intervalle entre le passage de taches ou groupes de taches importants au méridien central du Soleil et une perturbation magnétique éventuelle consécutive. Cet intervalle s'étage, pour 24 cas étudiés, entre 23,5 et 116,5 heures, la moyenne étant environ deux jours et demi, ce qui s'accorde avec la moyenne obtenue par la méthode statistique.

L. Eblé a étudié *la variation séculaire de la distribution des éléments magnétiques en France.* On possède des déterminations qui permettent d'établir des cartes et formules représentatives pour les dates 1858, 1875, 1885, 1896, 1901, 1911, 1924. Les coefficients de ces formules varient avec le temps et cette variation peut être représentée par des courbes qui permettent d'établir les valeurs pour une époque quelconque.

L. Eblé a étudié *l'agitation magnétique* en étendant une statistique commencée par Moureaux et dans laquelle l'agitation *mensuelle* est caractérisée par le nombre des valeurs horaires qui s'écartent de la moyenne mensuelle d'une quantité donnée, 3′ pour la Déclinaison. Cette statistique permet d'étudier divers problèmes concernant l'agitation magnétique, par exemple sa variation annuelle.

L. Eblé a étudié *la variation de la composante horizontale du champ magnétique terrestre autour des journées de calme magnétique.* Cette composante est, d'une façon très générale, relativement forte aux jours calmes internationaux, mais n'atteint son maximum que le lendemain. Cette remarque s'applique aux deux hémisphères. Il y a donc un rapport entre l'activité magnétique et la valeur absolue de la composante horizontale.

L. Eblé a étudié *l'anomalie magnétique du Bassin de Paris.* En comparant les valeurs des éléments magnétiques en 1901 et en 1924, dans les stations communes aux deux réseaux, il établit la *variation séculaire* entre ces deux dates. Les valeurs ne sont pas les mêmes pour tous les points, mais leur répartition présente un caractère systématique, surtout en ce qui concerne la composante verticale. La variation séculaire en région d'anomalie possède un terme secondaire d'origine locale.

L. Eblé et Mlle Homery ont étudié la *variation diurne de la Déclinaison* d'après les moyennes de 8 années. Cette variation n'a pas exactement la même forme aux Observatoires du Val-Joyeux et de Nantes, situés à peu près sur le même parallèle magnétique. Les différences, faibles du reste, mais supérieures aux erreurs d'observation, apparaissent bien sur les développements en série harmonique et affectent à la fois les amplitudes et les phases. Elles sont nettement différentes en hiver et en été. Les auteurs proposent l'explication suivante: un courant extérieur possède une variation diurne simple et induit dans la croûte terrestre des courants secondaires dont l'intensité est rendue un peu variable par l'état thermique de celle-ci.

H. Labrouste et Mme H. Labrouste ont appliqué à plusieurs cas la *méthode d'étude des phénomènes périodiques* qu'ils ont exposée au Congrès de Stockholm. Ils ont développé cette méthode en plusieurs mémoires comportant des *Tables* *périodiques* pour l'emploi de la méthode et des *Remarques sur les combinaisons de différences,* dans lesquelles sont examinés deux types de combinaisons complexes de différences permettant: le premier, d'isoler les composantes périodiques d'un graphique par ordre de périodes croissantes; le second, de mettre en évidence une période quelconque d'un graphique et aussi des combinaisons complexes très sélectives utilisant à la fois des combinaisons d'addition et de différence, enfin l'analyse de graphiques résultant de la superposition de sinusoïdes à amplitude variable.

Les variations périodiques suivantes de l'amplitude diurne de la Déclinaision au Val-Joyeux ont été étudiées par H. Labrouste et Mme H. Labrouste en relation avec la période undécennale et la période de 27 jours de l'activité solaire: composante undécennale; fluctuation undécennale dans l'amplitude de la composante annuelle; période de 27 jours.

Comparaison des périodicités trouvées dans l'activité solaire et dans l'amplitude diurne de la Déclinaison au Val-Joyeux. Influence de l'activité solaire sur les composantes annuelle et semi-annuelle de l'amplitude diurne.

Relation de phase et d'amplitude entre les composantes périodiques solaires et magnétiques, en particulier dans le cas de la période semi-undécennale.

Composantes périodiques de l'activité solaire.

P. Smetana a appliqué cette méthode à l'étude de la *composante undécennale de l'amplitude diurne de la Déclinaison en divers Observatoires du Globe;* l'amplitude est minimum à l'équateur magnétique et passe par un maximum aux environs de 50° de latitude magnétique.

H. Labrouste et Mme H. Labrouste ont étudié aussi les *Variations annuelle, semi-annuelle et quart-annuelle de l'amplitude diurne de la Déclinaison,* et les ont exprimées, en fonction des nombres W de Wolf et Wolfer, par une formule du type $y = (a + kW) \sin (\alpha t + \varphi)$, dont les coefficients sont déterminés à l'aide des données du Val-Joyeux. Ils en déduisent une expression numérique de l'amplitude diurne de la Déclinaison où ne figurent comme variables que l'indice W et le temps correspondant.

Mlle G. Homery, continuant un travail pour lequel elle a amassé des données très nombreuses, a établi *une Carte de la Déclinaison magnétique pour l'ensemble du Globe à l'époque 1931,0.* Elle a utilisé à cet effet les réseaux nationaux et un grand nombre d'observations éparses; la carte tient compte, dans la mesure du possible, des perturbations de quelque importance s'étendant sur une certaine surface. Elle a, d'autre part, établi une *Carte de la Déclinaison en Indo-Chine pour l'époque 1931,0* plus précise que celle qu'elle avait établie en 1921. Elle a publié une *Etude générale sur* *le magnétisme dans les possessions françaises,* pour la plupart desquelles elle a établi, depuis une dizaine d'années, des Cartes magnétiques.

P. Rougerie a entrepris une *Etude sur les courants telluriques enregistrés jadis à l'Observatoire du Parc Saint Maur,* et qui n'avaient pas donné lieu jusqu'à présent à une étude d'ensemble. Il a étudié en particulier la variation diurne d'après 475 graphiques journaliers correspondant à des situations magnétiques calmes ou peu agitées, de mai 1893 à juillet 1895. Les valeurs moyennes des composantes NS et EW sont 1,0 et 0,8 millivolt par kilomètre. La variation diurne est plus forte en été qu'en hiver.

E. Thellier a étudié *l'Aimantation rémanente et induite des argiles crues et cuites* par une méthode magnétométrique très sensible, mais dont la mise au point a été difficile au milieu de Paris. En particulier, il a mesuré l'aimantation acquise par les argiles pendant la cuisson dans un champ magnétique.

Mme Odette Thellier a modifié la méthode en accroissant sa sensibilité, de manière à l'adapter à la *mesure du coefficient d'aimantation des roches peu magnétiques:* elle a appliqué cette méthode à *la mesure du coefficient d'aimantation de nombreux échantillons de roches sédimentaires du Bassin de Paris.*

Jean Jung, professeur de géologie à l'Ecole supérieure du Pétrole de l'Université de Strasbourg, a publié un mémoire étendu dans lequel *il étudie la géologie profonde de la France d'après le Nouveau Réseau Magnétique et les mesures gravimétriques.* Ce mémoire contient deux Notes annexes de C. Alexanian.

Jean Chevrier, continuant des *mesures magnétiques en Syrie,* a déterminé les valeurs absolues des éléments en 66 stations.

A. Savornin a déterminé *la Déclinaison magnétique en 23 stations à Madagascar.*

Jean Rothé a étudié en détail au variomètre magnétique *l'anomalie du pays de Bray et une partie de celle de la région parisienne.* Il s'est proposé de montrer comment un anticlinal parfaitement défini au point de vue géologique, comme celui du pays de Bray, se traduit au point de vue magnétique. C'est seulement la présence en affleurement d'une couche légèrement ferrugineuse qui dénonce sur une carte magnétique, par sa direction bien définie, l'anomalie magnétique. Dès que cette couche-repère plonge, l'anomalie magnétique disparaît.

Les résultats donnés par la région parisienne de Rambouillet, comparés à ceux de l'anticlinal précédent montrent bien l'absence de relation entre l'anomalie et les plis de couverture du Bassin de Paris dont l'orientation presque semblable avait frappé plusieurs auteurs.

Pour attribuer à l'anomalie parisienne une cause plus profonde, il faut envisager les dislocations accompagnant la ligne de rebroussement des plis hercyniens dont la direction dans le Bassin de Paris est sensiblement la même. D'après les géologues, cette ligne de «Schaarung» s'incurve dans le Massif Central et se retrouve suivant une direction NE-SW dans l'Est des Pyrénées. En accord avec cette direction, une anomalie de la composante verticale Z s'étend du Massif Central aux Pyrénées à travers le fossé aquitain et dessine du Pays de Galles aux Pyrénées un vaste arc de cercle en coïncidence avec la ligne de rebroussement des plis hercyniens. Ce beau résultat établit une relation nette entre la géologie et le Magnétisme terrestre.

Au Congrès International d'Electricité qui s'est tenu à Paris en Juillet 1932, des Rapports ont été présentés par: Ch. Maurain (Le développement des études de Magnétisme et Electricité terrestres. — Les perturbations magnétiques, les aurores polaires). — L. Eblé (Le champ magnétique terrestre). — E. Salles (Conductibilité et ionisation de l'atmosphère).

Travaux de l'Institut et Observatoire de Physique du Globe du Puy-de-Dôme. J. Coulomb a conduit, avec beaucoup de méthode, un travail de mesure en même temps que de discussion sur *l'anomalie magnétique du Puy-de-Dôme.* L'énorme anomalie reconnue par Brunhes et David en 1902 a été explorée de nouveau. Certains résultats communs concernant la composante horizontale s'expliquent par la symétrie du champ perturbateur, et présentent ainsi quelque généralité. La comparaison du champ normal au champ obtenu par extrapolation du Réseau magnétique fait ressortir une anomalie régionale superposée à l'anomalie étudiée. L'étude de la composante verticale est difficile, par trop de sensibilité aux variations accidentelles. Elle concourt cependant à montrer que l'aimantation moyenne de la montagne doit être supérieure à celle des échantillons superficiels. Enfin, l'anomalie paraît avoir varié depuis 30 ans de façon importante et régulière sans qu'on puisse encore donner d'explication.

G. Grenet, dans le but d'étudier l'aimantation des roches de la région, a mis au point *un appareil pour déterminer avec précision les propriétés magnétiques des roches.* Les mesures doivent se faire facilement et, de préférence, sans entraîner l'obligation de tailler les échantillons suivant une forme déterminée. Enfin, il faut pouvoir évaluer toute aimantation capable de se traduire sur le terrain par une perturbation magnétique mesurable.

L'appareil réalisé repose sur l'emploi d'une méthode d'induction, et il est caractérisé par l'utilisation d'un galvanomètre à aimant mobile de grande sensibilité. La sensibilité maximum obtenue correspond à une déviation du spot de 1 mm à un mètre pour un moment magnétique de 0,0125 U. E. M. Comme le volume de l'échantillon peut atteindre 1 décimètre cube, l'aimantation correspondante est 12.5×10^{-6}. Pour évaluer une susceptibilité de 10^{-5} il suffit d'apprécier une élongation de 0.8 mm, ce qui est tout à fait possible.

H. Bellocq a publié des *Remarques sur la Déclinaison magnétique*. Habituellement, on détermine le nord géographique par l'angle A qu'il faut ajouter à l'azimut du Soleil pour avoir la trace du méridien géographique sur le cercle horizontal du théodolite par une formule qui donne $\operatorname{tg}\frac{A}{2}$. Il suffit de connaître l'heure à 5 minutes près, la déclinaison du Soleil ne variant pas sensiblement dans cet intervalle. Or, il y a 3 autres relations utilisables, dont l'une donnait autrefois aux Observatoires l'heure exacte connaissant le nord géographique. Un emploi judicieux de ces formules permet, après coup, de connaître les observations les meilleures et d'éliminer de la moyenne générale celles qui résultent de mesures discordantes.

Observatoires magnétiques français, métropolitains et coloniaux. — Des observations régulières (mesures absolues de D, I, H, enregistrement des variations de D, H, Z) sont faites dans deux Observatoires de l'Institut de Physique du Globe de Paris, au Val-Joyeux près Paris et à Nantes (Loire Inférieure). Les résultats sont publiés dans le Volume annuel des *Annales de l'Institut de Physique du Globe et du Bureau Central français de magnétisme terrestre,* par L. Eblé pour le Val-Joyeux et par L. Tabesse pour Nantes. Les observateurs en résidence au Val-Joyeux sont Gaston et Michel Gibault. — En août 1932 ont été établis en plus, au Val-Joyeux, des enregistreurs du type La Cour, employés dans les Stations de l'Année Polaire.

Les observations, avec enregistrement des variations de D, H, Z sont continuées à l'Observatoire de Tananarive, à Madagascar, dont le directeur est le P. Poisson, et la personne chargée des mesures magnétiques le P. Delpeut. Cet Observatoire est aussi muni actuellement d'appareils La Cour.

Un Observatoire magnétique a été installé à Tamanrasset, dans le Hoggar (Sud-Algérien) par les soins de J. Lasserre, Directeur du Service Géophysique et Météorologique de l'Algérie. Cet Observatoire est aussi muni d'appareils La Cour.

Des difficultés financières ont retardé l'établissement des

Stations magnétiques projetées à Tunis et à Dakar (Afrique Occidentale française). Une station magnétique est en installation à La Martinique (Antilles).

2° Electricité Atmosphérique

Travaux de l'Institut de Physique du Globe de Paris. — Le champ électrique de l'atmosphère est enregistré à l'Observatoire du Val-Joyeux depuis 1923, mais aucune publication détaillée n'avait encore été faite à ce sujet. Ch. Maurain, E. Salles et G. Gibault ont publié un mémoire donnant les *valeurs horaires* pour les 8 années 1923-1930 avec *l'étude de la variation annuelle de la variation diurne* et différentes indications générales. Une autre publication de Ch. Maurain, Mlle Homery et G. Gibault a porté sur le *courant électrique vertical,* étudié d'après les valeurs du champ et de la conductibilité.

C. E. Brazier et E. Salles ont étudié *la variation diurne du champ électrique à l'Observatoire du Parc Saint Maur,* d'après un ensemble de mesures effectuées dans cet Observatoire, et *l'influence des éléments météorologiques sur le champ.*

E. Salles a fait une *étude critique des différentes méthodes permettant d'évaluer la charge électrique cubique de l'atmosphère,* et en particulier étudié cette charge à l'Observatoire du Val-Joyeux d'après les *densités des ions.*

R. Guizonnier a appliqué la méthode analytique de Labrouste à *l'étude de la composante diurne du champ électrique au Val-Joyeux;* il a *étudié les variations rapides de phase et d'amplitude* que présente cette composante examinée au jour le jour, *et la variation annuelle de sa phase et de son amplitude.*

Ch. Maurain et J. Devaux, au cours d'un voyage et d'un séjour au Groenland, ont étudié la *conductibilité électrique de l'atmosphère,* qui a été trouvée au Groenland plus forte qu'au cours du voyage. Etudiant en même temps les *noyaux de condensation* (par l'appareil d'Aitken-Lüdeling), les auteurs les ont trouvés moins nombreux au Groenland qu'au cours du voyage, ce qui s'accorde avec le résultat précédent, *les petits ions* devant être d'autant plus nombreux que les *noyaux de condensation* le sont moins.

Mme F. Bayard-Duclaux a étudié *la conductibilité électrique de l'atmosphère à Paris* et l'a trouvée en moyenne 4 fois plus faible qu'au Val-Joyeux, situé en campagne à 30 kil. de Paris; ce rapport est sensiblement égal à celui du nombre moyen des *petits ions* à Paris et au Val-Joyeux.

L. Martinozzi a fait à l'Institut de Physique du Globe de longues mesures sur *l'ionisation atmosphérique,* qui ont donné lieu à un Mémoire dans les Annali dell'Ufficio Presagi et dans les Annales de l'I. P. G.

Travaux de l'Institut et Observatoire de Physique du Globe du Puy-de-Dôme. — E. Mathias a continué ses travaux sur la foudre. *L'action de la foudre sur les arbres et les végétaux* est considérée à divers points de vue: l'un d'eux étudie le mécanisme du foudroiement des arbres et des blessures produites, en insistant sur celles qui guérissent spontanément et qui affectent la forme de *sillons spiraux.* La cause des erreurs commises dans l'explication de l'action de la foudre réside dans la confusion des effets de la *foudre proprement dite* avec ceux de la *matière fulminante.* Le dernier point de vue se rapporte à la mort en foule des végétaux par l'éclair fulgurant, dont on propose une explication physique très simple et d'un mécanisme très général.

Le congrès international d'Electricité de 1932 a été pour E. Mathias l'occasion d'un Rapport sur «*l'Eclair*», mise au point qui suit la classification d'Arago, dans laquelle l'éclair de 2e classe, dont Marié-Davy a démontré la non-existence, est remplacé par l'éclair en chapelet. Un mémoire intitulé «*L'éclair fulgurant ascendant. L'éclair en chapelet*» apporte sur deux phénomènes rares les précisions nécessaires, en même temps que la littérature française relative à l'éclair globulaire est renouvelée par des *Observations nouvelles ou peu connues d'éclairs globulaires.*

E. Mathias a fait connaître de *Nouvelles recherches sur la matière fulminante.* Il insiste particulièrement sur deux points: une discussion serrée des hypothèses très peu nombreuses sur lesquelles repose son exposé synthétique des formes de la foudre et l'explication de leurs propriétés, et la publication de *nouveaux cas d'éclairs en boule sortis d'un réseau électrique, ou télégraphique ou téléphonique* sous l'influence certaine ou probable de la chute d'un éclair fulgurant sur le réseau en question. L'auteur est ainsi conduit à résumer les conditions qu'il faudrait réaliser, selon lui, pour aboutir à la synthèse expérimentale de l'éclair globulaire.

E. Mathias, dans un dernier mémoire, commence *l'étude de l'action de la foudre sur l'homme et sur les animaux.* Dans cette étude partielle, il s'attache en particulier à élucider le cas dit du *choc en retour,* lequel, suivant tous les cas connus et certains, ne se traduirait jamais par des accidents mortels.

E. Mathias et G. Grenet ont repris *l'étude du Champ électrique au Sommet du Puy-de-Dôme* en l'étendant cette fois au cas de la mauvaise saison pour lequel l'installation du plateau d'altitude 1440 mètres ne permet pas de lutter efficacement contre le froid et contre l'humidité. Le brouillard influe très peu sur la variation du champ électrique en hiver. Dès le mois d'octobre et pendant les mois d'hiver, on observe une variation diurne à un maximum et à un minimum, comme au Pic-du-Midi, le parallélisme des courbes de variation diurne en hiver, en ces deux stations, étant tout à fait remarquable.

E. Mathias et G. Grenet ont étudié *la conductibilité électrique de l'air au Sommet du Puy-de-Dôme.* Cet élément a été mesuré dans la maison d'habitation au moyen d'un appareil de Gerdien du type courant. On a déterminé expérimentalement le rapport de la capacité totale du système isolé à la capacité du système de conducteurs soumis à la déperdition. La correction relative à la fuite des isolants a été déterminée avant et après chaque expérience. En temps de brouillard, la conductibilité est très faible et tout à fait variable d'un moment à l'autre. En l'absence de brouillard, la variation est faible d'un moment à l'autre. La moyenne de 20 mesures de conductibilité totale effectuées en janvier, février et mars 1931 est

$$\lambda + \lambda' = 2.2 \times 10^{-4} \text{ U. E. S.}$$

Le rapport de la valeur moyenne de λ à la valeur moyenne de λ', pour toutes les mesures donne $\lambda/\lambda' = 1.13$. Ce résultat est en désaccord avec les mesures de déperdition de Brunhes et Baldit (1906).

G. Grenet a présenté au Congrès des Sociétés Savantes de Toulouse (1933) un travail sur *la mesure du champ électrique et de la conductibilité de l'air à la Côte de Landais.* Un enregistrement régulier a été effectué d'avril 1930 à avril 1931 à la Côte de Landais; il a été repris en avril 1932. Les caractéristiques principales du champ électrique sont celles d'une station de plaine. La comparaison avec les éléments météorologiques montre une influence importante de l'humidité, mais aucune action directe notable de la température ne se manifeste.

G. Grenet, à l'occasion du Congrès International d'Electricité de 1932, a été chargé d'y présenter un rapport sur le *Champ électrique terrestre.* Ce travail comporte, d'une part, l'exposé de l'état actuel de nos connaissances sur le champ électrique terrestre et ses variations, d'autre part, l'examen des hypothèses propres à expliquer l'existence et les variations du champ électrique. L'auteur conclut en montrant que nos connaissances sur ce sujet sont encore fort incomplètes et qu'il y a lieu de les étendre, en particulier par des observations faites dans les Stations de Montagne.

Travaux de l'Institut et Observatoire de Physique du Globe du Pic-du-Midi. — Les travaux de C. Dauzère se rapportent tous (directement ou indirectement) aux orages, c'est-à-dire à *la foudre et à la grêle qu'il considère comme ayant une origine commune.* A vrai dire il n'a fait que compléter la théorie de Simpson *en faisant intervenir les charges positives des cristaux de glace des cirrus et les charges négatives des gouttelettes des cumulo-nimbus formées sur les ions négatifs.* Les attractions entre les deux donnent naissance, à haute altitude, à des grêlons ou à des flocons de neige électrisés positivement, qui fondent ou non en tombant, et sont retenus par le courant d'air ascendant très violent de l'orage dans la partie inférieure du cumulo-nimbus, où les grosses gouttes provenant de la fusion peuvent subir la rupture de Simpson, et ainsi de suite, comme dans la théorie de ce dernier.

Il résulte de là deux conséquences: 1° l'électrisation positive de la plupart des précipitations; 2° *le transport d'électricité positive par les éclairs et l'attraction de la foudre par les lieux où les ions négatifs sont très abondants.*

L'ionisation de l'air détermine donc les points de chute de la foudre; le relief intervient d'une façon secondaire; la conductibilité du sol n'a aucune action. L'ionisation de l'air résultant en grande partie de la teneur des roches en produits radio-actifs, *la situation des lieux fréquemment foudroyés dépend de la condition géologique du sol.* Depuis 1930, C. Dauzère a obtenu de nouvelles vérifications de ces conséquences déjà formulées en 1929. En particulier, il a précisé le rôle des diverses roches à l'égard de l'ionisation de l'air et de la foudre dans une Conférence faite le 6 mars 1933 à la Société française des Electriciens.

Une autre conséquence est relative à la grêle, dont la théorie de formation est de 1928. C. Dauzère a montré, en 1930, *que la grêle se forme principalement au-dessus des lieux dangereux pour la foudre.* S'il n'y a pas de vent, elle tombe sur les lieux d'origine, dont la position dépend de la constitution géologique du sol. S'il y a du vent horizontal, la grêle est semée par ce dernier sur une bande de territoire, parfois très allongée, dont le point de départ est le lieu de formation. Les collines, le cours des rivières, en pays peu accidenté n'ont aucune influence sur les bandes de grêle.

Les informations nécessaires pour la confirmation des résultats précédents ont été obtenus par la distribution de feuilles de renseignements remplies par les maires. Des visites ont été faites très souvent dans les localités éprouvées signalées ainsi.

Ces travaux ont été la cause déterminante d'une mesure du *Ministère des Travaux Publics* prescrivant de recueillir dans chaque département les documents nécessaires au tracé de la Carte des lieux dangereux pour la foudre. *La carte de la foudre et de la grêle est déjà faite, dans ses grandes lignes, pour les Hautes-Pyrénées et la Haute-Garonne.*

Dans le but d'étudier d'une manière permanente l'ionisation de l'air qui joue un si grand rôle dans les orages, C. Dauzère a installé à Bagnères-de-Bigorre un appareil de Gerdien (modèle de l'année polaire) avec lequel il a effectué une série de mesures de la conductibilité de l'air depuis le 15 mars 1933. Il poursuit, en ce moment, une série de mesures de la conductibilité de l'air dans *les grottes et les galeries de mines,* en vue de compléter les travaux d'Elster et Geifel sur la question et d'expliquer *l'attraction exercée sur la foudre par les ouvertures de certaines grottes.* Bien que les résultats ne soient pas encore publiés, on peut dire que *la conductibilité de l'air des grottes possède* en général, des valeurs très élevées et subit des variations de grande amplitude.

C. Dauzère, dans un Rapport au Congrès International d'Electricité de 1932 sur les décharges atmosphériques, résume ainsi son travail.

Le transport des charges électriques par les précipitations (pluie, neige, grêle) constitue une catégorie de décharges, dont le mécanisme est suffisamment clair, et dont l'étude expérimentale donne des résultats incontestables. Il constitue la première partie de cet exposé, dans laquelle figurent également les théories qui expliquent l'origine des charges électriques transportées et celle des précipitations elles-mêmes.

La deuxième partie du rapport est consacrée à l'étude expérimentale de la foudre. Elle contient les résultats des expériences faites sur le champ électrique du nuage orageux, le champ magnétique de l'éclair, la conductibilité et l'ionisation de l'air dans les lieux frappés par la foudre, les surtensions produites dans une ligne électrique foudroyée, ainsi que l'indication des grandeurs approchées caractéristiques de la décharge: force électro-motrice, quantité d'électricité transportée, intensité du courant, énergie mise en jeu.

La troisième partie est relative aux divers effets de la foudre qui s'expliquent en admettant que l'éclair est constitué essentiellement par un transport d'ions. Les propriétés suivantes sont successivement passées en revue: sens de la décharge, points de chute de la foudre, influence secondaire du relief et de la conductibilité du sol, influence primordiale de l'ionisation, de la conductibilité de l'air, de la radioactivité des roches. L'origine de la décharge est ensuite examinée, ainsi que le bruit du tonnerre, la lumière de l'éclair, le caractère des dégâts produits et les effets physiologiques.

Dans une quatrième partie, le Rapport signale les conséquences des résultats précédents pour la défense contre la foudre.

La conclusion est relative aux courants produits par les diverses sortes de décharges et à leur action pour le maintien de la charge négative de la terre.

3° Publications

Magnétisme terrestre. — E. MATHIAS, CH. MAURAIN, L. EBLÉ et Mlle G. HOMERY. — Les anomalies du champ magnétique terrestre en France, avec 4 cartes au 1/2.000.000 en couleurs des anomalies de D, I, H, Z. *Annales de l'Institut de Physique du Globe de Paris,* 9, 1931, p. 37.

CH. MAURAIN. Comparaison de la quantité d'ozone de la haute atmosphère et de l'agitation magnétique. *Congrès des Sociétés Savantes, Alger,* 1930.

CH. MAURAIN. Sur l'intervalle de temps entre les phénomènes solaires et les perturbations magnétiques. *C. R. Acad. Sc. Paris,* 196, 1933, p. 1182.

L. EBLÉ. Variation séculaire de la distribution des éléments, magnétiques; application au tracé des cartes. *Ann. I. P. G. Paris,* 9, 1931, p. 87.

L. EBLÉ. Remarques sur l'agitation magnétique. *Congrès des Sociétés Savantes,* Toulouse, 1933.

L. EBLÉ. Variation de la composante horizontale autour des journées de calme magnétique. *C. R. Acad. Sc. Paris,* 196, 1933, p. 1429.

L. EBLÉ. Contribution à l'étude de l'anomalie magnétique du Bassin de Paris. *Congrès des Sociétés Savantes, Clermont-Ferrand,* 1931.

L. EBLÉ et Mlle G. HOMERY. Remarques sur la variation diurne de la Déclinaison. *Congrès des Sociétés Savantes, Besançon,* 1932.

Mlle G. HOMERY. Etude sur la variation de la Déclinaison en France depuis 1681. *Ann. I. P. G.* Paris, 9, 1931, p. 96.

Mlle G. HOMERY. Déclinaison magnétique sur l'ensemble du Globe (avec Carte). *C. R. Acad. Sc. Paris,* 196, 1933, p. 797.

Mlle G. HOMERY. Déclinaison en Indo-Chine. *Ann. I. P. G. Paris,* 11, 1933, p. 79.

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NÉCROLOGIE

La Section de Magnétisme et Electricité terrestres du Comité français de Géodésie et de Géophysique a perdu son président, le général FERRIÉ, le 16 février 1932. Gustave Ferrié était né le 19 novembre 1868. A sa sortie de l'Ecole Polytechnique, il devint officier du génie, et, après un court passage dans les Troupes, fut affecté à la Télégraphie militaire. Dès les débuts de la T. S. F., il porta ses recherches sur ce sujet, et réalisa en particulier un détecteur électrolytique. Il installa le poste de T. S. F. de la Tour Eiffel. Il joua ensuite un rôle de premier plan dans le développement de la T. S. F., par ses travaux scientifiques et par les organisations qu'il créa. Il fut élu membre de l'Académie des Sciences de Paris en 1922. Il avait acquis une autorité mondiale; il était Président de l'Union internationale de radiotélégraphie scientifique, Président de la Commission internationale des Longitudes par T. S. F., Vice-Président du Conseil International de Recherches. C'était un homme désintéressé, enthousiaste, simple et bon, et tous ceux qui l'ont approché avaient pour lui autant d'affection que d'admiration.

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	Brazier,	Directeur de l'Observatoire du Parc-Saint-Maur, Seine.
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GRANDE BRETAGNE

REPORT OF THE BRITISH NATIONAL COMMITTEE

The four British magnetic observatories at Abinger, Stonyhurst, Eskdalemuir and Lerwick have continued their normal programme since the last report, with the addition of special observations during the Polar Year, as requested by the International Commission for the Second Polar Year.

For the Second Polar Year a magnetic and meteorological expedition, under the leadership of Mr. J. M. Stagg, was sent to Fort Rae, the station occupied by a British party in the first Polar Year. Another British expedition directed by Professor E. V. Appleton, has carried on Radio Research at Tromsö during the Polar Year.

The Ordnance Survey has continued its programme of magnetic surveying by field tours in Scotland, including Orkney and Shetland: in 1930 24 stations were occupied including 6 visited by the late G. W. Walker in 1914-15: in 1931 21 stations including 3 repeat stations were occupied: in 1932 14 stations including 3 repeat stations were occupied. All three elements were measured at each station. The instruments used were a Schuster-Smith Coil Magnetometer (the first field instrument of its kind to be made) and a Dover Dip Circle. Experiments have been made during 1933 on a combination of a theodolite with a Smith fluid suspension magnetometer with a view to developing an apparatus for rapid declination survey.

Observations on the air-earth current at Kew, made by a new apparatus, are described in a separate communication by Dr. F. J. W. Whipple (p. 334).

Dr. Crichton Mitchell has continued his studies on magnetic activity (Proc. R. S. Edin. Vol. LVII, Pt. III (No. 23) see also (p. 283).

Among other observational or theoretical studies in terrestrial magnetism published in England from 1930 to 1933, mention may be made of the following: Dr. A. H. R. Goldie, on *The Electric Field in Terrestrial Magnetic Storms* (Proc. R. S. Edin. Vol. LVII, Pt. I, No. 4); by S. Chapman and J. M. Stagg on *The Variability of the Quiet-Day Diurnal Magnetic Variation* (Proc. Roy. Soc., A, 130, p. 668, 1931); by S. Chapman and V. C. A. Ferraro on *A New Theory of Magnetic Storms* (Terres. Mag., June, Sept. 1931, June, Dec., 1932, June 1933); and by S. Chapman on *The Field Energy of Magnetic Storms* (Terres. Mag., Sept. 1932) and on *The Effect of a Solar Eclipse on the Earth's Magnetic Field* (Terres. Mag., Sept. 1933).

ITALIE

RAPPORT SUR L'ACTIVITÉ ITALIENNE 1930-33 EN MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES

Par M. TENANI

I. — Pour ce qui concerne le magnétisme, on peut signaler:

a) La publication des résultats d'une révision des éléments magnétiques dans le Piémont, 1928-29, par M. le Prof. *Palazzo:* cette élaboration a été considérablement retardée par la mauvaise santé de l'auteur dont on regrette la perte.

b) L'établissement d'un observatoire magnétique permanent près de Gênes, en remplacement de l'Observatoire de Pola où les perturbations étaient devenues trop importantes.

La construction de l'observatoire, où l'on a mis en fonction, après une période expérimentale, les instruments de l'ancien observatoire, a été entreprise par les soins de l'*Istituto Idrografico della Regia Marina,* sur une colline près de Gênes à 370 m. de hauteur; on a pu constater jusqu'ici l'absence de toute perturbation locale.

Les caractéristiques des instruments de variation sont restées les mêmes qu'à Pola, c'est-à-dire analogues à celles de la plupart des observatoires magnétiques; les enregistrements obtenus permettent de considérer le nouvel observatoire comme la continuation de l'Observatoire de Pola.

Les constantes des instruments absolus (magnétomètre de *Bamberg,* inducteur de *Wild)* ont été déterminées à nouveau par divers observateurs. On peut trouver une description plus complète de l'observatoire dans le volume «*Rapporti sull'attività del Comitato Nazionale Italiano per la Geodesia e Geofisica*» (p. 67), présenté à Lisbonne.

Les premières tâches de l'Observatoire ont été de contribuer aux observations de l'Année Polaire et de continuer l'étude des corrélations entre les perturbations magnétiques et celles de la T. S. F.

L'installation et la direction de l'Observatoire ont été confiées au Prof. *M. Tenani* de l'Ist. Idr. de Gênes.

c) Le nouveau réseau magnétique: vers la fin de l'été 1932, l'Institut Géographique de Florence élabora un projet d'un nouveau réseau magnétique italien; les stations du réseau actuel seront complétées par de nombreuses stations à une distance moyenne de 20 km. env.; de cette entreprise, commencée par le regretté Général *N. Vacchelli,* on a déjà achevé 197 stations dans l'Italie Centrale et 50 dans l'Italie Septentrionale, et elle sera terminée, selon le projet, en 1938. Les observations sont actuellement rapportées à celles de l'Observatoire de Gênes où l'on a fait l'étalonnage des instruments utilisés en attendant un étalonnage des instruments de l'Observatoire avec les étalons internationaux pour les réductions définitives.

d) On a commencé un réseau magnétique de 15 stations dans les îles italiennes de l'Egée; pendant l'hiver prochain on fera plusieurs stations dans le sud de l'Erythrée.

e) L'Institut Hydrographique a construit un radeau non-magnétique pour des mesures systématiques sur la mer; les méthodes de mesures sont à peu près les mêmes que celles qui, dans la Baltique, ont rendu si bon service aux pays envirronnants cette mer et au Commandant *Gernet.*

Actuellement (1933) on occupe dans la Tyrrhénienne les points où, en 1931, le sous-marin «Vettor Pisani» a fait des stations gravimétriques.

f) Nombreuses sont les stations magnétiques faites pendant ces années pour la prospection minérale: dans la revue «*L'Universo*», le Dr. *Petrucci* a publié une carte détaillée des isodynames de la force verticale en Sicile; d'autres prospections magnétiques et électriques ont été faites par l'«*Azienda Generale Petroli*» dans la vallée du Pô et discutées par le Dr. *Belluigi* dans diverses publications.

g) Aux recherches magnétiques de l'Année Polaire, l'Italie a enfin contribué par la Station Géophysique de Mogadiscio (Somalie Italienne) établie par le *Conseil National de Recherches* et confiée à M. le Dr. *M. Bossolasco*. Les variomètres et leurs enregistreurs sont ceux construits par M. le Prof. la Cour et de qui nous les avons achetés; pour les mesures des valeurs absolues la station possède un magnétomètre de *Kew* et un inclinomètre de *Barrow*. La station est temporaire: il est probable que son matériel sera utilisé par le Conseil pour l'établissement d'un Observatoire Magnétique dans les Colonies Italiennes.

II. — Pour ce qui concerne les études d'électricité terrestre, on peut signaler:

a) L'étude d'une nouvelle méthode (par effluve) de mesure de la radioactivité atmosphérique et l'étude sur l'interprétation des résultats de nombreuses observations faites à Turin, à l'Institut de Physique de l'Université, par Madame la Prof. *G. Aliverti*: cette méthode a aussi été adoptée par le Prof. *Hess* à Innsbruck; l'instrument est actuellement mis dans le commerce.

b) Une recherche de M. le Prof. *Pacini* de l'Université de Bari, sur les relations entre les noyaux de condensation et la poussière.

c) Une recherche de M. le Dr. *L. Martinozzi* sur les relations entre la pluie, l'humidité, le type et la présence des ions dans l'atmosphère, faite à Paris et publiée dans les *Annales de l'Ufficio Presagi;* une recherche de Madame la Prof. *G. Aliverti* au Collège d'Olen sur la présence de substances radioactives dans l'air du Fœhn.

d) Une recherche du Prof. *I. Ranzi*, de l'Université de Camerino, sur les relations entre les phénomènes météoriques de la troposphère et les couches conductrices de la haute atmosphère, effectuée avec le nouveau dispositif, très simple et rapide, décrit dans «*Nuovo Cimento*», et qui permet, avec les diverses longueurs d'onde, de mesurer, presque simultanément, la conductibilité des couches élevées: ces recherches sont aussi exposées dans «*Nature*» 1932 et 1933.

e) Les recherches sur la radiation pénétrante, et en particulier celles de M. le Prof. *B. Rossi*, ont été exposées en synthèse par le même auteur dans «*Zeitschrift für Physik*», p. 82, 1933: à ces recherches on peut rattacher celles publiées dans «*Nature*» par M. *G. Bernardini*, sur les variations de la radiation pénétrante avec la distance zénithale. M. le Prof. *Rizzo* a fait des mesures avec un électromètre de *Kohlhörster* sur le Rocciamelone.

f) A la Station Géophysique de Mogadiscio, M. le Dr. *Bossolasco* vient d'enregistrer les courants telluriques de cette région équatoriale.

LUIGI PALAZZO

Un fascicule intitulé Luigi Palazzo, paru dans «La Meteorologia Pratica» Anno XIV, Num. 4 — 1933-XI, a été présenté à l'Association par M. *G. B. Rizzo* qui à Lisbonne remémora feu Luigi Palazzo dans les termes suivants:

Monsieur le Président, éminents Collègues.

Je vous remercie avant tout de l'amabilité avec laquelle vous me permettez de rappeler à votre souvenir, pour quelques instants, la mémoire de Luigi Palazzo, le savant collègue ravi, il y a peu de temps, à sa famille, à ses amis et à la Science.

Luigi Palazzo, né à Turin le 18 janvier 1861, obtint le degré de Docteur en Physique à l'Université de Turin le 13 juillet 1884. Il voua ses premiers travaux scientifiques à la Physique générale, mais son activité se dirigea bientôt vers les études du Magnétisme terrestre. Nommé assistant au Bureau Central Météorologique de Rome en 1888, sous la direction de Pietro Tacchini, Luigi Palazzo, après une préparation minutieuse, fut chargé de continuer les travaux de relèvement pour la construction de la Carte magnétique de l'Italie, déjà commencée par Ciro Chistoni qui venait de quitter sa place au Bureau Central pour occuper la chaire de Physique à l'Université de Modène. Luigi Palazzo continua le travail avec grande ferveur pendant quatre ans, et toutes ses observations sont caractérisées par les soins les plus minutieux dans le choix de l'emplacement des stations afin de les mettre à l'abri des perturbations accidentelles, par l'exactitude des mesures et par la rigueur des calculs. Les travaux de relèvement dans le Royaume furent achevés en 1902, et dans le courant de cette année-là, le Bureau Central publia les cartes des lignes isogones et des isoclines d'Italie. Les calculs des déterminations de la composante horizontale demandèrent plus de temps, et la carte des lignes isodynamiques fut présentée au Congrès géographique de Naples en 1904.

Promu Directeur du Bureau Central lors de la retraite de Pietro Tacchini, Luigi Palazzo, tout en accomplissant avec une grande dignité et une habileté exquise les devoirs de sa nouvelle charge, poursuivit avec ardeur ses études sur le Magnétisme terrestre. Mais, l'électricité atmosphérique, les radiations pénétrantes et tous les problèmes de l'aérologie dans lesquels il était en Italie comme un précurseur, furent aussi l'objet de ses recherches passionnées. Il trouva encore le temps et les moyens de faire des relèvements magnétiques dans les Colonies italiennes, en Tripolitaine, en Erythrée, en Somalie, où il réussit même à déterminer les variations séculaires.

Dans les terrains de l'Ecole pratique d'Agriculture à Saint-Pancrace près de Rome, et ensuite, lorsque cet endroit se trouva exposé aux perturbations des lignes électriques de la ville, à Terracina au bord de la mer, Luigi Palazzo effectua des observations magnétiques régulières pour des variations séculaires en Italie. Au cours de ces déterminations, il s'aperçut d'une singulière anomalie: la déclinaison, après une descente d'environ 2′ par an, avait ralenti sa marche et, pendant 1911-1913, restait presque stationnaire, ce qui faisait présumer une inversion probable dans l'allure de cet élément. La composante horizontale, qui d'abord augmentait d'environ 20 γ par an, resta stationnaire de 1901 à 1911, et une détermination faite en 1912 donna la certitude que la composante horizontale à cette époque commençait à diminuer.

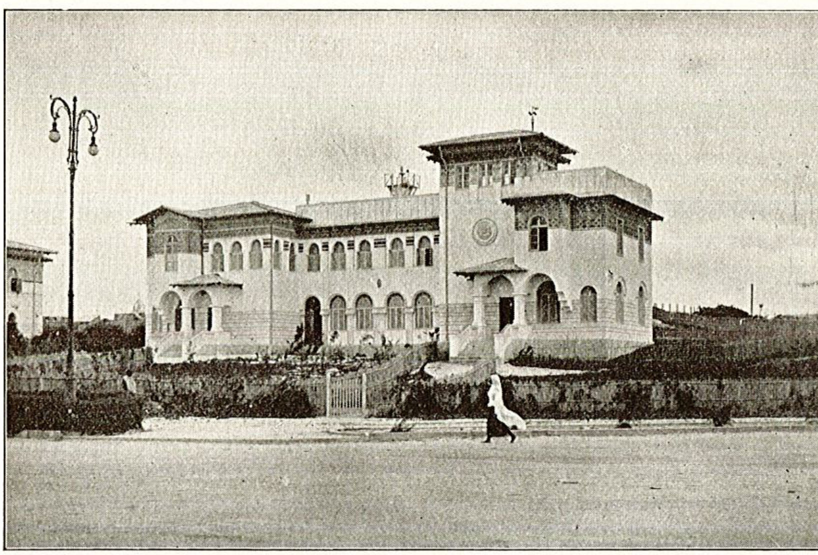
L'importance de ces phénomènes ne pouvait échapper à Luigi Palazzo, il conçut alors le dessein de refaire le relèvement magnétique de l'Italie, afin de mettre les cartes à jour: il n'hésita pas un instant à recommencer ses campagnes magnétiques, bien que déjà âgé de soixante ans et souffrant des yeux trop fatigués par de longues veilles de travail. Mais il était encore si jeune d'esprit et de cœur! — Les nouvelles mesures furent entreprises en 1921 et poursuivies jusqu'à la fin de 1929 avec une interruption en 1926 due à un voyage en Somalie, et une autre en 1928 due à une recrudescence de sa maladie des yeux.

Le 31 octobre 1931, Luigi Palazzo prit sa retraite avec le titre de Directeur honoraire du Bureau Central de Météorologie et Géophysique. Au printemps 1933 il rentra dans une clinique à Florence pour se soumettre à une opération des yeux, mais une septicémie indomptable survint, et le 6 juin de cette même année son âme quitta sa dépouille mortelle. A ce moment, Luigi Palazzo fut pieusement assisté par le savant sismologue Rev. P. Guido Alfani.

L'œuvre de Luigi Palazzo dans le vaste domaine du Magnétisme terrestre et des autres branches de la Physique du globe restera comme une pierre milliaire dans l'histoire de cette science en Italie, et tous ceux qui l'ont connu ne pourront jamais oublier sa grande modestie, son dévouement pour ses amis, la douceur et le charme de son caractère.

J'espère que l'Association de Magnétisme et Electricité Terrestres de l'Union Internationale de Géodésie et Géophysique, devant laquelle Luigi Palazzo avait toujours coutume de prendre parole pour faire bénéficier son auditoire des fruits de son savoir et de son expérience, voudra bien se joindre à moi pour adresser à sa mémoire une pensée d'admiration, de pitié et de douleur.

RAPPORT SUR LES TRAVAUX EXÉCUTÉS A LA STATION GÉOPHYSIQUE TEMPORAIRE DE MOGADISCIO, (AFRIQUE) ($\varphi = 2° 02'03''$ N; $\lambda = 45° 21'20''$ E) ENTRE LE 1er. AOUT 1932 ET LE 31 JUILLET 1933*)



Magnétisme terrestre

Les variations des éléments magnétiques ont été enregistrées continuellement — c'est-à-dire sans aucune interruption remarquable entre le 1er. août 1932 et le même jour de 1933 — avec l'appareil à marche normale de M. la Cour.

Surtout à la suite du défaut d'accumulateurs, mais quelques fois même pour d'autres raisons, p. ex. manque de papier

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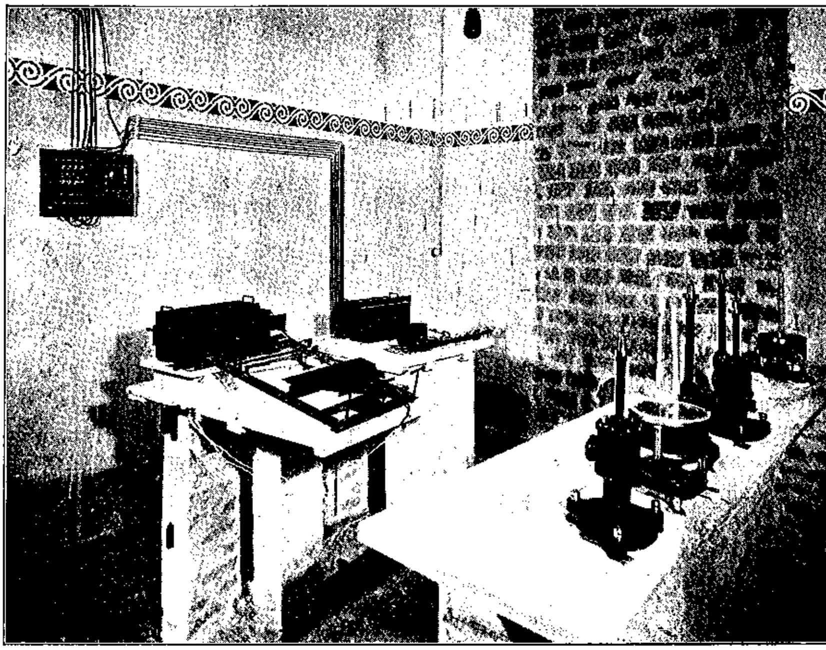
*) Pour plus de détails sur l'installation des appareils et le commencement des observations, cfr.: M. Bossolasco, «La Stazione Geofisica di Mogadiscio», dans le «Bollettino del Com. Naz. It. per la Geodesia et la Geofisica». N. II-12, 1932.
Note de la Rédaction: Les parties du rapport: «Météorologie», «Aérologie» et «Océanographie» ont été omises dans ce volume.



photographique, l'enregistreur à marche rapide a fonctionné seulement pendant quatre mois environ.

Les déterminations absolues des éléments magnétiques ont été faites en moyenne à un intervalle de moins d'un mois l'une de l'autre: faute de personnel et à la suite des autres travaux de la Station, il ne fut pas possible de rapprocher ces mesures davantage.

Électricité tellurique

Pour l'observation systématique des courants telluriques, on a établi deux lignes N-S et E-W avec une distance de presque un kilomètre entre les deux électrodes correspondantes de chaque ligne: les câbles ayant tous été posés sous terre à une profondeur moyenne de 70 cm. — L'installation de ces lignes a subi un retard déterminé par des détours dans l'expédition du câble. Le commencement des observations fut fort retardé, non seulement à la suite de la construction d'une petite maison pour l'installation des appareils d'enregistrements, mais surtout en raison des galvanomètres reçus cassés et du matériel disponible très limité et bien peu approprié; de plus, il est encore à signaler l'interruption de la ligne N-S provoquée par le déplacement des dunes de sable mobiles dans le voisinage de l'électrode N. — Avec tout cela, le commencement des enregistrements réguliers fut retardé jusqu'au mois de juin; d'ailleurs, à la suite de ce délai, l'établissement fonctionne encore à l'heure actuelle par les soins d'un électricien qui demeure à Mogadiscio; c'est la seule installation de la Station Géophysique de Mogadiscio qui est restée après la fin de l'Année Polaire.

Turin, le 10 *septembre* 1933.

MARIO BOSSOLASCO.

JAPON

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

The Central Meteorological Observatory is making systematic observations of terrestrial magnetism, atmospheric electricity and earth currents at its magnetic observatories at Kakioka and Toyohara.

The Kakioka Magnetic Observatory

Kakioka lies at a distance of 70 km to the northeast of Tokyo and has the geographical coordinates, 140° 11′ 21″ E, 36° 13′ 51″ N and 28.2 metres above sea level. At the observatory under the charge of Mr. S. Imamiti the variations of the three elements are recorded by a set of Ad. Schmidt's Magnetographs constructed by Askania Werke in Germany and set of absolute observations is made once a week by Ad. Schmidt's normal theodolite and earth-inductor also constructed by the same German firm. A special high-speed magnetograph after the design of Mr. Imamiti for observation of the sudden commencement of magnetic storms is installed. The magnetograph is constructed by the workshop of the Central Meteorological Observatory, Tôkyô. The variation of the atmospheric electric potential is recorded by Benndorf's electrometer, and the electric conductivity of air by a specially designed apparatus. The electric charge of rain water is measured. The variations of earth currents are recorded by a galvanometric method.

The Toyohara Magnetic Observatory

Toyohara in South Saghalin lies in 46° 58′ N and 142° 44′ E. At the newly established observatory magnetic registration is being made by a set of the Eschenhagen magnetographs constructed by Toepfer, Potsdam, and absolute observations are made by the magnetometers of the Indian Survey Pattern and an earth inductor once a week. For the observations of the sudden commencement of the magnetic storms a high-speed magnetograph of the same construction as in use at Kakioka is used. The records of earth-currents, atmospheric electric potential and the conductivity of the atmosphere are also taken. The Toyohara observatory is under the charge of Dr. H. Hatakeyama.

OBSERVATIONS OF TERRESTRIAL MAGNETISM, ATMOSPHERIC ELECTRICITY AND EARTH'S POTENTIAL AT A NEW LABORATORY

In 1932 Tokyo Bun-Rika University established a new geophysical laboratory at Simoda, Idu (Latitude 34° 40′ N, Longitude 138° 56′ E). At present, regular observations of terrestrial magnetism, atmospheric electricity and earth's potential are done here, under the control of Prof. S. Ono for the purpose of contributing to the second polar year observations. These observations will be continued to the beginning of 1934.

The situation of this laboratory is in a region of volcanic rocks, and actually, anomalous variations of terrestrial magnetism are found. The present purpose of the polar year observations is to find local variations (which should be separated from the general variations), by comparing the data there obtained with those observed at Kakioka Magnetic Observatory, which is some hundred kilometers apart from the present laboratory.

MAGNETIC OBSERVATIONS BY THE HYDROGRAPHIC DEPARTMENT, IMPERIAL JAPANESE NAVY

I. *Third complete magnetic survey of Japan.*

Since May, 1932, the Hydrographic Department has been carrying out its third complete magnetic survey of Japan with a two year's programme which favourably agrees with the observations of Polar Year.

A number of the Nippon Suirobu magnetometers designed by A. Muramoto, Naval Engineer, for the service of this survey, were compared with the standard at the Magnetic Observatory, Kakioka, at the beginning of the survey. This new magnetometer combines in itself the earth inductor for measuring dip and an electromagnetic magnetometer of 1922 type which in based on the combined principle of Prof. Dr. A. Tanakadate's method for measuring declination and Prof. N. Watanabe's method for measuring horizontal intensity.

II. *Occasional magnetic surveys.*

The Hydrographic Department conducted the surveys at two regions in the southern coast of Tyôsen in the summers of 1928 and 1930 for research in the local magnetic disturbances, the existence of which had been reported by merchant ships.

III. *Weekly magnetic observations.*

In order to study the secular variation of magnetic elements more precisely than before, at least as regards the declination over the whole region of the North-western Pacific, the Hydrographic Department has entrusted the Palau Observatory, the principal meteorological observatory in the South Sea Islands under Japanese Mandate, with the weekly observation of the declination since September, 1926. The Kew magnetometer and the Barrow's dip circle was replaced by the Nippon Suirobu magnetometer at the observatory of Zinsen since March in 1932, while the work of weekly observations of the magnetic elements at the observatories of Taihoku, Ôtomari, and Palau have been going on with the Kew magnetometers as projected and reported to the Rome Meeting, 1922. (see "Transactions", Bull. No. 3, pp. 40-42.)

PRELIMINARY REPORT OF THE SECOND POLAR YEAR OBSERVATIONS ON TERRESTRIAL MAGNETISM AND EARTH POTENTIAL GRADIENT AT SIMODA, AUGUST 1932-JUNE 1933

By S. ONO

Prepared for the Fifth General Meeting of the International Association of Terrestrial Magnetism and Electricity. It consists of short descriptions of:

I Observatory and Instruments
II Observations on Terrestrial Magnetism
III Earth Potential Gradient
IV Atmospheric Electricity
V Figures*)

*) *Note de la Rédaction:* Les figures ont été omises dans ce volume, vu qu'elles n'étaient pas appropriées à être imprimées.

I. *Observatory and Instruments.*

The Observatory constitutes a part of a new Geophysical Laboratory of the Tôkyô Bun-Rika University adjoining its Marine Biological Laboratory. It is at the west end of the Town of Simoda, on the shore of a small arm of the Bay. Its geographical co-ordinates are: 34° 40′ N and 138° 56′ E, and it is 137 km. from Tôkyô about S, 34° W, near the south end of Idu Peninsula, which projects southward from the middle of Hondô. The place is quite free, at present, from industrial electric disturbances and tramways.

There are two wooden non-magnetic buildings, one for magnetographs and the other for absolute instruments. They are 50 m. apart at their nearest points, from buildings containing any iron work.

For the observations of atmospheric electricity and earth current there is built a small house with two dark rooms at a corner of a flat ground of about 20 m × 20 m.

As the above buildings were not completed until December, owing to budgetary circumstances, observations were begun in a tent at the beginning of August 1932, so that some of the instruments had to be removed to their present posts. The mechanical shocks arising from the construction of the remainder of the Institute were carefully checked and found to be negligible except in very special cases.

Simoda is a remarkable place for hot and moist climate. Actual difficulties met with were beyond preconception. For example, some fine fibrinous bacteria grew on the magnetic needle and impaired its free motion inside the damper. This necessitated disinfection and cleaning of minute parts of the instruments before setting them in place. According to a bacteriologist, there are many bacteria which have their maximum power of developing in a moist place at temperatures of about 20° C.

For the constancy of temperature, the variometer room was made with triple walls and ceiling, the space between the inner two partitions was filled with sawdust, (thickness about 13 cm.), the doors of windows and entrance are doubled: the diurnal range of temperature variation thus arrived at is below 0.5° C. Yet some residual moisture in the sawdust seems to have been continuing its evaporation over some months. Although the author made his best effort to fight down scientific and administrative difficulties*) in order to partake in the Polar Year Observations for its full duration, he could not

*) The undertaking of the work was decided on July 7th and then the buildings and instrumental installations had to be designed according to funds available.

spend more than a few days each month in that Observatory owing to other duties. Consequently, complete set of the variation curves were obtained only in October, and the reduction of the absolute value can only be approximate until a later determination of the constants of the instrument. Mr. K. Imazato and two other computers have assisted in making the observations which are going to be continued till January 1934 or further.

II. *Observations in Terrestrial Magnetism.*

For the observation of variation of the horizontal intensity two instruments giving rectangular components along lines at 45° to the magnetic meridian*) and one declination variometer are installed. From these three we can deduce the variations of X Y components and of H D; and any one record can be utilized to verify the other two, or in case any one record is missed, it can be filled in from the remaining two. The two intensity variometers are designated hereafter as the magnetograph I and II. The north pole of the suspended magnet of the magnetograph I is directed NE, while that of the magnetograph II is directed NW. Two mirrors are fixed to each instrument to give images upon both the slow running and the quick running drums.

The vertical intensity variometer was designed after the Watson type, but it did not work well owing to defect of material. A special type of a very simple design was tried and is used. It gives fairly good results when it is properly adjusted. (Details will be reported later).

For measuring the absolute values, the electromagnetic type designed by Kaigun Suirobu (Hydrographic Department) is adopted. The constants of the coil are now going to be determined, and will be verified again in winter. The following are the preliminary results of some of the observations.

a) *Variation having a period of nearly a month.*

This variation is the one that is considered by some authors to have a lunar period. Variations of this kind appeared every month, after August 1932, continuing for several days, though accompanying no remarkable storm. The dates of the occurrences are:

1932,	August	21st	-	24th
	September	23rd	-	28th
	October	20th	-	26th
	November	12th	-	12st
	December	9th	-	12th

*) Union Géodésique et Géophysique Internationale, Section de Magnétisme et Electricité Terrestres, Comptes Rendus de l'Assemblée de Stockholm (15-23 août 1930), Bulletin No. 8, p. 323.

1933, January	15th - 18th	
—	22nd - 31st	
February	18th - 28th,	moderate storm
March	18th - 28th	
April	16th - 24th	
May	1st - 2nd,	a storm began with a commencement on April 30th
May	31st - June 5th	
June	26th - 30th	

b) *Variation having a period of nearly a day.*

An example of this kind appeared on October 15th, 1932 (G. M. T.), after a very calm day the 14th*), and repeated similar characteristic variations on the following three days, attenuating its feature on successive days until final disappearance. Its period of recurrence is about 21 hours. The next case of this type was again observed from December 15th to 17th, 1932 (G. M. T.). The period in this case was 26 hours approximately. Detailed investigations of such periodic variations will be an interesting problem for international cooperation.

c) *Variations with short periods.*

Another type of variations of short periods are often observed on comparatively calm days. It should be noticed that the variation of this type always accompanies similar variation of the earth potential gradient, and therefore, the magnetic variations of this type may be considered as due to the earth current.

In simultaneous observations of the earth potential gradient and terrestrial magnetism we generally find a parallelism between them. But a careful examination reveals two cases; namely, the one in which the magnetic variation predominates remarkably, and the other where the earth potential gradient predominates. In the latter case the variations of the earth current may be taken as local events. Examples of this kind are shown in a later paragraph on the earth potential gradient.

d) *Sudden Commencement on April 30th 1933.*

Since the last August till June only a few cases of sudden change of the terrestrial magnetism were observed at Simoda. Among these, the one on April 30th was followed by a storm continuing till May 2nd. Details of this sudden commencement are as follows:

Time of beginning, April 30th (1933) 16th 28m 10s — 15s.
Maximum point of the horizontal component, 16th 32m 30s.

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*) The record of the sudden commencement at 17th 47m (G. M. T.) is missed. It falls at 15th 2h 47m local time. A. T.

Variation of	the north component,	$X = 40.7\gamma$	(from the initial point to the next maximum point
„	the east „	$Y = 6.4\gamma$	
„	the vertical „	$Z = 42.8\gamma$	
„	the horizontal „	$H = 39.9\gamma$	
„	the declination „	$D = -1'.2$	

Duration of time from initial point to maximum point $\Delta t = 4m\ 20s$ about.

Time rate of change.

$$\frac{\Delta X}{\Delta t} = 9.4\ \gamma/\text{min.} \qquad \frac{\Delta Y}{\Delta t} = 1.5\ \gamma/\text{min.} \qquad \frac{\Delta Z}{\Delta t} = 9.9\ \gamma/\text{min.}$$

$$\frac{\Delta H}{\Delta t} = 9.2\ \gamma/\text{min.} \qquad \frac{\Delta D}{\Delta t} = 0'.28\ /\text{min.}$$

These are only provisional values without proper corrections such as temperature effect on scale values etc. H is calculated from the records of the magnetographs I and II, whose needles are deviated from the true meridian about $\varphi_1 = 48° 02'$ and $\varphi_2 = 54° 59'$ respectively. The value of D calculated with the above data gives $-1'.14$, while direct record of the declination variometer gives $-1'.17$ or $1'.2$ in round number as above given. Negative sign of ΔD means the diminution of its west value.

The time scale on the quick running drum is about 4.28 mm/min. or 0.071 mm/sec. The rate of the electrically controlled clock is of the order of 1 sec/day; the light source for all the recorders is cut off every 5 min. for 30 sec. Thus the time error in the record is also of an order of one second. However, the smooth minimum of the commencement in the present case makes an uncertainty of about 5 seconds.

III. *Earth Potential Gradient.*

For the observations of the earth potential gradient, the electrode is made of a copper tube insulated by a bamboo tube.*) This tubular electrode descends a few meters down to the water stratum and terminates inside a porous pot containing copper sulphate solution, which is supplied from above through the electrode tube at proper intervals. The distance between electrodes for NS component is 110 meters, and that for EW component is 60 meters, being restricted by the extent of the ground, and the currents between these electrodes are photographically recorded. If the current in the circuit is too strong, polarization at the electrode becomes objectionable: to

*) The author tested this type of electrode some years ago with a glass tube which is a better insulator, but too fragile under the present circumstances.

obviate this effect the potential difference was compensated by applying a known electromotive force from a battery. But this arrangement is naturally upset when the direction of the current is reversed. So the current is largely reduced by inserting a set of resistances. The current in the measuring circuit is given by the potential difference between the ground and the inserted resistances. The change in conditions of contact of the electrode on the soil causes deviations of the galvanometer deflection. In order to take account of this effect, the scale value of the record is measured every day by the compensation method (null method). This is utilized for estimating the degree of polarization at the same time. If polarization exists, since it varies with the strength of current in the circuit, the galvanometer deflection will show a discontinuous change, before and after the application of the zero method. Such a case may happen when the electrode terminal is out of order, e. g. loss of copper sulphate solution. The degree of polarization may be tested by strengthening the current in the circuit for a time by diminishing the inserted resistance; if polarization exists, it will fall in the usual asymptotic way, provided the earth current remains steady.

a) *Effect of Heavy Rain and Thunderstorm.*

The earth potential gradient is often affected considerably by rain, likely owing to local change of stream lines of the ground current due to irregular change of resistance. The change of potential gradient caused by heavy rain is abrupt in general, especially in thunderstorms. In ordinary rain the variations are not so great, though the changes are pretty abrupt.

b) *Other Phenomena of the Earth Potential Gradient.*

The variations of the earth potential gradient are more complicated than magnetic variations which generally accompany them. There are cases, however, when the variations of the earth potential gradient are remarkable though the magnetic values change showly, showing that the current is not due to that induced in the local region by the change of magnetic flux. A detailed investigation on this subject must be reserved for future report.

IV. *Atmospheric Electricity.*

In the present observations an uranium collecter is used; though its collecting power is rather low, it is sufficiently effective to get photographic records, by using a gold leaf electrometer of small capacity. The apparent value on ordinary records of the atmospheric electricity is depending of the difference between the collecting rate and the leaking rate. In the present observations, both of them are measured and corrections to observed values are applied.

Variations of atmospheric potential seems to be most complicated and the causes of variations are very difficult to elucidate at the present moment.

NORVÈGE

REPORT REGARDING INVESTIGATIONS ON THE AURORAL SPECTRUM CARRIED OUT IN NORWAY SINCE THE CONGRESS AT STOCKHOLM, 1930

By L. VEGARD

A complete account of spectral observations of the aurorae undertaken at Tromsö during the period from 1922-1926 were published by the writer in *Geophys. Publication of Oslo,* Vol. IX No. 11. The paper gives the wavelength of 50 lines and bands, and the spectrum has been fairly thoroughly explored in the region of short waves.

Measurements of the typical intensity distribution within the spectrum are given, as well as observations and quantitative measurements of typical variations. Fairly accurate values are obtained for the altitude effect discovered 1923, consisting in the enhancement with altitude of the negative nitrogen bands relative to the green auroral line. The enhancement of a certain red line responsible for the red aurora of type A has been shown and the importance of this enhancement discussed. The enhancement of the red lines is found to be of universal nature and it appears to follow the sunspot cycle.

By means of the development of the R-branch of the negative nitrogen bands appearing in the auroral spectrum the temperature of the emitting centres in the auroral regions was measured. An average temperature of —30° C was found, corresponding to an altitude interval of 100-125 km. These temperature determinations will be continued at the new Auroral Observatory by the writer in collaboration with Mr. E. Tønsberg.

The electrical state and coronal structure of the upper atmosphere and their relation to zodiacal light and the night sky luminescence, found by the writer in 1923, were briefly discussed and found in accordance with new facts.

At the new Auroral Observatory at Tromsö investigations on the auroral spectrum were continued in collaboration with Mr. Leiv Harang. Special attention has been paid to the exploration and measurements of the region of long waves including the infra red region to about 9000 Å. For the investigations of the long wave region a grating spectrograph of high light power was constructed and built. In a recent work in *Geophys. Publ. Oslo,* Vol. X No. 4, 1933 an account was given of the instrumental equipment, the plan of the work, and the first results obtained at the new Observatory. Some further results from the winter season 1932-33 were published by the writer and Mr. L. Harang in *Geophys. Publ. Oslo,* Vol. X No 5.

Up to the present 85 lines and bands have been recorded and measured in the auroral spectrum. In the infra red 8 bands are found which are to be refered to the first positive group of nitrogen. In the red part two lines 6302 and 6365 were measured with fairly large dispersion. Within the limit of errror these lines coincide with the oxygen lines ($^1D_2$-$^3P_2$) and ($^1D_2$-$^3P_1$) respectively. A considerable number of red lines were measured belonging to the 1st positive group of nitrogen.

Apart from the strong green line and the two oxygen lines mentioned no other OI lines were observed. In order to explain the large intensity of the green line, the appearance of two red ones and the absence of other OI lines the writer assumed the oxygen atom to be brought to the $^1S_0$ state through collision of the second kind with active nitrogen, a process which should be stimulated by resonance.

In the red lines the enhancement of which produce the red aurorae of type A, is identical with the ($^1D_2$-$^3P_{1,2}$) lines, the problem arises how to find which changes of physical conditions of the upper atmosphere are responsible for this enhancement. In the case of another type of red aurorae called B, the red colour is restricted to the lowest part near the bottom edge. This type, the writer explains as due to the relative enhancement of the red bands of the 1st positive group, which is found to be relatively strong at higher pressure and small velocities of the electric rays, conditions which might correspond to those near the bottom edge of low aurorae. Harang and Bauer actually found that an aurora of this type reached down to an altitude of only 65-70 km.

In accordance with announcement at the Stockholm congress the writer in collaboration with Mr. Harang undertook interferometer measurements of the strong green line. The results have shown that the auroral green line is identical with that of the night sky luminescence. Interference pictures taken parallel and perpendicular to the auroral ray streamers gave no indication of doppler effect. The interference measurements are to be extended to other auroral lines, especially those in the red part responsible for the red aurorae of type A. A more complete account of the interferometer measurements will soon be published.

Oslo, October 1933.

RAPPORT SUR MES TRAVAUX RELATIFS A L'AURORE BORÉALE ET AUX PHÉNOMÈNES ANNEXES, DEPUIS LE CONGRÈS DE STOCKHOLM JUSQU'AU CONGRÈS DE LISBOA

1. Théorie:

Grâce à une subvention totale depuis 1929 de 12000 couronnes norvégiennes de la fondation «Det videnskapelige Forskningsfond av 1919», les intégrations numériques des équations différentielles des électrons dans un champ magnétique, déjà commencées en 1904, pouvaient être reprises et un travail de plus de 6000 heures fut consacré à ces calculs. Les résultats, comprenant les trajectoires périodiques dans un champ d'un aimant élémentaire, des trajectoires passant par l'aimant et des faisceaux de trajectoires venant de l'infini, sont publiés en partie dans les mémoires suivants:

1. *Periodische Elektronenbahnen im Felde eines Elementarmagneten und ihre Anwendung auf Brüches Modellversuche und auf Eschenhagens Elementarwellen des Erdmagnetismus.* Zeitschr. für Astrophysik, T.I, 4. 1930.
2. *On pulsations of terrestrial magnetism and their possible explanation by periodic orbets of corpuscular rays,* Terrestrial Magnetism, June 1931.
3. *Über die Probleme des Polarlichtes,* Ergebnisse der kosmischen Physik, T. I (akademische Verlagsgesellschaft, Leipzig).
4. *How the horse shoe-formed auroral curtains can be explained by the corpuscular theory,* Terrestrial Magnetism, September 1931.

Comme on le voit par le titre de ces mémoires, les résultats de calculs ont été appliqués aux phénomènes du magnétisme terrestre et des aurores polaires.

En outre, les recherches d'ordre purement analytiques relatives aux propriétés des trajectoires ont été poursuivies, aussi bien au cas d'un champ d'un aimant élémentaire qu'au cas plus général, où est superposé un champ avec force inversement proportionelle au carré de la distance. Voir les mémoires:

1. *Ein Fundamentalproblem der Bewegung einer elektrisch geladenen Korpuscel im kosmischen Raume* I, II, III, Zeitschrift für Astroph. T. III, 1, 3, et T. IV, 4, 1931 et 1932.

2. *Angenäherte Integration der Bewegungsgleichungen von Elektronen im Felde eines magnetischen Dipols,* Ibid. T. 6, 5, 1933.

2. *Observations.*

Le travail des stations permanentes d'aurores boréales dans la Norvège méridionale a été poursuivi d'après le programme adopté. Ces stations sont: *Oslo* (Station double), *Oscarsborg, Kongsberg, Tömte, Lillehammer,* et pendant l'année dernière aussi *Lökken Verk,* formant des lignes de base depuis 27 jusqu'à plus de 300 km. Chaque station est munie de chambres photographiques, plaques et téléphone, de manière qu'elles peuvent vite être mises en action dans le cas d'une aurore boréale.

Dans la période en question les nombres suivantes de photographies réussies d'aurore boréale ont été pris (I d'une seule station, II simultanément de deux stations, III de trois stations et IV de quatre stations pour mesurer la hauteur):

Année	I	II	III	IV
1930-31	26	126	51	0
1931-32	80	80	42	6
1932-33	221	103	85	17
en tout	327	309	178	23

En outre, sur une expédition d'aurore boréale à Trondheim en mars 1933, j'ai réussi à prendre pendant quatre nuits un nombre de 103 photographies d'une seule station et 254 simultanément de Trondheim et Lökken Verk (Base 48 km), toutes réussies.

La mesure et le calcul de ce grand matériel de plaques est en train d'être fait, mais comme il y a environ quelques milliers de photographies depuis 1922 qui doivent être soigneusement mesurées, le travail n'est pas encore fini.

Des listes d'aurores boréales ont été publiées dans *l'Annuaire astronomique et météorologique Camille Flammarion, publié par l'Observatoire de Juvisy, Années 1931-34.*

Oslo, octobre 1933.

Carl STÖRMER.

REPORT REGARDING RESEARCH WORK AT THE AURORAL OBSERVATORY, TROMSÖ, NORWAY.

By Leiv HARANG

I. *Terrestrial Magnetism.*

Registration of D, H and V have been continuously running. The magnetic year-book for the years 1930 and 1931 is now in print. In sept. 1932 a new set D, H and V variometers and a la Cour's rapidregistrator have been in function. The rapid-registrations will be continued. In august 1933 a magnetic observatory with D, H and V registrations have been erected at the island of Jan Mayen, — north of the auroral zone.

II. *Atmospheric Electricity.*

Registrations of the electric potential gradient by means of a Russeltvedt collector and a quadrant-electrometer have been running since january 1932.

III. *Auroral Photography.*

Usually parallactic photos of the aurorae have been taken on every evening if possible, — in order to watch the occurrence of more unusual types of aurorae. Several thousands parallactic photos have been collected during the last winters. During these observations, an auroral arc with deep red colour at the lower border was photographed parallactically. The height-measurements showed that the height above the earth's surface of the lower border of this arc was 65-75 km, which is 20-40 km *lower* than aurorae usually appearing. (L. Harang and W. Bauer: *Gerlands Beitrage zur Géophysik, 37,* 109, 1932 and *Nature, 130,* 764, 1932.).

Investigations of the spectral distribution of the luminosity in the individual aurorae with regard to altitude and different types have been performed by means of filter-photography. By using suitable filters, plates and objectives of high light-power photos of individual aurorae have been taken in infra-red, red, green, blue + violet and ultraviolet. (*ZS. f. Geophys.* 7, 324, 1931, and "Filteruntersuchungen von Polarlicht", *Geofysiske Publikasjoner, Oslo,* — now in print.).

REPORT REGARDING THE WORK AT THE MAGNETIC BUREAU, BERGEN

By O. KROGNESS

The elaboration of the magnetic material from various Norwegian stations and work in connection with the publication of magnetic observations from the Auroral Observatory, Tromsö, has been continued at the Bureau. A magnetic year-book series has been started in the new publication series *"Publikasjoner fra Det Norske Institutt for Kosmisk Fysikk"*.

For the study of the magnetic storms and their relation to the auroral and solar phenomena the Norwegian Institute of Cosmical Physics has found it desirable that the year-book should give a more detailed report of the magnetic phenomena than has been the case up to the present. The question as to the best form of publication has been thoroughly considered at the Bureau and by the Board of Directors of the Institute who in a preface to the year-book series have given the following general remarks regarding the plan adopted:

"On the one hand we have tried to give the results in the form of tables which correspond to the usual way of representation, on the other hand the investigations of *Kr. Birkeland* and his analysis of magnetic storms have shown the importance of a separate study of the perturbing forces and the fields of the magnetic perturbations, and we feel certain that a further study of magnetic phenomena along these lines will be of far reaching importance for the elucidation of these phenomena. It has therefore been our endeavour to find a representation of the observational data, which would meet both these requirements and facilitate a separate study of the various physical phenomena which are responsible for the magnetic variations.

These considerations have led us to adopt the following procedure of publication:

For each magnetic element we give two series of tables. One series gives in the usual way the actually observed hourly values of the magnetic elements. Two separate columns are given containing the daily mean (M) and the daily range (R). For each month we give one line (M) containing the monthly mean diurnal variation of the actual observed values and another line (MQ) containing the monthly mean diurnal values corresponding to undisturbed (quiet) conditions.

The second series of tables gives the magnetic storminess or we might say the average perturbing force for each hour interval. This series of tables also contains five columns. One headed M gives for each day the mean perturbing force. (Storminess). The columns headed P_s, N_s and A_s give the diurnal mean of the positive, negative and absolute storminess respectively.

From the column A_s we can see the "magnetic character" of the day and we use these values for defining "character numbers" C, which are given in the last column.

For each month we give one line (M) containing the monthly mean diurnal distribution of the storminess (Mean perturbing force) and two lines marked MPS and MNS giving the monthly mean diurnal distribution of the positive and negative magnetic storminess respectively.

Methods for separating the influence of the perturbations from the rest of the field have been given by Birkeland.

His method, which depends on drawing "normal lines" on the magnetograms have not been strictly followed, but we adopted a somewhat modified method worked out by Krogness which enables us to determine the perturbing force by a calculation process, and which will be described in the present paper."

The last volume of the series giving the results of the Roald Amundsen Expedition with "Gjöa" to the magnetic north Pole has been completed, and published in Geophys. Publ. Vol. VII, Oslo 1933 by Aksel S. Steen, Nils Russeltvedt and K. F. Wasserfall.

The writer has continued the work with the magnetic survey of the Southern Norway. The expenses for this work have been partly covered by grants from the Geophysical Institute at Bergen.

POLOGNE

RAPPORT DU DIRECTEUR DE L'INSTITUT NATIONAL MÉTÉOROLOGIQUE DE POLOGNE

Par J. LUGEON

I. *Observatoire Magnétique de Hel.*

L'Observatoire Maritime de l'Institut National Météorologique sis au port polonais de Gdynia, sur la mer Baltique, comprend une Section de Magnétisme qui s'occupe de la détermination du champ magnétique terrestre dans la partie nord-ouest du pays et de la vérification des compas sur les navires de la marine polonaise. Mes prédécesseurs à la direction de l'Institut Météorologique, MM le Prof. A. B. Dobrowolski et St. Hlasek décidèrent d'installer la station d'enregistrements à l'extrémité de la péninsule de Hel ($\varphi = 54°\ 36'.5$, $\lambda = 18°\ 48'.9$ E de Gr.), soit à une vingtaine de kilomètres de Gdynia.

C'est le Prof. Hlasek, ancien directeur des Instituts Magnétiques de Pawlowsk et constructeur de l'Observatoire de Tiflis qui en dresse les plans. La construction des bâtiments fut achevée en 1931. Mon éminent collègue commanda à Paris l'enregistreur Mascart chez Carpentier et Pellin et acquis plusieurs magnétomètres pour les mesures absolues chez Askania, à Berlin. Il n'eut toutefois pas la joie de voir son œuvre achevée, puisqu'il se retira dans la vie privée avant la livraison des appareils.

En 1931, je pus commencer la construction des piliers et le montage du Mascart aux composantes H, Z, D. Mais mon travail administratif me rappelant constamment à Varsovie, je dus confier l'achèvement du réglage délicat de l'enregistreur à mes collaborateurs Liana, Dluski, et Cynk. Vers la fin de l'année 1931 le magnétographe fonctionnait normalement. La nouvelle station fut alors définitivement rattachée à la Section Maritime de l'Institut, à Gdynia. M. Cynk, physicien surveille les appareils magnétiques et dépouille les diagrammes.

J'ai décrit la station magnétique de Hel dans mon ouvrage en langue française sur l'Institut National Météorologique de Pologne, organisation du Bureau Central Météorologique, Observatoire Aérologique, Observatoire Maritime, Station Magnétique, in 8°, 222 pages, *Varsovie* 1932. Cette publication préliminaire devrait être complétée sans retard, de manière à renseigner les spécialistes avec plus de détails sur nos travaux. C'est pour celà que j'ai prié mon adjoint à Gdynia, M. Dluski, Capitaine aux longs cours, chef intérimaire de l'Observatoire Maritime et son collaborateur M. le Dr. Cynk d'écrire la Notice que je dépose sur le Bureau de l'Association intitulée: «Mesure des éléments du champ magnétique terrestre sur le littoral polonais de la Mer Baltique en 1932, in 4° 35 pages avec tableaux, *Mémorial de l'Institut National Météorologique de Pologne*, n° 3, *Varsovie* 1933». Les auteurs ont rappelé les méthodes de calcul en usage et présenté quelques résultats tirés d'une année et demie d'enregistrements. Les travaux sont poursuivis méthodiquement et la carte magnétique de la Baltique Polonaise sera publiée à grand échelle, dès qu'on aura pu la compléter par des mesures sur le golfe de Puck gelé.

Les données journalières de l'Observatoire de Hel seront publiées dans l'Annexe A de *l'Annuaire de l'Institut Météorologique,* dès juillet 1932. Actuellement nous envoyons régulièrement les résultats du dépouillement mensuel, sous la forme de chiffres exprimant le caractère magnétique journalier à la Commission Internationale de Magnétisme Terrestre de l'O. M. I.

Quand la situation le permettra nous comptons développer la station de Hel en y installant les enregistreurs à marche rapide de la Cour qui seront probablement prêtés à la Pologne grâce à l'extrême amabilité du Président de la Commission Internationale de l'Année Polaire. Nous installerons, également, des pavillons pour les mesures absolues. Notre programme prévoit encore des enregistrements de courants telluriques sur la ligne Gdynia-Hel et de champ électrique.

II. *Tables crépusculaires.*

J'ai fait calculer des Tables crépusculaires donnant l'altitude au Zénith des rayons rasants du Soleil pour chaque degré de latitude de l'équateur au pôle et pour chaque degré de déclinaison du Soleil. Ces tables qui embrassent donc l'ensemble du globe forment un livre de 438 pages d'un maniement facile. Elles sont destinées à simplifier les calculs de l'altitude des aurores éclairées et de contribuer à l'étude ou au dépouillement de nombreux phénomènes de météorologie optique, de transmission des ondes radioélectriques, du sondage par les parasites atmosphériques, etc., qui sont en rapport avec le coucher et le lever du Soleil ou d'une manière générale de l'altitude des rayons du Soleil pendant la nuit.

Une introduction donne tous les détails sur les procédés de calcul et modes d'emploi.

Aujourd'hui les tables crépusculaires sont imprimées pour les latitudes de 35° à 90°; le volume sera terminé probablement à la fin de cette année et on pourra l'obtenir à l'Institut National Météorologique de Pologne à Varsovie.

Lisbonne, septembre 1933.

RAPPORT DE LA COMMISSION NATIONALE POLONAISE DE L'ANNÉE POLAIRE

Par J. LUGEON

La Pologne a installé une station magnétique pour la durée de l'Année Polaire à l'Ile des Ours ($\varphi = 74° 28' 57''$, $\lambda = 19° 13' 33''$ E, alt. 29m.).

Les magnétographes ont été prêtés par la Commission Internationale de l'Année Polaire. Ce sont deux enregistreurs La Cour à marche normale et à marche rapide. Ces appareils ont été ramenés en Europe en septembre 1933, mais le pavillon très solide et bien aménagé est resté sur place ainsi que les tables et plaques de marbre et la tente pour les mesures absolues. Ces dernières ont été faites à l'aide du «Reisetheodolit d'Askania».

Pendant l'expédition on n'a pu faire qu'un petit nombre de photographies d'aurores à cause du brouillard quasi-permanent qui enveloppe l'île. Par contre, les enregistrements de parasites atmosphériques, de météorologie générale et de radiation solaire sont satisfaisants.

Un enregistreur de parasites atmosphériques (atmoradiographe) avait été installé à Nordlysobservatoriet à Tromsö où il a fonctionné pendant une partie de l'Année Polaire. Sur la demande du Prof. L. Vegard, nous avons laissé cet appareil sur place.

Une «Notice préliminaire sur l'Expédition Nationale Polonaise à l'Ile des Ours» a été publiée en langue française, par Jean *Lugeon* dans le *Bulletin de la Société géophysique de Varsovie,* fasc. 7.-8., 1933; une autre en langue polonaise dans le *Bulletin de la Société de Géographie de Pologne,* tome XIII, 1933. Ces brochures contiennent tous les renseignements nécessaires et des plans et photographies des installations.

Les résultats seront publiés par l'Institut National Météorologique de Pologne où le matériel des observations a été déposé provisoirement pour être mis à la disposition de toute personne ou organisation intéressée.

Lisbonne, septembre 1933.

RAPPORT SUR LES TRAVAUX DE L'INSTITUT DE GÉOPHYSIQUE DE L'UNIVERSITÉ DE LWOW

Par H. ARCTOWSKI

La station de Daszawa a été transférée à Janów, près de Lwów. Les coordonnées de cette nouvelle station sont approximativement 40° 54′ 30″ N et 23° 44′ 20″ E. La situation est très favorable et il est à espérer qu'on pourra, avec le temps, transformer ce poste nouveau en un observatoire géophysique permanent.

Pour le moment nous n'avons qu'un pavillon-cave où fonctionnent, depuis juillet 1933, les enregistreurs des Askania-Werke et un pavillon pour les observations absolues à l'aide des instruments de Chasselon que nous possédons.

Nous avons également un magnétomètre de Schuster pour lequel un pavillon spécial sera installé bientôt.

Avec plusieurs collaborateurs, M. H. Orkisz a également poursuivi cette année les levers détaillés de la distribution de la composante verticale à l'aide de balances de Schmidt, levers commencés en 1930. Précédemment les points d'observation étaient fixés de kilomètre en kilomètre. A présent, les réseaux sont beaucoup plus serrés de préférence suivant certains alignements. Il s'agit d'un travail de prospection des terrains pétrolifères fait en collaboration d'autres recherches géophysiques et géologiques et de forages de la Société «Pionier».

Les résultats obtenus cet été sont particulièrement intéressants, mais il est compréhensible qu'il n'y aura lieu de les faire connaître que lorsque l'ensemble du travail sera terminé.

TRAVAUX DE L'OBSERVATORIE DE SWIDER

Magnétisme terrestre

Note de M. KALINOWSKI présentée par M. GORCZYNSKI

En 1930 j'ai eu l'honneur de présenter à l'Assemblée de Stockholm un bref rapport sur le levé magnétique de la Pologne, en y joignant une carte de notre réseau et la première carte des isogones, tracée d'après les données d'observation pour l'an 1930,5. Je ne pouvais pas prévoir alors que des difficultés d'ordre financier empêcheraient la publication d'un rapport détaillé traitant l'ensemble de nos travaux magnétiques. Ce n'est que maintenant que j'ai pu achever la publication annoncée en 1930. Je viens de l'envoyer à tous les observatoires magnétiques et à tous les instituts et personnes qui peuvent s'intéresser au magnétisme terrestre. Ce volume contient un bref historique de nos études magnétiques, une description de l'Observatoire de Swider, des informations concernant nos instruments et les méthodes d'observation et de calcul que nous avons appliquées, une description de toutes nos stations, les résultats des mesures obtenus pendant toutes les excursions, un tableau des valeurs de tous les éléments magnétiques réduites à 1928,5 pour toutes nos stations au nombre de 375, et enfin les cartes des courbes isomagnétiques pour l'an 1928,5. J'ai été obligé de choisir pour la réduction l'an 1928, car c'est précisément pendant cette année-là que la plupart de nos mesures ont été faites. Le choix n'était pas heureux, parce que l'année 1928 se distinguait par une activité solaire extrême, mais les conditions de notre travail ne nous laissaent pas trop de liberté, en nous forçant de nous conformer à des conditions qui ne dépendaient pas de notre volonté. Quoi qu'il en soit, nous avons enfin construit le tableau magnétique de notre terrain; s'il n'est pas sans erreurs, celles-ci sont dues à des causes déjà citées, ainsi qu'à la difficulté de la réduction qui d'autre part provient de l'insuffisance de la connaissance des variations séculaires dans les diverses parties de notre pays. Ces défauts, s'ils existent, seront corrigés — espérons-le — par des études qui vont suivre. Les courbes isomagnétiques*) (isogones, isoclines, isodynames H) indiquent positivement l'existence d'anomalies locales dans beaucoup d'endroits de notre pays; ces auomalies font à présent l'objet d'une étude, exécutée avec beaucoup d'empressement par l'Observatoire de Swider. D'autre part, notre Observatoire a entrepris un travail assez vaste, concernant les variations séculaires des éléments magnétiques dans les diverses régions du territoire de la Pologne. Ces études se proposent de tracer une carte d'isopores qui serait basée sur les données d'observations systématiques, faites d'après un plan établi et non pas sur des suppositions. Ce travail est étroitement lié à la question de la marche séculaire des éléments magnétiques étudiée sur le globe terrestre entier, une question qui fera l'objet d'une discussion à l'Assemblée de Lisbonne dans laquelle on examinera les propositions d'une Commission spéciale, nom-

*) *Note de la Rédaction:* Les cartes ont été omises dans ce volume. Elles sont données dans les «Travaux de l'Observatoire Magnétique de Swider N 5, Warszawa 1933».

mée au Congrès de Stockholm, à laquelle j'ai l'honneur d'appartenir.

Le travail quotidien de l'Observatoire de Swider était régulier pendant ces trois dernières années, seulement les dures conditions matérielles ont causé que le personnel a été diminué (deux assistants au lieu de quatre) et que par conséquent les forces de ces travailleurs moins nombreux s'épuisaient davantage. Nous avons augmenté l'étendue de nos mesures, en ajoutant, à celles qu'on effectuait par la méthode classique, les mesures de la composante horizontale par la méthode électrique, à l'aide du magnétomètre de *Smith* (de la Maison «The Cambridge Instrument Co.») qui avait été acheté grâce à la subvention accordée à l'Observatoire par le Fonds de la Culture Nationale. La caractéristique de cet instrument et l'appréciation des résultats qu'on obtient avec lui ont été présentées au VIe Congrès des Physiciens Polonais à Varsovie en 1932. Ceux qui s'intéressent à ce sujet peuvent trouver les détails dans le compte-rendu de ce Congrès.*) Je me borne ici à constater que l'instrument est excellent dans le sens de la rapidité des mesures. Une mesure ne dure que 5 minutes; sous d'autres rapports il vaut moins que les magnétomètres classiques. Ces derniers permettent de mesurer H à $\pm$ 1γ près; avec le magnétomètre de Smith, l'erreur atteint $\pm$ 2γ. En outre il faut procéder très attentivement et prendre des précautions, car la pile normale enfermée dans le potentiomètre cause parfois des surprises fâcheuses. Nous nous basons donc en général sur les mesures exécutées par la méthode de Gauss en appliquant la méthode électrique lorsqu'il s'agit d'une orientation rapide au sujet de variations de la valeur de la composante horizontale. Nous ne traitons donc la méthode électrique que comme une méthode relative.

La crise générale des finances a placé notre Observatoire dans une situation vraiment tragique: possédant des matériaux considérables, il est trop pauvre pour pouvoir les publier. Avant l'Assemblée de Stockholm j'ai publié un volume sur les mesures de la déclinaison à Swider au cours des années 1921-1929. Les volumes contenant les valeurs de la composante horizontale et de la composante verticale devaient paraître successivement. Toutefois, les matériaux rédigés pour cette époque et les années dernières, y inclus l'an 1932, restent non publiés, ce qui nuit non seulement à nous, mais aussi à la connaissance du phénomène du magnétisme terrestre. Quelques brèves notes dans le «Terrestrial Magnetism» et dans les «Bulletins» du «Bureau Central» à De Bilt et de l'Observatoire de Greenwich parlent de notre travail, en citant les valeurs des éléments. Je ferai mon possible pour publier aussi promptement que possible les matériaux que nous possédons.

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*) Acta Physica Polonica, v. I, fasc. IV, p. 491, Varsovie, 1932.

J'ai joint à mon rapport présenté à l'Assemblée de Stockholm un tableau contenant les valeurs moyennes annuelles des éléments magnétiques à Swider et leur marche séculaire pour les années 1921-1929. Voilà ce que je puis ajouter à présent pour les années suivantes:

Valeurs moyennes annuelles des éléments magnétiques à Swider (Pologne) au cours des années 1930-1932

$\varphi = 52° 6'.9$ N $\lambda = 21° 15'.2$ E

Années	Éléments D	I	H	T	X	Y	Z
1929.5	-2° 6'.3	66° 57'.6	18507γ	47289γ	18495γ	-680γ	43517γ
1930.5	-1° 57'.3	67° 1'.1	18476	47321	18465	-630	43565
1931.5	-1° 49'.1	67° 3'.2	18463	47356	18454	-586	43608
1932.5	-1° 39'.9	67° 5'.6	18440	47374	18432	-536	43638

Marche séculaire des éléments magnétiques à Swider (Pologne) au cours des années 1930-1932

Années	Éléments D	I	H	T	X	Y	Z
1929.5							
	+ 9'.0	+ 3'.5	— 31γ	+ 32γ	— 30γ	+ 50γ	+ 48γ
1930.5							
	+ 8'.2	+ 2'.1	— 13	+ 35	— 11	+ 44	+ 43
1931.5							
	+ 9'.2	+ 2'.4	— 23	+ 18	— 22	+ 50	+ 30
1932.5							

Swider (près de Varsovie), Août, 1933.

PORTUGAL

RAPPORT DU SERVICE MÉTÉOROLOGIQUE DES AÇORES

Par J. AGOSTINHO

Rien n'a été changé au service de l'Observatoire Magnétique de San Miguel. Nous y avons installé les instruments à enregistrement rapide qui ont été mis à notre disposition par la Commission Internationale de l'Année Polaire. Ils fonctionnent depuis le mois d'Août 1932. L'enregistrement ordinaire est maintenu par des instruments Mascart.

Des mesures absolues ont été faites sur des piliers fixes à l'île de Terceira pour l'étude de la variation séculaire des éléments magnétiques. La station à Horta a été rendue inutilisable à ce but en raison des fers qu'on a dû employer dans les murs, lors de la reconstruction de l'Observatoire, après le tremblement de terre en 1926.

La station, où Thorpe avait mesuré l'inclinaison le 16 septembre 1880, a été occupée une fois de plus, le 25 Mai 1933, et les valeurs de I obtenues depuis 1880 conduisent à la loi suivante de la variation de I:

$$I\ 64{,}27 - 0{,}071\ (t - 1880).$$

La loi de la variation de I que nous avons établie, très approximativement, aussi pour notre observatoire de San Miguel est la suivante:

$$I\ 63{,}00 - 0{,}065\ (t - 1880).$$

Cette loi est basée sur des mesures absolues faites plusieurs fois par année depuis 1911.

On voit donc que I décroît plus rapidement à Terceira qu'à San Miguel, bien que les deux stations ne soient séparées que par une distance de 160 km environ.

Les deux stations sont situées sur des terrains volcaniques et les perturbations locales y sont assez importantes, comme d'ailleurs sur toutes les îles de l'archipel.

Ponta Delgada, août 1933.

SUÈDE

RAPPORT SUR LES TRAVAUX DE MAGNÉTISME ET D'ÉLECTRICITÉ TERRESTRES EN SUÈDE

Par V. CARLHEIM-GYLLENSKÖLD

Nous examinerons successivement, dans ce qui suit, ce qui est relatif au Magnétisme terrestre, à l'Aurore boréale, puis à l'Electricité des orages.

Travaux relatifs au magnétisme terrestre. — Nous nous occuperons d'abord des études de magnétisme terrestre dans la Suède continentale, en renvoyant à un Rapport spécial de M. Bouveng pour ce qui concerne les opérations auxquelles s'est livré le Service hydrographique de la marine.

Le service géologique de la Suède a continué les observations du Réseau magnétique de la Suède continentale, commencées en 1928; cinq campagnes consécutives avaient été faites pendant les étés de 1928 à 1932, la sixième campagne eut lieu en 1933.

Les travaux sur le terrain doivent être terminés en 1934. Les mesures complètes des éléments magnétiques auront alors été faites en plus de 1400 stations réparties, assez régulièrement, sur tout le territoire suédois.

Il reste ensuite à faire les calculs nécessaires pour ramener ces observations à une même époque, fixée pour le Réseau entier.

Pour étudier les variations séculaires, des mesures furent faites, à nouveau, en plusieurs endroits choisis parmi les anciennes stations.

Voici les détails des campagnes de 1931, 1932 et 1933.

Années	Observateurs	Départements	Nombre de stations	Anciennes stations
1931	M. Werner	Gävleborgs, Jämtlands, Västerbottens, Norrbottens, Västmanlands	227	32
	M. Rothstein	Västerbottens, Norrbottens, Norvège	66	1
	M. Sanner	Jämtlands, Jävleborgs, Kopparbergs	116	13
	M. von Hofsten	Jämtlands, Västernorrlands, Gävleborgs, Kopparbergs, Värmlands, Örebro, Västmanlands	108	6
		Total	517	52
1932	M. Tyrén	Örebro, Kopparbergs, Värmslands, Älvsborgs, Göteborgs et Bohus	129	60
	M. Werner	Norrbottens	129	10
1933	M. Werner	Skaraborgs, Norrbottens, Norvège	225	58
	M. Tyrén	Hallands, Jönköpings, Malmöhus, Kristianstads, Blekinge	260	102

En 1931, M. Rothstein se servit du magnétomètre et de la boussole d'inclinaison de Chasselon; M. Werner, d'un théodolite de voyage, sorti des ateliers Askania, et de la boussole d'inclinaison de Dover no. 60; M. von Hofsten, d'un théodolite de Bamberg no. 12014; M. Sanner, d'un théodolite de Bamberg no. 2312 et d'une boussole d'inclinaison de Dover no. 72.

En 1932, M. Tyrén utilisa le théodolite no. 12014, appartenant à l'Ecole de navigation (Navigationsskolan) de Stockholm, et la boussole d'inclinaison Dover no. 230, appartenant à l'Etat finlandais; M. Werner, le magnétomètre de Chasselon et la boussole d'inclinaison de Dover no. 60; M. Tyrén, le théodolite Askania et les boussoles d'inclinaison Dover no. 60 et Dover no. 230.

En 1933, M. Tyrén se servit du théodolite Askania, M. Werner utilisa le théodolite de Chasselon no. 83, pour l'intensité horizontale et la déclinaison, et la boussole d'inclinaison de Dover no. 60 pour l'inclinaison.

Grâce aux étalonnages des appareils faits aux observatoires de Lovö et d'Upsala, les résultats sont, en tous points, comparables.

Travaux des observatoires magnétiques. Les travaux d'observatoire proprement dits, relatifs au Magnétisme Terrestre, furent effectués, exclusivement, à l'observatoire d'Abisko, par 68° 21′ N et par 18° 49′ E de Greenwich, et à celui de Lovö, près Stockholm.

Le fonctionnement des observatoires pendant les trois dernières années, depuis l'Assemblée de Stockholm, a été parfaitement régulier et normal à l'exception de l'Année Polaire, où des variomètres à enregistreurs à déroulement rapide furent établis.

MAGNETIC WORK PERFORMED BY THE HYDROGRAPHIC OFFICE OF SWEDEN (KUNGL. SJÖKARTEVERKET) FROM 1930-1933

By E. BOUVENG

Survey work. The establishment of the net of magnetic repeat stations, started in 1928, and presented at the Stockholm Meeting in 1930, has been concluded. The net-work embrace 86 stations fairly evenly distributed over the whole area of Sweden. The results of this survey are now for the greatest part ready for printing, and will, probably, appear during the next year.

In 1931 and 1932 the declination at sea was examined in some supposed anomalies east of Gotland.

The swedish-finnish magnetic measurements, made in the Baltic Sea in 1925 and 1926 from the non-magnetic launch "Cecilie", were in 1932 and 1933 completed and extended through determinations of the magnetic declination at about 100 stations, mainly northwest of Gotland. These determinations were carried out from an ordinary motor boat. During these two years the older magnetic land-measurements were completed with a number of new stations.

Intercomparison of the magnetic standards. The standards of the field instruments of the Kungl. Sjökarteverket were in June 1932 at Signilskär compared with the finnish instruments.

In December 1931, and in November 1932, the Earth-inductor of the Magnetic Observatory at Lovö (Stockholm) was tested at the Magnetic Observatory at Rude Skov (Copenhagen).

The Magnetic Observatory at Lovö (Stockholm). Since the report in 1930, the observatory has continued with registering D, H and Z. During the International Polar Year, a set of the la Cour variometers for rapid registering is in function.

A temporary observatory at Lycksele. From November 1932, also, a set of the la Cour variometers for rapid registering are in function at Lycksele, Sweden. The coordinates of that temporary Polar Year observatory are: 64° 35′ 3″ N. and Long. 18° 41′ 5″ E. Gr.

Publications

Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Lovö (Stockholm) im Jahre 1929.

An attempt to determine the magnetic declination at sea on board an ordinary motor boat, by GUSTAF S. LJUNGDAHL, *K. Sjökarteverkets jordm. publ.* Nr. 8, *Hydrogr. Rev.*, Vol. X, No. 1, 52-60 (May 1933).

Being printed:

Ergebnisse der Beobachtungen des magnetischen Observatoriums zu Lovö (Stockholm) im Jahre 1930.

Note.

During the Aeroarctic Expedition of the Airship "Graf Zeppelin" in July 1931, Dr. Ljungdahl as a member of the scientific staff carried out magnetic measurements.

The results have been published in the following papers:

Preliminary report of the magnetic observations made during the Aeroarctic Expedition of the "Graf Zeppelin", 1931, by GUSTAF S. LJUNGDAHL. *Terr. Magn.*, 1931, 349-356.

Die magnetischen Arbeiten während der Arktisfahrt des Luftschiffes "Graf Zeppelin" 1931, von GUSTAF S. LJUNGDAHL, *Peterm. Mitt., Ergänzungsheft* Nr. 216, 81-87.

Stockholm, August 1933.

ÉTUDES DES DÉCHARGES ÉLECTRIQUES DANS LES ORAGES ET DES PERTURBATIONS ATMOSPHÉRIQUES CAUSÉES PAR LES ORAGES

Par H. NORINDER

Les recherches d'électricité atmosphérique en Suède pendant la période 1930-33 ont compris des études de décharges électriques dans les orages et de perturbations atmosphériques causées par les orages. Les études sont exécutées par H. Norinder dans un laboratoire, près d'Uppsala, qui appartenait à la Direction royale des Forces Hydrauliques de l'Etat de Suède jusqu'au 1er. juillet 1932. Après cette date ces études furent faites dans un institut de recherches à haute tension appartenant à l'Université d'Uppsala et placé sous la direction de H. Norinder.

Instruments et méthodes

Comme instruments principaux des recherches on se servit d'oscillographes cathodiques spécialement construits dans les ateliers du laboratoire. Dans les observations, les oscillographes furent reliés à des antennes exposées dans l'atmosphère libre. On se servit d'antennes linéaires ou d'antennes à cadre, et les arrangements expérimentaux furent spécialement disposés afin d'obtenir des observations sans distortion dans les mesures des champs électriques ou magnétiques émis par les décharges électriques des orages. On eut, également, par intercalation d'amplificateurs, la possibilité d'enregistrer exactement les variations électriques causées par des perturbations atmosphériques émises à grandes distances du lieu d'observation.

On a, dans certains cas, relié les oscillographes aux lignes à haute tension afin d'observer les surtensions causées par la foudre.

Résultats

Les résultats, que l'on avait obtenus plus tôt, ont été vérifiés et développés pendant la période 1930-33. On obtint aussi, par une étude plus détaillée, des mesures sur les variations très brusques des champs électriques dans certains types d'éclairs.

En analysant les oscillogrammes des éclairs, on identifia des décharges successives se développant l'une après l'autre dans le même canal de décharge. Ces décharges successives ont un caractère électrique similaire.

On obtint des résultats très importants par des études de perturbations atmosphériques à grande distance. Ces perturbations sont, d'après les observations, très souvent composées de variations brusques et successives du champ électrique. Les variations du champ atteignent leur valeur maxima pendant 20 à 40 microsecondes. Le résultat indique qu'il est toujours nécessaire, dans les observations exactes de perturbations atmosphériques, d'utiliser des oscillographes cathodiques, qui permettent des enregistrements à très grande vitesse.

On peut aussi noter, comme recherches d'un grand intérêt, les nouvelles mesures des variations du champ magnétique causées par des éclairs. Ces variations furent enregistrées par des oscillographes cathodiques reliés aux antennes à cadre, avec des dimensions de cadres permettant un enregistrement sans distortion de la variation du champ.

On obtint, par ces observations, une méthode de mesure des variations du courant dans les éclairs.

Changements de l'organisation

Dès le 1er. juillet 1932, l'organisation des recherches fut changée. Les recherches avaient été précédemment exécutées dans un laboratoire appartenant aux Forces Hydrauliques de l'Etat de Suède; c'est après cette date que fut fondé un institut pour des recherches à haute tension à l'Université d'Uppsala, et à cet institut fut incorporé le laboratoire mentionné ci-dessus.

Ce changement d'organisation permit d'étendre le champ d'activité et d'augmenter les ressources.

Dans le nouvel institut il fut établi, entre autres, un laboratoire à haute tension avec un équipement pour 2.5 million de volts.

L'institut a pour but de faire des recherches sur les phénomènes de décharges électriques dans l'atmosphère et leur conséquence, sous forme de différentes perturbations provoquées par les décharges dans des objets unis à la terre.

Publications 1930-33

1. Surges and Overvoltage Phenomena on Transmission Lines, Due to Lightning. The Journal of the Institution of Electrical Engineers, Vol. 68, 1930.
2. Recherches sur les surtensions des orages dans les grands réseaux de distribution. Bulletin de la Société française des électriciens, 1930, no. 6.
3. Ein besonderer Typus des Kathoden-Oscillographen. Zeitschrift für Physik, Bd. 63, 1930.
4. Measurements of Lightning Surges on Transmission Lines in Sweden. International conference of Large High tension System, no. 26, Paris 1931.
5. Die Blitzenladungen als Ursache atmosphärischer Rundfunkstörungen. Elektrische Nachrichtentechnik. Berlin, Band 9, 1932, Heft 6.
6. Recherches oscillographiques sur le mécanisme de décharge des éclairs. Congrès International d'Electricité, Paris, 1932, XIe section, rapport no. 8.

RAPPORT SUR LES OBSERVATIONS MAGNÉTIQUES ET D'AURORES BORÉALES FAITES AUX STATIONS SUÉDOISES DE L'ANNÉE POLAIRE

Par V. CARLHEIM-GYLLENSKÖLD

Station de Sveagruvan au Spitzberg. — M. Lindholm, chef de la Mission suédoise du Spitzberg pendant l'année polaire, a établi la station magnétique à Sveagruvan, dans la baie Van Mijen; M. Lindholm était accompagné de M. von Zeipel. M. Olsson a établi une station météorologique sur la Montagne de Nordenskiöld près d'Adventbay, à 1050 mètres au-dessus du niveau de la mer.

On apporta à l'observatoire de Sveagruvan un jeu d'instruments enregistreurs de Toepfer et un autre jeu emprunté à la Commission Internationale de l'Année Polaire. On installa en outre des variomètres, système la Cour, avec un enregistreur à marche rapide.

Les enregistrements de variations magnétiques furent poursuivis depuis août 1932 jusqu'en août 1933. Les enregistrements des instruments de Toepfer, à marche lente, sont presque sans lacunes, et les enregistrements à marche rapide en ont, également, très peu.

Des observations absolues ont été faites, en général, une fois par semaine. On utilisa, pour ce but, un théodolite de voyage de Lamont, appartenant à l'Université d'Upsala, et une boussole d'inclinaison de Casella, empruntée à l'Académie des sciences de Stockholm.

Des observations absolues des éléments magnétiques ont été faites aussi au Cap Thordsen où se trouvait la station suédoise pendant l'Année Polaire de 1882-1883. Ces observations ont été faites au commencement du mois d'août 1933, pour déterminer la variation séculaire pendant l'intervalle de cinquante années, 1883-1933.

On procéda à des observations d'aurores boréales visuelles et photographiques, conformément au plan de la Commission Internationale de l'Année Polaire 1932-1933.

81 dessins d'aurores boréales sur cartes célestes ont été exécutés.

Une station supplémentaire fut établie à Longyear City, à Adventbay, à 45 kilomètres de distance de la station principale, dans la direction du NW. Les deux stations ont été en communication l'une avec l'autre par radiotélégraphie. On obtint 690 plaques photographiques à Sveagruvan, et un nombre égal à Longyear City, pour servir à la détermination de la parallaxe.

Les mesures de la radiation infra-rouge entreprises par M. Lindholm, au mois de février 1933, fourniront les matériaux destinés à trancher la question de la variation de la radiation cosmique avec la latitude si, toutefois, une telle variation existe. On obtint le même degré de précision dans ces observations que dans les mesures faites à Stockholm, mais, pour avoir un résultat définitif, les enregistrements devront être répétés à Stockholm.

Travaux géophysiques à Abisko pendant l'Année Polaire août 1932-août 1933. — L'Observatoire d'Abisko (Laponie) est situé par 68° 21′ de latitude Nord et 18° 49′ de longitude Est de Greenwich. M. Corlin fut nommé observateur pour l'Année Polaire; il fut assisté par Mme Elsa Corlin.

Les enregistrements des variations magnétiques avec les appareils de Toepfer, à marche lente, furent constamment poursuivis. Pour l'Année Polaire, il fut installé un deuxième jeu de variomètres, type la Cour, avec enregistreur photographique à déroulement rapide.

Afin d'obtenir des déterminations absolues, la station est munie d'un théodolite de Lamont et d'une boussole d'inclinaison de Gambey. Le théodolite de Lamont fut échangé contre un théodolite anglais au cours de l'Année Polaire. A Abisko, où l'inclinaison est de 76 degrés, une erreur de 0′.2 dans l'inclinaison produit une erreur de 12 γ dans la composante verticale. Il vaut donc mieux déterminer la composante verticale directement par une méthode électromagnétique. C'est pourquoi on a acheté, à Cambridge Instrument Company, un magnétomètre de Dye, qu'on n'a pas encore trouvé l'occasion de monter dans l'observatoire.

A l'observatoire d'Abisko, des observations continues sur les aurores boréales ont été faites, au cours de l'hiver dernier, d'après le plan de la Commission de l'Année Polaire. Des mesures de la parallaxe furent faites, avec la station de Riksgränsen, à 33 kilomètres de distance dans la direction WNW. Les deux stations furent en communication, l'une avec l'autre, par téléphone. On y obtint un grand nombre de plaques photographiques, dont 190, à chaque station, peuvent être mesurées pour déterminer la parallaxe.

102 dessins, très détaillés, d'aurores boréales s'étendant sur le ciel entier, furent faits sur des cartes célestes.

Outre les observations de magnétisme terrestre et d'aurores boréales, M. Corlin fit aussi des observations de la radiation cosmique avec l'appareil de Steinke. Nous renvoyons, pour ces observations, aux publications originales déjà parues ou en préparation. (Corlin: Measurements of the Cosmic Ultraradiation in Northern Sweden. *Lunds Observatory Circular, No.* 6 *Mars* 25, 1932.).

OBSERVATIONS OF POLAR LIGHT ON BOARD SWEDISH STEAMERS

On the request of Statens Meteorologisk-Hydrografiska Anstalt, Polar light observations have been ordered by the Swedish-American line to be carried out at the steamers Gripsholm, Kungsholm and Drottningholm belonging to the said line.

The reports have recently been received and as regards the content the following information may be given.

The observations have been carried out according to the general program adopted by the International Polar Commission.

On M/S Gripsholm observations have been made from Sept. 23. 1932 — Aug. 5, 1933. The report contains detailed descriptions of Polar lights during 8 separate days.

On M/S Drottningholm observations have been made from Aug. 13, 1932 — Aug. 31, 1933. The report contains detailed descriptions of Polar lights during 21 separate days.

In the reports from Drottningholm and Gripsholm detailed descriptions have been given on form, southerly boarder line, colour and spectroscopic intensity. Remarks on changes and other phenomena in connection with the same are added.

The report from M/S Kungsholm is more limited on account of the reduced sailing time for the ship. Only three separate Polar lights are recorded in the report.

AÅ.

SUISSE

RAPPORT SUISSE A LA SESSION DE LISBONNE

Par P-L. MERCANTON

La période triennale qui s'achève à Lisbonne a vu en Suisse l'aboutissement heureux du vaillant effort fait par le Dr. W. Brückmann, de l'Institut fédéral de Météorologie, à Zurich, pour doter enfin notre pays de la carte magnétique qui lui faisait si fâcheusement défaut. Avec des moyens limités, mais en ne ménageant pas sa peine, le Dr. Brückmann a réalisé une oeuvre excellente, dont les Annales de l'Institut de Zurich ont publié l'essentiel: données et cartes (*Année* 1930: déclinaison; *année* 1931: inclinaison et composante horizontale). La Commission fédérale de Météorologie, appréciant l'importance du travail entrepris et désireuse d'en poursuivre le perfectionnement, a décidé le maintien de la station de variation installée par M. Brückmann à Regensberg (Zurich) pour son travail.

Le professeur Mercanton, de Lausanne, utilisant à chaque occasion les ressources que l'Association a bien voulu naguère mettre à sa disposition, a recueilli de nouveaux échantillons de basaltes tertiaires et roches similaires tant dans les Iles Féroé qu'en Islande, au cours de deux croisières (1929 et 1931) à bord du «Pourquoi-Pas» portant le Dr. Charcot à Jan Mayen et au Scoresbysund. Des prélèvements ont été faits dans les diverses assises basaltiques superposées affleurant dans certains fjords des Féroé. En général, les épanchements les plus anciens ont marqué une inclinaison *australe;* les laves plus récentes (Islande) ont indiqué le sens *boréal* de l'inclinaison qui nous est familier actuellement. (Cf. *Comptes rendus de l'Académie des Sciences;* séances du 13 avril 1931 et du 18 avril 1932).

Lausanne, 12 *septembre* 1933.

LEVÉ MAGNÉTIQUE DE LA SUISSE

Par W. BRÜCKMANN

Le levé magnétique de la Suisse, dont les Comptes-rendus des Assemblées de Prague et de Stockholm contiennent les premiers rapports, a pu être continué et achevé pendant les années suivantes. A un levé général du pays entier (25 stations à distances d'environ 40 km) exécuté en 1927 on a fait suivre des levés de détail (distances d'environ 20 km) dans les diverses parties de la Suisse. Nous avons dû répartir ces travaux sur divers étés en raison des moyens financiers annuels disponibles et parce que c'était un seul observateur qui les exécutait. Après le levé de détail du Tessin (1928) et de la Suisse occidentale (1929), on pouvait étendre en été 1930 le travail à une grande partie des autres régions du pays en occupant 66 stations situées surtout dans la région du Jura, sur le plateau suisse entre les lacs de Neuchâtel et de Constance et aux Grisons. En quelques-unes de ces stations la déclinaison seule a été déterminée, aux autres, tous les trois éléments magnétiques. En automne 1931, nous avons complété notre réseau magnétique en occupant encore 18 points de l'est de la Suisse. L'emploi d'un auto en 1930 et 1931 nous a démontré les grands avantages de cette méthode de transport qui permet d'exécuter d'une manière rationelle et économique les travaux de campagne de cette sorte.

Pour tous ces levés, nous avons utilisé le théodolite Hechelmann et la boussole d'inclinaison Brunner, qui nous ont été très aimablement prêtés par l'observatoire de Potsdam et par l'Institut de Physique du Globe à Paris. Quant à l'intensité horizontale, on a mesuré à chaque station non seulement l'angle de déviation mais aussi la durée des oscillations de l'aimant, en employant dans ce dernier but un des excellents chronographes rattrappants de la maison Ulysse Nardin au Locle (Suisse).

De nouveau, les variomètres aimablement prêtés par le Markscheide — Institut de la Technische Hochschule Aachen — et installés dans notre petite station magnétique de Regensberg près de Zurich, nous ont fourni l'enregistrement des variations pour la réduction des observations de campagne. Après l'achèvement de nos levés, nous avons pu acheter ces variomètres, de sorte qu'il nous est possible de maintenir cette modeste station. Nous espérons de bientôt pouvoir la perfectionner un peu par l'acquisition de nouveaux instruments.

Les résultats définitifs de nos levés magnétiques sont publiés — avec texte, tableaux et cartes — dans les «Annales du Bureau central météorologique suisse pour l'année 1930 (Déclinaison)» et 1931 (Intensité horizontale, intensité verticale et inclinaison). Les lignes isomagnétiques de ces cartes, valables pour le milieu de l'année 1931, montrent toutes l'influence de la distribution irrégulière des masses alpines sur la distribution du magnétisme terrestre. La grande anomalie tessinoise, annoncée déjà dans les rapports de Prague et de Stockholm, semble s'étendre le long du bord sud entier des Alpes, ce que montrent d'une manière distincte surtout les mesures magnétiques faites aux Grisons. De même nous avons déjà fait mention de l'anomalie caractéristique bipolaire qui se trouve dans la région du Lac Léman et s'étend vers les Lacs de Thoune et de Neuchâtel. Cette anomalie figure également sur les cartes magnétiques françaises. De plus, le bord nord des Alpes suisses présente quelques autres anomalies de la même sorte mais de moindre intensité et extension.

TROISIÈME PARTIE

RAPPORTS SUR DES SUJETS SPÉCIAUX

REPORT OF COMMITTEE TO CONSIDER EXISTING AND DESIRABLE DISTRIBUTION OF MAGNETIC AND ELECTRIC OBSERVATORIES AND THE BETTER COORDINATION OF WORK AND PUBLICATIONS OF EXISTING OBSERVATORIES

A special committee, to consider existing and desirable distribution of magnetic and electric observatories, as well as plans for the better coordination of observatory-work and publications of existing observatories, was appointed at the Stockholm Assembly of the Association of Terrestrial Magnetism and Electricity in August 1930. It consists of S. Chapman, D. la Cour, J. A. Fleming (Chairman), Ch. Maurain, and L. Rodés. The Committee has borne in mind in its deliberations and in the following report the economic impossibility of an ideal distribution of observatories which would be indicated from the purely theoretical desiderata. It is immediately apparent that practical economic limitations must be of primary consideration in any suggestions for additional observatories or for rearrangement of existing observatories because of the great expenses necessary not only initially for equipment and for buildings but for subsequent maintenance and publication.

There are at present in operation some 75 observatories devoting attention, in whole or in part, to terrestrial magnetism and terrestrial electricity. In 1933, forty-eight of these regularly reported the magnetic character-numbers for publication in the circular "Caractère magnétique de chaque jour", which is published quarterly under the auspices of the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization by the Institut Météorologique Royal des Pays-Bas at De Bilt. This circular has been issued with character-numbers beginning with the year 1906. Not all of these compile and publish fully the results of their continuous registrations. Of the 48 observatories contributing data to the circular of magnetic character-numbers thirty, following the recommendation of the Stockholm Assembly of our

Association in 1930, are supplying the numerical magnetic character-numbers as defined at that time. These are printed in "Caractère magnétique numérique des jours" published under the auspices of the Association of Terrestrial Magnetism and Electricity of the International Union of Geodesy and Geophysics, by the Institut Météorologique Royal des Pays-Bas at De Bilt. The first volume of this publication appearing in 1932 gives values beginning with the year 1930.

A portion of this network of existing observatories is particularly dense in Europe and thus the present world-distribution is far from being a uniform one. The large number of stations located in Europe is the result of the fact that observatory-work in terrestrial magnetism and electricity had its origin early in the nineteenth century and its earlier incentive for many years thereafter in Europe.

This intense distribution of observatories in Europe finds justification in the study of regional phenomena, as, for example, giant micro-pulsations, possible differences in diurnal-variation phenomena due to magnetic anomalies, etc. The Committee is of the impression that the investigations and accumulation of data at the European observatories possibly might be coordinated in ways which, while preventing overlapping of effort, would permit obtaining material and promoting more effective discussion of these special problems without increasing present expenses of operation. For this reason, a subcommittee of the general Committee was designated by the Chairman to consider and report any rearrangements and coordinated division of research among European observatories which might be suggested as possibly serving to advance research in terrestrial magnetism and electricity. The subcommittee designated consisted of S. Chapman, D. la Cour (Chairman), and Ch. Maurain. Its report follows the present report of the general Committee in this volume of Transactions (voir p. 115).

Accepting as axiomatic the comment made above as to practical economic limitations of distribution, the Committee believes any recommendations to increase the number of existing observatories should take account of those regions of the Earth where secular changes are unusual. It further feels, because of the necessarily sparse observatory-distribution set by existing conditions and limitations, that the Association should support and heartily recommend to all governments and organizations their active support of systematic field-work to obtain well-distributed secular-variation data to supplement those obtained from observatory-operations.

As has long been recognized, the distribution of observatories in the Southern Hemisphere is now quite inadequate for that long-time accumulation of magnetic data so necessary in world-wide discussion of the Earth's magnetic and electric phenomena. Thus, in the total of 75 existing observatories, only 10 are in the Southern Hemisphere, and even taking account of the difficult geographic limitations of the great oceanic areas in that Hemisphere their distribution is by no means as good as it might be. This is true particularly of the southern portion of the African Continent and adjoining portions of oceanic areas, which include a region of unusual secular-variation change, and of the great areas of the southeastern Pacific and the south Indian oceans.

The Committee calls attention to the substantial contribution of the Government of New Zealand which, with some assistance from interested organizations, has continued both the Christchurch (Amberley) and Apia observatories, despite the difficult economic conditions. It is recommended that the Association pass Resolutions bearing on the desirability of continuing the complete programs of both of these observatories, because of their unique locations and great importance from theoretical considerations in the world-net of observatories.

Again, below 60° south latitude, there is now only one station, namely, Orcadas, maintained these many years through the scientific zeal of the Government of Argentina, which operates in addition two other first-class observatories, namely, La Quiaca and Pilar. The Committee recommends that there be extended to the Government of Argentina and to its Meteorological Office the appreciative thanks of the Association for the continued maintenance of these observatories, and particularly of Orcadas Observatory. The last is peculiarly difficult of access and of continued operation, but the prominent part which its data must occupy in world-wide investigations justifies fully its continuance. The region below 60° is peculiarly inaccessible and difficult, and the Committee realizes that continued maintenance of observatories in Antarctica is almost hopeless. It, therefore, recommends to the Association the importance of an expression to the effect that advantage should be taken of every possible opportunity to establish, for periods of one year or more, temporary magnetic and electric observatories whenever made possible by the infrequent expeditions to that part of the world.

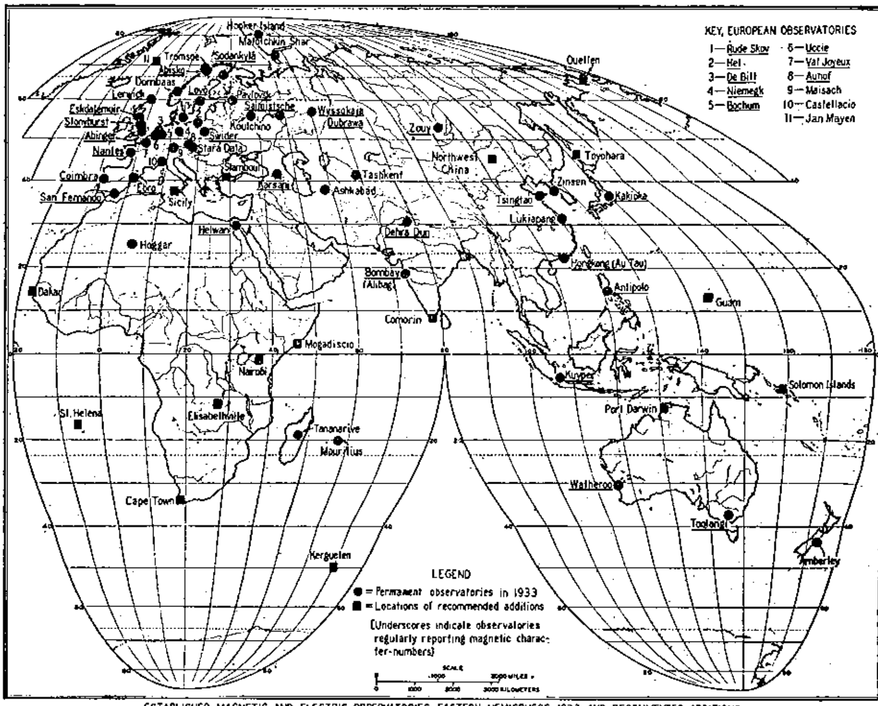
The Committee, noting the splendid success attending the International Polar Year of 1932-33 in the occupation of so many temporary stations — made largely possible through the Rockefeller Foundation's generous grant of $ 40,000 for the purchase of instruments — believes that success may make it possible to add to the permanent network of observatories. This might be done in part by continuing on a permanent basis the work at certain of the locations and in part by assigning equipment — as was contemplated when the grant was originally made by the Rockefeller Foundation — to governments and organizations which would undertake the maintenance of observatories in other desirable localities.

While the question of distribution of observatories was originally regarded as requiring utmost uniformity of distribution, it has been generally felt that magnetic phenomena in polar regions were so much more varied than in tropical regions that the equatorial belt could be satisfactorily represented by relatively few stations. Thus, for some time, efforts were concentrated toward the establishment of new stations in the polar regions. Later theoretical considerations of magnetic and electric phenomena have, however, clearly indicated that, in order to advance our knowledge of the laws and causes of the geophysical phenomena evidenced in terrestrial magnetism and electricity, attention must be given as well to the accumulation of data within the tropical and subtropical regions. The Committee feels that all interested in the Association's fields of investigation must be grateful to the Carnegie Institution of Washington, which in determining upon the locations of two observatories to be operated by its Department of Terrestrial Magnetism, anticipated this fact and placed them in the Southern Hemisphere, namely, practically on the magnetic equator at Huancayo in Peru and at Watheroo in Western Australia. Both stations are most fittingly located to test more recent developments in magnetic theory concerned with electric currents in the upper atmosphere. The startling records of Huancayo as compared with those of Batavia emphasize the needs of more and better equipped observatories in the equatorial belt. These and the results at Watheroo enhance the potential value of accumulated and continued work at Apia and point to the utmost importance of additional stations in Africa.

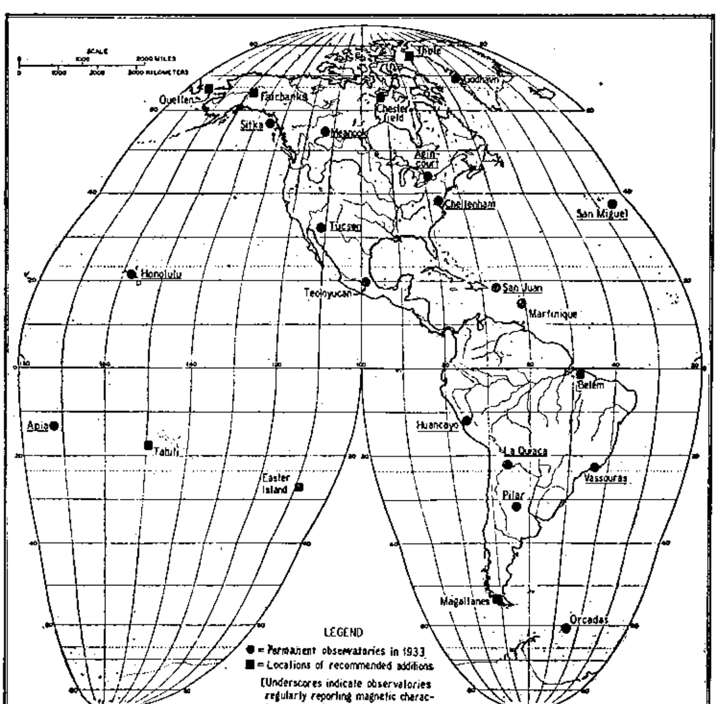
The recommendations of the Committee for establishing new stations are embodied graphically in the attached charts of the Eastern and Western Hemispheres. These show established magnetic and electric observatories and recommended additional observatories. It is to be noted, however, that of the 75 existing observatories in 1933, nine, which do not operate complete recording-equipment or make absolute observations regularly only of one or more elements, are not indicated on the two charts: Valencia (51° 56′ north, 10° 15′ west); Hermsdorf (50° 46′ north, 16° 14′ east); Beuthen-Mikilow (50° 09′ north, 18° 54′ east); Otomari (46° 39′ north, 142° 46′ east); Capodimonte (40° 52′ north, 14° 15′ east); Taihoku (25° 02′ north, 121° 31′ east); and Palau (7° 20′ north, 134° 29′ east).

Those observatories regularly functioning in 1933*) (except as above noted) are indicated by black circles. The general

*) *Note de la Rédaction:* Stations temporaires de l'Année Polaire non comprises.



ESTABLISHED MAGNETIC AND ELECTRIC OBSERVATORIES, EASTERN HEMISPHERE, 1933, AND RECOMMENDED ADDITIONS



ESTABLISHED MAGNETIC AND ELECTRIC OBSERVATORIES, WESTERN HEMISPHERE, 1933, AND RECOMMENDED ADDITIONS localities which the Committee regards as representative, not only of a desirable distribution of new stations under the limitation of practical considerations above indicated but also of the number which world-wide scientific interest and development fully justify, are shown by the black squares. It is recommended that the Association take such steps as may appropriately bring to the attention of interested governments, organizations, and individuals its considered judgment regarding (1) the establishment of all or of as many as possible of the new stations indicated on these charts, (2) the great importance to science of continuing the maintenance and operation of the existing observatories, and (3) the desirability of prompt publication of the results obtained.

The following resolutions, passed at the final general meeting of the Fifth Pacific Science Congress at Victoria, Canada, June 14, 1933, are recorded here to indicate the attitude of that body which concerns itself with scientific endeavor in the Pacific region and countries adjoining:

WHEREAS the Fifth Pacific Science Congress considers the continuation on a full program of existing observatories and the establishment on a permanent basis of additional observatories at strategic points in the countries of the Pacific Science Congress as being of the utmost importance in the study of magnetic and other geophysical phenomena, and whereas the Congress has learned with much interest of the efforts of the International Geodetic and Geophysical Union to increase the network of observatories, particularly in the Southern Hemisphere, and to have a network of designated secular-variation stations with a program of occupations for submission to all nations with a request for the cooperation of each.

RESOLVED that this Congress express the hope

(a) That the Government of the Dominion of Canada will permanently maintain the observatory established at Chesterfield Inlet for the International Polar Year 1932-33 on account of its near proximity to the north magnetic pole and being north of the aurora-zone.

(b) That the Government of Chile will continue permanently the observatory at Magallanes established for the International Polar Year 1932-33 and establish a geophysical observatory on Easter Island on account of the very urgent need of additional observatories in the Southern Hemisphere.

(c) That the Government of Japan will make permanent the magnetic observatory at Toyohara in view of its importance due to its geographical location.

(d) That the Government of the Dominion of New Zealand will continue the full geophysical program at both Apia and Christchurch-Amberley observatories, especially on account of their unique locations and on account of their importance to geophysical science.

RESOLVED further that the Congress very strongly approve of the proposed program of the International Geodetic and Geophysical Union and urges all countries in the Pacific Science Congress to cooperate as far as possible.

The Committee was hampered in its deliberations by the lack of detailed and authentic information regarding the building and instrumental equipments, the types of records, and the publication of records for existing observatories. It is recommended that the Committee be authorized to prepare and publish a new edition of a world-list of magnetic and electric observatories including such information. The "Liste des observatoires magnétiques et des observatoires séismologiques", by E. Merlin and O. Somville, was published under the auspices of the Royal Observatory of Belgium in 1910 and is now quite out of data.

The Committee suggests it may be desirable that the Association continue a like committee until the next Assembly to forward in all possible ways realization of resolutions adopted by the Association at Lisbon. Further consideration should be given to questions pertaining to the form and manner in which observatory-data are published and to possible improvements in preparing and coordinating such publications for more ready use of investigators engaged in world-wide researches.

Lisbon, Portugal, September 1933.

Jno. A. FLEMING, Chairman
For the Committee

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the Agenda for the Lisbon meeting.... (New observatories for terrestrial magnetism and electricity, by O. W. TORRESON and H. F. JOHNSTON.

REMARQUES SUR LES NOUVEAUX OBSERVATOIRES ET LES PROJETS DE CRÉATION DANS LES COLONIES FRANÇAISES

Par Henry HUBERT

Le projet d'un réseau international de stations magnétiques, au sujet duquel est demandée l'opinion du délégué du Ministère français des Colonies paraît très judicieusement établi. Il se trouve d'ailleurs en harmonie avec des intentions qui se seraient déjà entièrement matérialisées si des difficultés financières très sérieuses n'en avaient pas entravé la réalisation.

C'est ainsi que l'établissement d'une station magnétique à Madagascar, proposé dans le projet international, est déjà un fait accompli. Cette station, qui dépend de l'Observatoire de Tananarive, fournit, avec régularité et précision, tous les travaux qui lui incombent et je suis heureux de profiter de l'occasion qui m'est offerte ici de joindre mes compliments les plus sincères aux félicitations si justifiées dont le R. P. POISSON, directeur de cet Observatoire, est l'objet de la part de l'Association de Magnétisme terrestre.

Il n'y a plus à s'occuper de la station de Tananarive que pour souhaiter qu'elle puisse normalement poursuivre ses travaux. Je pense que, du point de vue matériel, elle ne rencontrera pas de difficultés, le Gouverneur Général de Madagascar ayant doté cette institution d'une subvention annuelle.

Le projet de l'Association prévoit une station aux îles Kerguelen. Or, il ne semble pas que d'ici un certain nombre d'années une telle station puisse normalement fonctionner. Il y a là une question de conditions climatiques — qui vaut a fortiori pour les îles Crozet, par exemple. Il ne semble pas, en effet, qu'on puisse envisager, d'ici longtemps, l'installation d'Européens à demeure dans ces îles. Les tentatives faites au cours des dernières années par des particuliers ont abouti à des résultats si fâcheux que le Gouvernement français ne peut sérieusement imposer là-bas un séjour permanent à ses nationaux. Il ne pourra être réalisé dans ces îles que des installations temporaires, impropres, par conséquent, au fonctionnement d'une station de magnétisme terrestre.

Si, de l'Océan Indien, nous passons à l'Océan Atlantique, nous voyons qu'un des points préconisés pour une nouvelle station est Dakar. Ce point paraît bien choisi. Il correspond à celui qui avait été envisagé par les autorités locales pour l'établissement d'une station magnétique. L'emplacement que celle-ci doit occuper est déjà déterminé sur le terrain.

Mais la Colonie, qui a été durement touchée par la crise, est amenée actuellement à porter tout l'effort de son service de physique du Globe sur la protection de la navigation aérienne. Il est donc raisonnable de ne pas escompter, avant deux ou trois ans, l'installation de cette station.

De l'autre côté de l'Atlantique, le projet de l'Association ne prévoit qu'une station, à San Juan, alors que la France est en train d'en installer une à la Martinique. Sans doute, au point de vue réseau international, cela paraît faire un peu double emploi. Mais il faut savoir que la Station Martiniquaise a comme premier objectif une étude permanente des variations magnétiques au voisinage du volcan de la Montagne Pelée, dont les éruptions sont un sujet de préoccupations de la part du Gouvernement français. Il sera d'ailleurs sans doute très facile de réaliser une entente à propos des stations de la Martinique et de San Juan, lesquelles pourront toujours au moins se prêter l'appui d'une féconde collaboration.

Reste le Pacifique. Il sera sans doute aisé d'établir, d'ici quelques années, une station en Indochine, à Phu-Lien, conformément au désir déjà exprimé par le Chef du Service Météorologique. On notera à ce sujet, qu'il existe déjà à Phu-

Lien, un Observatoire qui contribue cette année aux opérations des longitudes et une station séismologique. Quant à Taïti, qui est, si l'on peut dire, le symétrique dans l'hémisphère sud d'Honolulu, il s'y trouve déjà un excellent élément pour l'établissement d'une station de magnétisme terrestre. C'est la présence d'un jeune ingénieur-météorologiste, qui offre toutes les garanties requises pour assurer le fonctionnement d'une telle station, puisqu'il a été à Paris l'élève de M. MAURAIN. Mais l'argent manque pour l'achat des appareils et il me paraît difficile de demander à une colonie, d'ailleurs peu peuplée et peu fortunée, de consentir à une dépense qui, par son caractère de spécialisation scientifique, devrait peut-être être internationale.

Les faits prouvent qu'il est déjà malaisé, pour des Gouvernements Généraux, de réaliser sur leur territoire, et avec leurs propres ressources, des installations analogues à celles demandées par l'Association. Cela devient impossible pour des colonies comme les Etablissements français de l'Océanie.

Si l'on voulait bien ne pas leur imposer l'achat des appareils, j'ai l'impression qu'elles montreraient toute leur bonne volonté en donnant le personnel chargé des observations. Car, et c'est par là que je voudrais terminer la série de mes remarques, je suis persuadé que tous les Chefs des Colonies ont le sentiment très net de l'importance des recherches scientifiques à entreprendre dans le domaine tropical; ils sont très fiers des études qui sont poursuivies dans les territoires qu'ils administrent et ils sont tout prêts à les favoriser.

RAPPORT DE LA SOUS-COMMISSION SUR LA RÉPARTITION DES TRAVAUX D'OBSERVATOIRES EN EUROPE

Par D. la COUR

La Sous-Commission sur la répartition des travaux d'observatoires en Europe tient à souligner dès le début qu'elle a considéré la question seulement du point de vue des recherches dont les observations faites individuellement par les observatoires ne font qu'une partie, tandis qu'elle ne s'est pas du tout occupée de la question des recherches qui peuvent être faites par chaque observatoire séparément.

1. Pour préciser les idées, la Commission va exposer en peu de mots sa conception d'une organisation rationelle de la collaboration internationale; puis, la Sous-Commission fera ses propositions sur la base du travail qui se fait déjà aux observatoires, tout en ayant soin d'éviter des dépenses inutiles.

Les observatoires d'Europe doivent servir les deux buts *internationaux:*

a. faire parti du réseau mondial des observatoires magnétiques environnant le Globe et qui sert aux recherches du magnétisme et de l'électricité terrestres,
b. contribuer à l'étude des forces perturbatrices magnétiques et électriques qui s'étendent sur des parties plus ou moins vastes du globe,

et les observatoires ou leurs bureaux doivent accomplir leur participation aux travaux internationaux

a. en se chargeant de faire certaines observations,
b. en traitant ces observations selon les manières convenues,
c. en faisant imprimer certains résultats,
d. en faisant publier le plus vite possible un aperçu complet des enregistrements, des traitements et d'autres documentations disponibles à l'observatoire,
e. en envoyant, en prêt ou à prix de revient, des enregistrements ou d'autres documentations aux institutions ou aux experts qui en demanderaient des copies et qui en auraient besoin pour leurs recherches.

2. Vu les grands océans et la distribution des continents et des îles qui s'y trouvent, un réseau d'observatoires magnétiques composé de stations régulièrement réparties sur toute la terre ne présenterait que très peu d'observatoires dans toute l'Europe. Par contre, un réseau de stations plus rapprochées sur une certaine partie du globe est de grande valeur pour l'étude de bien des recherches.

3. Les stations faisant partie du réseau mondial uniforme devraient faire des observations tout à fait comparables, c'est-à-dire qu'elles soient faites par des étalons exacts ou bien comparés à d'autres, que les observations aient en vue les mêmes sujets et qu'elles soient faites avec la même exactitude et traitées selon la manière convenue.

4. Quant à l'emploi des observations et du travail fait aux observatoires, la question principale qui se pose est de savoir comment mettre *toutes* les observations, recueillies à l'observatoire, à la disposition de *tous* ceux qui désirent en faire usage pour leurs recherches. D'autre part, tout le monde et même tous les experts n'ont pas besoin de toutes les informations qu'un observatoire pourrait leur envoyer. Pour agir d'une manière rationelle, il faut donc différentier la publication des résultats en tenant compte de leur emploi. Ce ne sont alors que les données dont un grand nombre d'experts a besoin que la Sous-Commission propose d'imprimer et d'envoyer aux experts et aux archives où ceux-ci vont chercher leurs informations.

Mais la Sous-Commission recommande aussi très instamment qu'on rende possible et qu'on facilite autant que possible, à ceux qui le désireraient, de se procurer toutes les autres données et même les copies en grandeur originale de tous les enregistrements.

Il est encore à recommander chaudement que les observatoires en question prennent soin que les valeurs horaires des éléments soient portées sur des cartes Hollerith pour des traitements ultérieurs.

5. Un aperçu du contenu des annuaires magnétiques des observatoires d'Europe présente des différences assez considérables entre les publications des divers observatoires (voir page 118). La cause de ceci semble provenir de raisons un peu accidentelles, tandis que la persistance contre tout changement a son origine dans la tendance — d'ailleurs louable — des magnéticiens pour le conservatisme. La question d'une revision de l'ensemble des annuaires s'impose dans le double but: de rendre plus comparables les parties qui visent aux recherches internationales, et de recommander d'arrêter certaines parties afin de favoriser d'autres informations plus utiles aux mêmes recherches. Comme exemple de ces deux buts, mentionnons, pour le premier, qu'il serait fort désirable de pratiquer une introduction générale des indications des maxima et minima diurnes et, pour le second, d'omettre dans les annuaires imprimés les reproductions plus ou moins complètes de quelques courbes considérées intéressantes par la station, et de favoriser par là l'envoi ou le prêt de reproductions complètes à ceux qui désireraient s'en servir.

6. Pour faire des propositions définitives à ce sujet, il faut prendre des informations détaillées sur l'activité, les moyens et les ressources des divers observatoires. Ceci coïncide avec le besoin sensible de publier une nouvelle liste des observatoires magnétiques remplaçant la «Liste des Observatoires magnétiques et des Observatoires Séismologiques» dont la publication fut préparée par MM Rykatchew et Adolf Schmidt et, en 1910, achevée par MM Merlin et Somville. Les changements qui ont eu lieu depuis lors du réseau des observatoires et dans leurs moyens sont si nombreux et d'une telle importance que la publication d'une nouvelle liste s'impose. On propose que l'Association charge son Bureau Central de prendre par des questionnaires des informations sur les Observatoires magnétiques du monde entier dans le double but de s'en servir comme base pour des propositions sur la distribution du travail international et pour une nouvelle édition de la liste des observatoires.

La Sous-Commission a rédigé un projet de questionnaire, mais, vu des changements désirables, elle a préféré différer la présentation de cette proposition.

ANNEXE

Extrait du contenu des annuaires
des observatoires magnétiques européens

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
a	×	×			×	×	×					×	×			×	×	×
b	×	×		×	×	×	×	×		×	×	×	×			×	×	×
c D	×		×	×	×(W)	×	×	×	×	×	×		×				×	×
c H	×		×	×	×(N)	×	×	×		×	×		×				×	×
c Z	×			×	×	×	×	×		×			×				×	×
d	×				×	×	×	×		×		×	×		×			
e	×									×								×
f	×									×								
g	×				×	×		×(D)			×	×			×	×	×	
h	×					×												
i	DH ZX YI		DH	DH XY ZI	DI HN WZ	D H Z	DH ZI	D H Z		D H Z	DH	X Y Z	DH ZN EI			×		×
k	×		DH	×	×	×				DH ZX Y		X Y Z				×	×	
l	×				×	×						×						
m	×				×	×						×						
n	×		×		×	×						×						×
o	×				×	×												
p	×			×	×	×						×						
q	×		×		×													
r	×		×								×	×					×	×
s					×	×												
t				×	×	×	×			×			×			×	×	
u												×						
v																		×

a moyennes mensuelles et annuelles
b observations «absolues»
c valeurs horaires (instantanées ou moyennes)
d moyennes diurnes
e moyennes mensuelles: «jours calmes»
f – – : «jours troublés»
g maximum et minimum
h amplitude diurne (valeurs inst. ou horaires)
i marche diurne: tous les jours
k – – : «jours calmes»
l – – : «jours troublés»
m moyennes mensuelles de la marche diurne
n analyse harmonique
o «non cyclic change»
p amplitude
q tableau des perturbations
r reproductions
s température
t caractère magnétique des jours
u activité
v litérature

1 Abinger
2 Cahirciveen
3 Coimbra
4 De Bilt
5 Eskdalemuir
6 Lerwick
7 Lovø
8 Nantes
9 Prague
10 Rude Skov
11 San Fernando
12 Seddin (Niemegk)
13 Sodankylä
14 Stara Dala
15 Stonyhurst
16 Swider
17 Tortosa
18 Val Joyeux

REPORT OF THE SPECIAL COMMITTEE ON MAGNETIC SECULAR-VARIATION STATIONS

Coast and Geodetic Survey, Washington, D. C.,
August 7, 1933.

Dr. John A. Fleming, President,
International Association of Terrestrial Magnetism and Electricity,
5241 Broad Branch Road, Washington, D. C., U. S. A.

My dear Sir:

I submit herewith the report of the special committee on magnetic secular variation which includes: 1. Tentative plan submitted by committee*). 2. Maps of both hemispheres showing position of proposed stations*). 3. Reprints of articles related to the subject*). 4. Copies of letters from five members of the committee with comments on the proposed plans. 5. Suggested resolutions to be considered at Lisbon*).

As chairman of the committee, I call attention to certain comments by members of the committee and present a review of the situation as follows:

S. *Chapman* makes practical suggestions as to the obtaining of observations in Persia and Tristan de Cunha.

H. *Kalinowski* calls attention to the need for a resolution regarding the continuation of magnetic repeat observations by the various governments.

H. P. L. *Jolly* calls attention to the possibility of obtaining the desired observations from relatively unskilled observers. He admits that suitable instruments for the purpose will have to be developed.

J. A. *Fleming* states that the Department of Terrestrial Magnetism of the Carnegie Institution of Washington will as heretofore make such observations as available funds permit in countries where the governments are unable to make such observations. He mentions proposed observations in Africa and China. He also calls attention to need for replacing the CARNEGIE.

E. *Mathias* approves the list in principle, but is pessimistic over the possibility of carrying through the plan in view of the world economic situation.

With this last viewpoint in mind, it appears desirable to appraise the present situation. The proposed number of stations is

*) 1) Voir p. 120-133; 2) voir p. 134; 3) voir p. 135; 5) voir p. 135-136.

not large and many of them are provided for. Europe, on account of its large numbers of observatories, needs few if any additional repeat stations. North America is not in this fortunate condition, but existing arrangements will take care of the situation nearly as well. South America presents a more difficult problem, but in addition to work by governments the Carnegie Institution of Washington has recently completed the occupation of a considerable number of magnetic repeat stations. The situation in Africa is not unfavorable. In Asia it can be assumed that needs will be met in India, Japan and the U. S. S. R. Definite plans have been made for China.

In Oceania, Australia and New Zealand there are places where the needs are met, but definite lack of meeting the needs in others.

It will be seen that, while the situation is not wholly unfavorable, there are many gaps and the importance of and difficulty in filling these must not be minimized. The existence of these gaps is the chief reason for the existence of the committee. The adoption of a definite plan seems essential to the solution of this problem.

Proposed resolutions are attached.

Very truly yours,

N. H. HECK, *Chairman,*
Special Committee on Magnetic Secular-Variation Stations.

TENTATIVE LIST OF INTERNATIONAL REPEAT-STATIONS FOR CONSIDERATION BY THE SPECIAL COMMITTEE ON MAGNETIC SECULAR-VARIATION STATIONS

(1) The special committee is charged with the duty of suggesting plans for bringing about the occupation, at suitable intervals, of magnetic secular-variation stations to meet the needs of world-wide studies.

(2) The committee has available for a starting point the "Proposed Tentative List of International Repeat-Stations" presented by Mr. Jno. A. Fleming at the Stockholm meeting of the International Geodetic and Geophysical Union, an article on the same subject by Mr. Fleming in the September (1932) number of the *Journal of Terrestrial Magnetism and Atmospheric Electricity,* and reproductions of several maps in the article on

a larger scale, which are enclosed herewith. The list presented by Mr. Fleming has been brought up to date and modified. There are several points to be considered.

(3) A continuously operating magnetic observatory is the best possible repeat-station and for a region such as Europe where such stations are not far apart, very few additional repeat-stations are needed, and suggestions from members of the committee as to further needed stations are desired and invited.

(4) The exact scheme of suggested repeat-stations is not important in the case of such countries as the United States and Canada, which, in spite of the fact that their magnetic observatories are far apart, regularly occupy many more repeat-stations at frequent intervals than covered in the suggested list.

(5) There are extensive areas where magnetic secular-variation work has not as yet been carried on by the governments of the countries concerned or is inadequate to meet all the needs. In many such areas much work of this character has been done by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. In view of the fact that this organization has maintained adequate secular-variation repeat-observations in such regions, it undoubtedly has the best view of what is desirable and possible in the future.

(6) While the special committee cannot make specific recommendations as to the future secular-variation observations on the oceans, since this problem apparently cannot be solved until some means is found of carrying on the work formerly done by the *Carnegie,* its report may well stress the urgent need for this work and, if possible, suggest means. The members of the committee are invited to send suggestions. Consideration should also be given to the question of the reoccupation of repeat-stations at remote oceanic islands heretofore visited only by the *Carnegie.* In fact the committee may well consider means of occupation of repeat-stations on other isolated islands which, although difficult of access, are so situated as to make them important locations for secular-variation stations even though there may not now be record of previous observations at them; some such places are designated in the list by an asterisk (*).

(7) In the case of countries of large extent which do not adhere to the Union, the suggestions as to possible stations are included only because it is necessary to treat the Earth as a whole.

(8) Attention of the committee is called to the valuable feature of Mr. Fleming's paper, also brought out in the maps,

that distribution need not be uniform but that preferably there be more repeat-stations in the vicinity of foci (see pp. 280-292, *Comptes Rendus de l'Assemblée de Stockholm).* It is for this reason that the distribution of proposed stations in the tentative list and accompanying maps is more concentrated in such regions as central and south Africa and South America than in Australia and China for example.

(9) The committee also may well consider methods of maintaining repeat-observations with successive exact reoccupations in spite of loss of individual stations through the encroachment of buildings, electric car-lines, etc. Referring again to the work of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, the plan followed by this organization has been to occupy, in addition to a main station in a given region, one or even two supporting stations in order to insure an exact future reoccupation at one or the other of the group. As represented on the map, larger circles enclosing pairs of proposed stations indicate places where this practice has been followed.

(10) A number of dates are given indicating the years within which observations have been made, though no attempt has been made to include all available occupations. Since there are few regions of any considerable extent for which isopors may be drawn corresponding to an epoch earlier than the beginning of the present century but few dates earlier than that time have been included. With the exception of the United States and Canada, the dates given are those of occupations by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, those by other organizations being placed in parentheses. Those in the United States (including Alaska) are by the United States Coast and Geodetic Survey, a few by the Carnegie Institution of Washington being indicated by references to a foot-note and those in Canada are from observations by Canadian observers, either the Topographical Survey of Canada, or the Dominion Observatory, the few by the Carnegie Institution of Washington and the United States Coast and Geodetic Survey being indicated by similar references.

TENTATIVE LIST OF INTERNATIONAL REPEAT-STATIONS

Continent and country	Station	Latitude	Longitude	Remarks re occupations**
		° ′	° ′	
Africa				
Abyssinia	Addis Abeba	9 02 N	38 47 E	1914, 1918, 1921
Algeria	Algiers	36 48 N	3 02 E	1912, 1922
	Touggourt	33 08 N	6 05 E	1912, 1922
Anglo-Egyptian Sudan	Khartum	15 36 N	32 33 E	(1911), 1917
	Wadi Halfa	21 56 N	31 21 E	(1911), 1918
	Port Sudan	29 37 N	37 12 E	1911, 1914, 1918
Angola	Loanda	8 49 S	13 14 E	1914, 1915, 1916, 1920, 1927
	Benguela	12 34 S	13 24 E	1915, 1920
	Moxico	11 51 S	20 04 E	1920, 1927
Belgian Congo	Stanleyville	0 31 N	25 11 E	1914
	Leopoldville	4 20 S	15 14 E	1914, 1916, 1927
	Lusambo	4 58 S	23 26 E	1914, 1927
	Ma tadi	5 52 S	13 06 E	1914, 1920, 1927
	Kabolo	6 03 S	26 56 E	1914
	Elisabethville	11 40 S	27 39 E	1914, 1920
Cameroun	Douala	4 02 N	9 43 E	1915, 1919
Egypt	Helwan	29 52 N	31 20 E	(Observatory)
Eritrea	Massaua	15 36 N	39 27 E	1911, 1914, 1918, (1924), (1926)
French Equatorial Africa	Fort Lamy	12 06 N	15 02 E	(1908), 1917, 1919, 1927
	Bangui	4 22 N	18 35 E	1916, 1927
	Libreville	0 23 N	9 27 E	(1895), 1916, 1927
French Somaliland	Jibuti	11 34 N	43 09 E	1914, 1918, 1921
French West Africa	Timbuctu	16 46 N	356 58 E	1913, 1926
	Dakar	14 42 N	342 34 E	(1897),1912, 1913, 1925
	Koulikoro	12 53 N	352 28 E	1913, 1926
Gold Coast Colony	Kumasi	6 41 N	358 26 E	1914, 1926
Kenya Colony	Kisumu	0 06 S	34 45 E	1909, 1921,
	Nairobi	1 17 S	36 49 E	1909, 1921, 1931
	Mombassa	4 03 S	39 41 E	1909, 1921
Liberia	Cape Palmas	4 22 N	7 44 E	(1889), 1912, 1919, 1926,
Morocco	Mogador	31 32 N	350 16 E	1912, 1925
Mozambique	Mozambique	14 55 S	40 45 E	(1906), 1920
	Chinde	18 35 S	36 28 E	1909, 1920
	Beira	19 49 S	34 51 E	(1903), (1906), 1920, 1930

** The entry I. P. Y. refers to International Polar Year station for 1932—1933.

Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
Africa (continued)				
Nigeria	Kano	12 01 N	8 33 E	1914, 1926
	Lagos	6 27 N	3 24 E	1913, 1914, 1915, 1926
Rhodesia	Victoria Falls	17 56 S	25 51 E	(1904), 1909, 1920, 1930
	Bulawayo	20 09 S	28 36 E	(1898), (1904), 1909, 1930
Sierra Leone	Freetown	8 30 N	346 44 E	1911, 1912, 1925
Somaliland (Italian)	Mogadiscio	2 00 N	45 10 E	I. P. Y. 1932–33
	Kismayo	0 22 S	42 33 E	(1910), (1926)
South Africa	Mafeking	25 52 S	25 40 E	(1903), (1906), 1909, (1911), 1930
	Gingindhlovu	29 02 S	31 25 E	(1903), 1908, 1916, 1928
	Upington	28 28 S	21 15 E	(1904), 1916
	Bloemfontein	29 07 S	26 12 E	(1903), 1916, 1928
	Matjesfontein	33 14 S	20 36 E	(1899), (1900) (1904), (1905), (1906), (1912), 1908, 1928, 1930
	Grahamstown	33 20 S	26 32 E	(1902), 1928
	East London	33 00 S	27 56 E	(1902), (1911), 1928
	Cape Town	33 56 S	18 29 E	(Numerous), 1916, 1920, 1926 I. P. Y. 1932–33
Southwest Africa	Otavi	19 38 S	17 30 E	1909, 1929
	Swakopmund	22 41 S	14 32 E	1909, 1916, 1929
	Keetmanshoop	26 35 S	18 04 E	1909, 1916, 1929
Tanganyika	Tabora	5 02 S	32 49 E	1909, 1921
	Dar es Salaam	6 50 S	39 18 E	1909, 1921
Uganda	Wadelai	2 42 N	31 35 E	1909
	Entebbe	0 04 N	32 28 E	1909
Asia				
Arabia and Mesopotamia	Baghdad	33 20 N	44 26 E	1910, 1928
	Basra	30 32 N	47 49 E	1909
	Jidda	21 28 N	39 11 E	(1895), 1911, 1918, 1922
	Aden	12 47 N	44 59 E	1909, 1911, 1914, 1918, 1921
	Mascat	23 38 N	58 35 E	(1906), 1911
Asiatic Russia (Siberia)	(Note: The Carnegie Institution of Washington has made but few observations in this country, but the following list is included as desirable locations, most of which have been frequently occupied in the past by various observers.)			
	Yakutsk	62 05 N	129 40 E	(Proposed observatory)
	Krasnoyarsk	56 08 N	93 00 E	
	Omsk	55 00 N	73 38 E	
	Nikolevsk	53 08 N	140 44 E	
	Irkutsk	52 28 N	104 02 E	(Observatory)
	Chita	52 02 N	113 30 E	
	Khabarovsk	48 29 N	135 04 E	

Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
Asia (continued)				
Asiatic Russia (Siberia)	Zaisansk	47 28 N	84 53 E	(Proposed observatory)
	Vladivostock	43 11 N	131 53 E	(Proposed observatory)
	Tashkent	41 20 N	69 18 E	1909, (proposed observatory)
	Kazalinsk	45 46 N	62 06 E	1909
	Askabad	37 57 N	58 24 E	1909, (proposed observatory)
Baluchistan	Nushki	29 33 N	65 59 E	1928
China	Kalgan	40 51 N	114 51 E	(1868), 1915, 1916, 1922, 1932
	Peking	39 57 N	116 25 E	1907, 1909, 1916, 1922, 1932
	Liangchowfu	37 57 N	102 45 E	1909, 1916
	Tsingtao	36 04 N	120 19 E	(Observatory)
	Sianfu	34 16 N	108 57 E	1909, 1916, 1932
	Lukiapang	31 19 N	121 02 E	(Observatory)
	Hangkow	30 37 N	114 20 E	(1898), (1903), 1907, 1916, 1922
	Chungking	29 33 N	106 33 E	1916
	Foochow	26 02 N	119 19 E	1906, 1917
	Yunnan	25 05 N	102 05 E	1911, 1917
	Mengtsze	23 28 N	103 25 E	1911, 1917
	Hongkong	22 19 N	114 10 E	(Observatory)
Chosen (Korea)	Zinsen	37 30 N	126 38 E	(Observatory)
India, Farther India and Siam	Dehra Dun	30 19 N	78 03 E	(Observatory)
	Benares	25 15 N	82 59 E	1928
	Karachi	24 49 N	67 02 E	1911
	Barrackpore	22 46 N	88 22 E	(Observatory discontinued)
	Hanoi	21 03 N	105 50 E	1911
	Toungoo	18 56 N	96 27 E	(Observatory discontinued)
	Alibag	18 38 N	72 52 E	(Observatory)
	Hue	16 26 N	107 12 E	1911
	Lophburi	14 48 N	100 37 E	1911, various 1916–1926
	Phantiet	10 58 N	108 05 E	1912, 1923
	Saigon	10 48 N	106 47 E	1912, 1924
	Kodaikanal	10 14 N	77 28 E	(Observatory)
	Colombo	6 58 N	79 52 E	1911, 1918, 1920
	Singapore	1 16 N	103 49 E	(1904), 1914, 1918, 1921, 1923
Persia	Teheran	35 40 N	51 22 E	1908, 1928
	Kerman	30 18 N	57 07 E	1908
Turkey and Syria	Angora	39 57 N	32 48 E	1910
	Aleppo	36 13 N	37 19 E	1910, 1922, 1928
Australasia				
Australia	Thursday Island	10 34 S	142 13 E	1912, 1913, 1915, 1923
	Darwin	12 27 S	130 50 E	1912, 1914, 1923
	Derby	17 18 S	123 38 E	1914, 1921
	Townsville	19 15 S	146 50 E	1912, 1913, 1923
	Port Hedland	20 19 S	118 35 E	1914, 1921
	Cloncrurry	20 42 S	140 30 E	1913, 1923

Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
Australasia (Continued)				
Australia	Rockhamptom	23 22 S	150 30 E	1913, 1914, 1922
	Alice Springs	23 41 S	133 54 E	1912
	Charleville	26 34 S	148 48 E	1913, 1922
	Meekatharra	26 35 S	118 30 E	1912, 1914
	Brisbane	27 27 S	153 02 E	1913, 1914, 1922
	Oodnadatta	27 33 S	135 28 E	1911, 1912, 1923
	Geraldton	28 47 S	114 37 E	1912, 1921
	Watheroo	30 19 S	115 53 E	(Observatory)
	Coolgardie	30 57 S	121 11 E	1912, 1914, 1922
	Ceduna	32 08 S	133 36 E	1911, 1923
	Port Augusta	32 30 S	137 46 E	1914, 1923
	Sydney (Red Hill)	33 45 S	151 04 E	1906, 1913, 1916, 1921
	Albany	35 01 S	117 55 E	1912, 1914, 1916
	Toolangi	37 33 S	145 29 E	1920, (observatory)
	Hobart (Tasmania)	42 52 S	147 21 E	1914, 1923
New Zealand	Auckland	36 52 S	174 46 E	1906, 1922
	Christchurch	43 32 S	172 37 E	(Observatory)
	Clinton	46 13 S	169 26 E	(1899), 1916, 1922
Europe	Spitsbergen	78 25 N	18 00 E	. . . .
	Matochkin Shar	73 16 N	56 14 E	(Observatory)
	Sodankylä	67 22 N	26 29 E	(Observatory)
	Archangel	64 32 N	40 30 E	(Weinberg's catalog)
	Bergen	60 24 N	5 24 E	
	Lerwick	60 08 N	358 49 E	(Observatory)
	Pavlovsk	59 41 N	30 29 E	(Observatory)
	Stockholm (Lovö)	59 20 N	18 10 E	(Observatory)
	Katharinenburg	56 50 N	60 38 E	(Observatory)
	Rude Skov	55 51 N	12 27 E	(Observatory)
	Kazan	55 50 N	48 51 E	(Observatory)
	Koutchino	55 46 N	37 58 E	(Observatory)
	Eskdalemuir	55 19 N	354 48 E	(Observatory)
	Stonyhurst	53 51 N	357 32 E	(Observatory)
	Potsdam (Seddin)	52 23 N	13 04 E	(Observatory)
	Swider	52 06 N	21 15 E	(Observatory)
	De Bilt	52 06 N	5 11 E	(Observatory)
	Valencia	51 56 N	349 45 E	(Observatory)
	Kursk	51 42 N	31 11 E	Region near magnetic anomaly
	Bochum	51 29 N	7 14 E	(Observatory)
	Kew	51 28 N	359 41 E	(Observatory)
	Uccle	50 48 N	4 21 E	(Observatory)
	Prague	50 05 N	14 25 E	(Observatory)
	Val Joyeux	48 49 N	2 01 E	(Observatory)
	Munich	48 09 N	11 37 E	(Observatory)
	O' Gyalla	47 53 N	18 12 E	(Observatory)
	Nantes	47 15 N	358 26 E	(Observatory)
	Odessa	46 26 N	30 46 E	(Observatory discontinued)

Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
Europe (continued)				
	Astrakan	46 23 N	48 03 E	(Weinberg's catalog)
	Pola	44 52 N	13 51 E	(Observatory)
	Tiflis (Karsani)	41 43 N	44 48 E	(Observatory)
	Rumeli Hissar (Stamboul)	41 05 N	29 05 E	1908, 1909, 1910, 1911, 1922
	Capodimonte	40 52 N	14 15 E	(Observatory)
	Ebro (Tortosa)	40 49 N	0 31 E	(Observatory)
	Coimbra	40 12 N	351 35 E	(Observatory)
	Athens (Kephisia)	38 05 N	23 51 E	1911, 1922
	San Fernando	36 28 N	353 48 E	(Observatory)
North America Alaska[1]	Point Barrow	71 23 N	203 33 E	(Oglamie polar station) I. P. Y. 1932–33
	College-Fairbanks	64 51 N	212 16 E	1918, 1928, I. P. Y. 1932–33
	St. Michael	64 51 N	197 59 E	1898, 1900, 1908, 1921
	Seward	60 06 N	210 34 E	1905, 1912, 1918, 1929
	Sitka	57 03 N	224 40 E	(Observatory)
	Dutch Harbor	53 54 N	193 30 E	1900, 1903, 1908, 1910, 1911 1913, 1915a, 1925
	Kiska	51 59 N	177 32 E	1904
Canada (Newfoundland and Labrador)[2]	Dawson	64 04 N	220 34 E	1907a, 1908b, 1912b
	Chesterfield Inlet	63 18 N	269 08 E	I. P. Y. observatory 1932–1933
	Port Burwell	60 25 N	295 08 E	1884, 1909, 1912, 1914a, 1922a 1923
	Fort Churchill	58 48 N	265 48 E	1908, 1910, 1912, 1923
	Chippewyan	58 43 N	248 51 E	1888, 1910, 1922, 1931
	York Factory	57 00 N	267 34 E	1884, 1908, 1912, 1923
	Meanook	54 37 N	246 39 E	(Observatory)
	Prince Rupert	54 15 N	229 30 E	1915, 1919, 1924, 1927
	The Pas	53 49 N	258 37 E	1908a, 1918, 1919, 1922, 1927, 1930
	Battle Harbor	52 16 N	304 25 E	1905, 1914
	Fort Albany	52 22 N	277 22 E	1913a, 1929
	Banff	51 11 N	244 27 E	1907a, 1908, 1911, 1918, 1919, 1922, 1927, 1930
	Winnipeg	49 53 N	262 51 E	1906a, 1908a, 1910, 1913, 1915, 1918, 1919, 1927
	Vancouver	49 18 N	236 53 E	1898, 1908, 1915, 1920, 1927
	Fort William	48 24 N	270 46 E	1902, 1906a, 1907, 1910, 1913a 1916, 1918
	Riviere du Loup	47 50 N	290 27 E	1906a, 1912, 1918, 1920, 1926, 1931
	St. Johns N. F.	47 34 N	307 18 E	1905a, 1909a

[1] All occupations by the United States Coast and Geodetic Survey except those followed by (a), which are by the Department of Terrestrial Magnetism.

[2] All occupations by the Topographical Survey of Canada or the Dominion Observatory except those followed by (a) which are by the Department of Terrestrial Magnetism and (b) by the United States Coast and Geodetic Survey.

Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
North America (continued)				
Canada (Newfoundland and Labrador)	Sydney	46 09 N	299 48 E	1905a, 1909a, 1914a, 1923a, 1925
	Agincourt	43 47 N	280 44 E	(Observatory)
Central America	Belize	17 28 N	271 49 E	1907, 1909, 1923
	Guatemala	14 38 N	269 30 E	1909, 1923, 1926
	Managua	12 16 N	273 44 E	1909, 1923
	San José	9 57 N	275 54 E	1907, 1923, 1931
	Colon	9 21 N	280 03 E	1905, 1907, 1908, 1909, 1912 1915, 1916, 1921, 1922, 1926
Mexico	Guaymas	27 55 N	249 08 E	(1881), 1906, (1923), 1924
	Monterrey	25 40 N	259 40 E	1907, (1922), 1924
	Mazatlan	23 11 N	253 35 E	(1907), (1923), 1924
	Tampico	22 16 N	262 08 E	(1907), 1924
	Teoloyucan	19 45 N	260 49 E	(Observatory)
	Merida	20 58 N	270 24 E	(1907), 1924
	Oaxaca	17 04 N	263 16 E	1907, 1924
United States[3]	Seattle, Wash.	47 40 N	237 42 E	1900-1922 various, 1930
	Glendive, Mont.	47 07 N	255 18 E	1896, 1906, 1916, 1921, 1926 1929
	Marquette, Mich.	46 33 N	272 38 E	1902, 1904, 1908, 1922, 1927, 1932
	Eastport, Maine	44 55 N	293 00 E	1906, 1909, 1910, 1916, 1919, 1925, 1929
	Burlington, Vt.	44 28 N	286 48 E	1898, 1905, 1910, 1914, 1919, 1925, 1929
	Roseburg, Ore.	43 13 N	236 38 E	1908, 1930
	Yankton, S. D.	42 53 N	262 37 E	1896, 1905, 1909, 1912, 1916, 1922, 1929
	Providence, R. I.	41 46 N	288 32 E	1855, 1904, 1916, 1919, 1925, 1929
	Cleveland, Ohio	41 29 N	278 24 E	1900, 1907, 1910, 1921, 1928
	Ogden, Utah	41 13 N	248 00 E	1905, 1910, 1915, 1917, 1923, 1930
	Golden, Colo.	39 45 N	254 48 E	1913, 1927
	Baldwin, Kans.	38 47 N	264 50 E	(Observatory discontinued), 1918, 1929
	Cheltenham, Md.	38 44 N	283 10 E	(Observatory)
	San Francisco, California	37 49 N	237 38 E	1905a, 1908a, 1916a, 1919, 1921a, 1923, 1926, 1929a, 1930, 1933
	Bristol, Va.	36 36 N	277 50 E	1906, 1910, 1915, 1921, 1925a, 1928, 1933
	Amarillo, Tex.	35 13 N	258 09 E	1902, 1910, 1914, 1917, 1922, 1927, 1930, 1933
	Corinth, Miss.	34 55 N	271 29 E	1905, 1909, 1914, 1917, 1921, 1928
	Wilmington, N.C.	34 13 N	282 04 E	1891, 1898, 1921, 1924

3) Occupations all by the United States Coast and Geodetic Survey except those marked (a), which are by the Department of Terrestrial Magnetism.

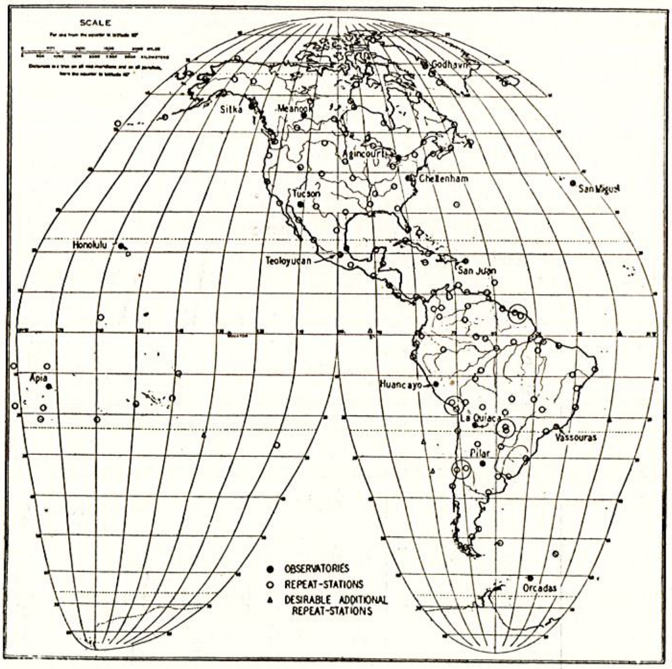
Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
North America (continued)				
United States	San Diego, Cal.	32 43 N	242 48 E	1905a, 1906a, 1907, 1908, 1912, 1922, 1930
	Brookhaven, Miss.	31 35 N	269 33 E	1901, 1905, 1908, 1914, 1918 1922, 1929, 1932
	Tucson, Ariz.	32 15 N	249 10 E	(Observatory)
	El Paso, Tex.	31 48 N	253 34 E	1895, 1905, 1910, 1914, 1922, 1925, 1927
	Waycross, Ga.	31 14 N	277 37 E	1905a, 1908, 1915, 1917, 1922a, 1925a, 1929, 1932
	Austin, Texas	30 16 N	262 14 E	1901, 1906, 1908, 1912, 1915, 1922, 1930
	Fort Lauderdale, Florida	26 06 N	259 53 E	1920, 1932
South America				
Argentina	La Quiaca	22 07 S	294 25 E	(1913), 1917, 1923, 1926, 1932, (observatory)
	Tucuman	26 51 S	294 46 E	(1908), (1913), 1917, 1923
	Corrientes	27 29 S	301 10 E	(1904), (1912), 1913, 1925
	Pilar	31 40 S	296 07 E	1911, 1913, 1917, 1923, 1926, 1932
	Mendoza	32 54 S	291 08 E	(1904), (1908), (1912), (1914), 1917, 1926, 1932
	Mercedes	34 40 S	300 33 E	(1904), (1912), 1917, 1919, 1925, 1932
	Bahia Blanca	38 47 S	297 44 E	(1904), (1908), (1913), 1917, 1919, 1925, 1932
	Puerto Deseado	47 46 S	294 05 E	(1913), 1919, 1925, 1933
	Santa Cruz	50 01 S	291 30 E	(1913), 1919, 1925, 1933
Bolivia	La Paz	16 31 S	291 47 E	1912, 1914, 1917, 1923, 1924, 1932
	Guayaramerin	10 48 S	294 41 E	1911, 1914, 1917, 1924, 1932
	Santa Cruz	17 47 S	296 26 E	1914
Brazil	Santa Isabel	0 25 S	294 58 E	1913, 1924, 1932
	Barcellos	0 58 S	297 07 E	1913, 1924, 1932
	Pinheiro	1 18 S	311 31 E	(1903), 1910, 1911, 1914, 1915, 1918, 1919, 1923, 1931
	Obidos	1 46 S	304 08 E	1911, 1918, 1923, 1932
	Sao Luiz de Maranhao	2 30 S	315 43 E	(1903), 1923
	Manaos	3 08 S	300 00 E	(1903), 1910, 1911, 1913, 1914, 1917, 1918, 1924, 1932
	Alcobaça	3 45 S	310 19 E	1915, 1923
	Pernambuco	8 04 S	325 07 E	(1903), (1907), 1913, 1919, 1923, 1931
	Porto Velho	8 46 S	296 05 E	1911, 1914, 1917, 1924, 1932
	Joazeiro	9 24 S	319 29 E	(1911), 1923
	Guayara Mirim	10 49 S	294 41 E	1911, 1914, 1917, 1924, 1932
	Bahia	13 00 S	321 29 E	(1904), 1913, 1917, 1919, 1925, 1931

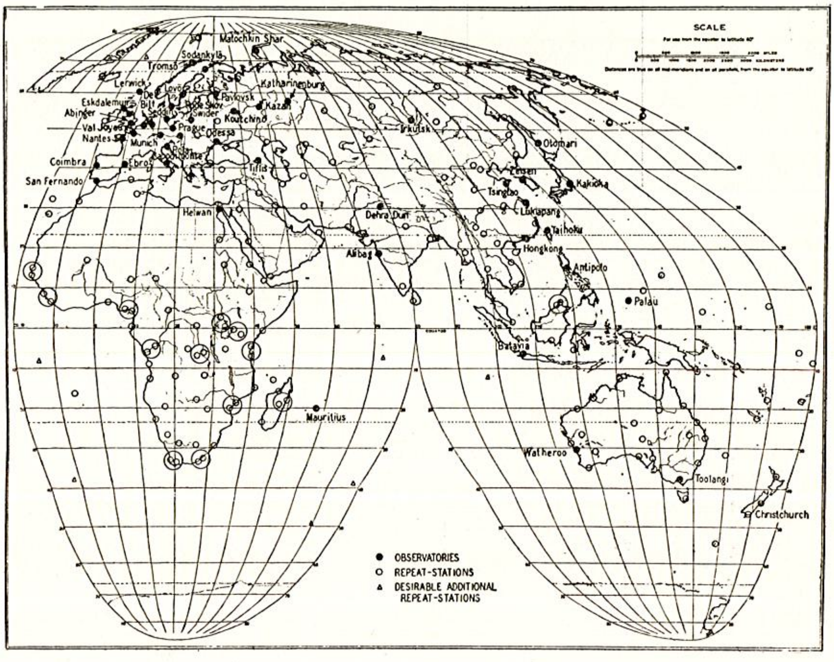
Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
South America (continued)				
Brazil	Cuyaba	15 36 S	303 54 E	(1904), 1925
	Goyaz	15 57 S	309 52 E	1915, 1925, 1933
	Caravellas	17 44 S	320 47 E	(1904), 1923
	Catalao	18 11 S	312 07 E	1915, 1925, 1933
	Corumba	19 00 S	302 21 E	(1904), (1912), 1913, 1914, (1923), 1925
	Santos	23 58 S	313 36 E	(1904), 1923, 1925
	Porto Alegro	30 02 S	308 46 E	(1904), 1914, 1923, 1925
	Vassouras	22 24 S	316 21 E	(Observatory)
Chile	Arica	18 29 S	289 40 E	1913, 1914, 1917, 1924, 1932
	Antofagasta	23 39 S	289 38 E	1912, 1917, 1925, 1932
	Valparaiso	33 04 S	288 25 E	(1900), 1913, 1917, 1925, 1932
	Coronel	37 02 S	286 51 E	(1907), 1912, 1913, 1917, 1918, 1925
	Puerto Montt	41 29 S	287 04 E	1913, 1919, 1925, 1933
	Punta Arenas	53 10 S	289 08 E	(1913), 1919, 1925, 1933, I. P. Y. 1932-33
Colombia	Cartegenas	10 26 N	284 27 E	1908, 1909, 1922
	Puerto Berrio	6 52 N	286 15 E	1909, 1922, 1932
	Medellin	6 15 N	284 25 E	1922
	Bogota	4 38 N	285 54 E	1909, 1914, 1922, 1932
Ecuador	Quito	0 13 S	281 29 E	1908, 1916, 1924, 1926, 1932
	Guayaquil	2 11 S	280 09 E	1908, 1916, 1926, 1932
Guiana	Georgetown	6 49 N	301 51 E	1908, 1913, 1918, 1923, 1931
	Paramaribo	5 50 N	304 51 E	1908, 1918, 1923, 1931
	Cayenne	4 56 N	305 59 E	1908, 1918, 1923, 1931
Paraguay	Asuncion	22 49 S	302 28 E	(1904), 1913, 1925
	Concepcion	23 24 S	302 34 E	1913, 1925
Peru	Piura	5 11 S	278 54 E	1912, 1924, 1932
	Iquitos	3 46 S	286 45 E	1910, 1924, 1932
	Huancayo	12 02 S	284 40 E	(Observatory)
	Arequipa	16 22 S	288 27 E	1912, 1923, 1924, 1926, 1932
Uruguay	Colon	34 48 S	303 45 E	1913, 1919, 1925, 1932
Venezuela	Caracas	10 30 N	293 04 E	1905, 1912, 1913, 1914, 1922, 1931
	La Urbana	7 08 N	293 03 E	1913, 1914, 1931
	San Fernando de Atabapo	4 03 N	292 19 E	1913, 1932
Islands Atlantic Ocean				
Greenland	Etah	78 20 N	287 18 E	1908, 1923, (1925)
	Godhavn	69 15 N	306 28 E	1908, 1924, (observatory)
	Holstensborg	66 56 N	306 22 E	1908, 1924, (1925)
	Godthaab	64 12 N	308 17 E	1923, 1924, (1925)

Continent and country	Station	Latitude	Longitude	Remarks re occupations
		° ′	° ′	
Islands Atlantic Ocean (continued)				
West Indies	Nassau	25 04 N	282 39 E	(1903), 1922
	Matánzas	23 04 N	278 27 E	1905, 1922
	Santiago	20 00 N	284 13 E	(1903), 1909, 1922, 1931
	San Juan	18 23 N	293 53 E	(1901,) (1911), (observatory)
	Kingston	17 59 N	283 11 E	1905, 1908, 1914, 1922, 1931
	Bridgetown	13 05 N	300 25 E	1905, 1908, 1919, 1923, 1928, 1931
	Willemstad	12 06 N	291 05 E	1913, 1922, 1926
	Port of Spain	10 40 N	298 28 E	1905, 1908, 1913, 1923. 1931
Jan Mayen	....	71 04 N	352 24 E	(1882–83), I. P. Y. 1932–33
Iceland	Reykjavik	64 10 N	338 05 E	1914, 1928. I. P. Y. 1932–33
Azores	Ponta Delgada	37 46 N	334 21 E	(Observatory)
Madeira	Funchal	32 38 N	343 05 E	1909, 1914, 1925
Bermuda	....	32 18 N	295 11 E	1907, 1910, 1922
Canary	Santa Cruz	28 28 N	343 45 E	1911, 1914, 1915, 1925
*St. Paul Rocks	....	0 56 N	330 38 E	....
*Ascension	....	7 57 S	345 39 E	....
St. Helena	....	15 57 S	354 19 E	1913, 1920
*Trinidad	....	20 30 S	330 10 E	....
*Tristan da Cunha	....	38 00 S	348 00 E	....
Falkland	Port Stanley	51 41 S	302 10 E	1913, 1925
South Georgia	....	54 18 S	323 34 E	1916, 1926
Orcadas	....	60 43 S	315 13 E	(Observatory)
Islands Indian Ocean				
*Chagos	....	7 14 S	72 24 E	....
*Keeling (Cocos)	....	12 06 S	96 53 E	....
Comoro (Mayotta)	Zaoudzi	12 47 S	45 16 E	(1898), (1900), 1921
Madagascar	Majunga	15 43 S	46 19 E	(1900), (1906), 1920, 1921
	Tamatave	18 10 S	49 24 E	(1902), (1921)
	Tananarive	18 55 S	47 32 E	(Observatory), 1920, I. P. Y. 1932–33
	Tulear	23 21 S	43 37 E	(1907), 1920, (1924)

Continent and country	Station	Latitude	Longitude	Remarks re occupations
Islands Indian Ocean (continued)		° ′	° ′	
Mauritius	....	20 05 S	57 33 E	(Observatory)
*St. Paul	....	38 43 S	77 32 E	....
Kerguelen	....	48 40 S	69 04 E	(1902–03)
Islands Pacific Ocean				
Bismark Archipelago	Rabaul	4 13 S	152 12 E	1915, 1921
Caroline	Palau	7 20 N	134 29 E	(Observatory)
	Yap	9 29 N	138 04 E	1907
Cook	Rarotonga	21 12 S	200 15 E	1906, 1922
Ellice	Funafuti	8 32 S	179 11 E	1915, 1921
	Nanomea	5 42 S	176 08 E	1915, 1921
Easter Island	....	27 10 S	250 34 E	(1906), 1916, 1929
Fanning Island	....	3 54 N	200 37 E	....
Fiji	Suva	18 08 S	178 26 E	1906, 1915, 1921
*Galapagos	....	0 59 N	268 30 E	....
Hawaiian Islands	Honolulu	21 19 N	201 56 E	(Observatory)
Japan	Kakioka	36 14 N	140 11 E	(Observatory)
	Otomari (Sakhalin)	46 39 N	142 46 E	(Observatory)
	Taihoku (Formosa)	25 02 N	121 31 E	(Observatory)
*Juan Fernandez	....	33 38 S	281 10 E	....
Lord Howe Island	....	31 31 S	159 04 E	1915, 1923
Macquarie Island	....	54 31 S	158 57 E	1911
Marquesas	Atuona	9 49 S	220 58 E	1922
Marianas	Guam	13 28 N	144 40 E	1906, 1916, 1929
Marshall	Jaluit	5 54 N	169 39 E	1906
Malay Archipelago	Kudat (Borneo)	6 53 N	116 50 E	(1903), 1923
	Jesselton (–)	5 58 N	116 09 E	(1903), 1923

Continent and country	Station	Latitude	Longi-tude	Remarks re occupations
		° ′	° ′	
Islands Pacific Ocean (continued)				
Malay Archipelago	Bandjermassin (Borneo)	3 20 S	114 35 E	(1907), 1923
	Makassar (Celebes)	5 08 S	119 25 E	(1905), (1918), 1923, (1924)
	Batavia-Buitenzorg	6 11 S	106 49 E	(Observatory)
New Caledonia	Noumea	22 16 S	166 28 E	(1890), 1915, 1922
New Guinea	Samarai	10 37 S	150 40 E	1915, 1921
New Hebrides	Fila	13 48 S	168 19 E	1915, 1922
*Pitcairn	....	25 04 S	229 52 E	....
Philippines	Antipolo	14 36 N	121 10 E	(Observatory)
*Rapa	....	27 36 S	215 43 E	....
*Saint Felix	....	26 16 S	279 48 E	....
Samoan Islands	Apia	13 48 S	188 14 E	(Observatory)
Society (Tahiti)	Papeete	17 32 S	210 27 E	1906, 1907, 1912, 1922
Solomon	Makambo	9 05 S	160 12 E	1915, 1921
Tokelau	Atafu	8 32 S	187 30 E	1915, 1921
Tonga	Neiafu	18 39 S	186 01 E	1915, 1921
	Nukualofa	21 08 S	184 47 E	1915, 1921
Tuamotu Archipelago	Fakahina	15 58 S	219 51 E	1922


SCALE
Godhavn
Sitka
Meanook
Agincourt
Cheltenham
San Miguel
Tucson
Honolulu
Teoloyucan
San Juan
Apia
Huancayo
La Quiaca
Vassouras
Pilar
Orcadas
OBSERVATORIES
REPEAT-STATIONS
DESIRABLE ADDITIONAL REPEAT-STATIONS


SCALE
Matochkin Shar
Sodankylä
Tromsö
Lerwick
Katharinenburg
Pavlovsk
Kazan
Eskdalemuir
Abinger
Koutchino
Val Joyeux
Prague
Odessa
Nantes
Munich
Irkutsk
Otomari
Coimbra
Ebro
Tiflis
San Fernando
Tsingtao
Kakioka
Helwan
Dehra Dun
Taihoku
Alibag
Hongkong
Antipolo
Palau
Batavia
Mauritius
Watheroo
Toolangi
Christchurch
OBSERVATORIES
REPEAT-STATIONS
DESIRABLE ADDITIONAL REPEAT-STATIONS

DISTRIBUTION OF MAGNETIC OBSERVATORIES AND SECULAR-VARIATION STATIONS

By J. A. FLEMING

Voir: Terr. Magn., Vol. 37, 245-251.

SECULAR CHANGE OF THE EARTH'S MAGNETISM

By Daniel L. HAZARD

Voir: Terr. Magn., Vol. 37, 231-234.

THE UNSYMMETRICAL DISTRIBUTION OF MAGNETIC SECULAR VARIATION

By Harlan W. FISK

Voir: Terr. Magn., Vol. 37, 235-240.

SUGGESTED RESOLUTIONS OFFERED BY THE SPECIAL COMMITTEE ON MAGNETIC SECULAR-VARIATION STATIONS FOR CONSIDERATION BY THE INTERNATIONAL ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY AT THE LISBON ASSEMBLY, SEPTEMBER 1933

I. WHEREAS, The International Association of Terrestrial Magnetism and Electricity recognizing the need from both theoretical and practical points of view for more systematic observations to determine magnetic secular-variation, regards it essential that at least a minimum program of such work approximating that favorably recommended in the report of the Special Committee of the Association on Magnetic Secular-Variation Station, be it

RESOLVED, That the International Association of Terrestrial Magnetism and Electricity expresses the hope that the governments of all countries which make or have made systematic magnetic surveys, including the occupation of repeat-stations, to determine adequately secular-variation, will continue to do so and wherever possible extend such service, not only in their own geographical limits but also to their colonies and mandated territories, and that other governments which have not made such surveys will undertake them.

II. WHEREAS, The loss of the *Carnegie* has resulted in stopping world-wide magnetic observations at sea and at certain remote islands, and

WHEREAS, In most parts of the oceans no magnetic repeat-observations are being made, be it

RESOLVED, That the International Association of Terrestrial Magnetism and Electricity urges the desirability of finding funds for the construction and maintenance of another vessel similar to the *Carnegie*, with facilities not only for the magnetic and electric work but for other geophysical observations, especially in oceanography and meterorology, such as were carried out during the last cruise of the *Carnegie*.

III. WHEREAS, There are many remote or infrequently visited islands where magnetic repeat-observations have been made or which are suitable for such observation, be it

RESOLVED, That the International Association of Terrestrial Magnetism and Electricity urges governmental and private organizations, including individuals, undertaking expeditions to such islands, to extend facilities for transportation of magnetic observers and equipment, in order that magnetic secular-variation observations may be obtained.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting .... (International repeat-stations, by H. F. JOHNSTON).

REPORT ON INTERNATIONAL COLLABORATION TO ADVANCE THE STUDY OF THE MOON'S EFFECT UPON GEOPHYSICAL PHENOMENA

By S. CHAPMAN

1. The moon is known to produce a tide in the atmosphere, which has been determined at many stations by analysis of the hourly values of the barometric pressure. Likewise it produces a semidiurnal change in the atmospheric temperature, which has so far been determined for one station only, Batavia. Again, the terrestrial magnetic field undergoes a lunar diurnal variation, which has been extensively studied; electric earthcurrents also have been found to show a lunar diurnal variation. Doubtless many other geophysical elements will be found to show a similar lunar periodicity. The material for all these investigations consists of hourly or bihourly (possibly also trihourly) values of the element considered. On account of the smallness of the lunar variation, and the presence of both a

larger solar diurnal variation, and accidental variations, it is necessary to deal with a large amount of material, derived from many years' observations. Hence the investigation of the lunar diurnal variation for even a single element at a single station is a work of considerable magnitude and expense. Only a few observatories include such work in their regular program of reductions, and not many more undertake it as an occasional special research. It seems desirable that such lunar geophysical researches should be conducted more systematically, and over a wider field both of locality and of elements; this would be facilitated if some scheme of international cooperation for this purpose could be instituted.

2. The essential feature of all methods of determining the lunar diurnal variation is the re-arrangement of the data according to lunar time. But the methods hitherto adopted have differed from one another in many important respects, both in respect of the computational arrangement, and as regards the subdivision of the data for the purpose of examining how the lunar variation is influenced, by various accessory factors, such as the season, the moon's distance or declination, the sunspot epoch, and so on. A further important matter, to which insufficient attention has until recently been paid, is the determination of the probable error of the results obtained. Considerable advances in the technique of this lunar geophysical work have been made in late years, but the investigation for each element and station still has to some extent the character of an original research, each case having special features that must be considered. Experience in previous work of a similar kind is naturally advantageous both in the planning and execution of such researches.

3. These reasons, and others mentioned later, argue in favour of the establishment of one or a few centres at which systematic lunar geophysical researches should be conducted; the necessary experience and special knowledge could be acquired by such centres, and a computing staff trained to carry out an extensive program, facilitated by standardization of the work as far as practicable. Of course it would and should still be possible for individual workers to cultivate the same field, and to contribute new ideas to the current stock: though past history suggests that such isolated workers will not be numerous.

4. In most of the lunar geophysical investigations hitherto made, the original hourly data have been re-written one or more times on special computing sheets, according to lunar time, in order to form lunar sums for chosen groups of days. Recently more mechanical methods have been applied to the same work, and have proved to possess advantages over the "manuscript" methods. The hourly data are "entered" on special cards by means of holes punched at appropriate places

in columns, of which (in the case of the machines usually used for this purpose) there are 45 or 80 on each card. Each card can contain the data for one day or half a day, according as bihourly or hourly data (each of not more than three digits) are used. The holes are punched on the cards with great rapidity, by means of suitable machines having a simple keyboard. Besides the hourly values of the element considered, the date, the hour of lunar transit, and certain additional data for the day (such as the moon's distance, or the sunspot epoch) are punched on the cards. By placing a pack of cards (containing the data for a great number of days) into a sorting machine, the pack can be divided into sub-packs having some chosen characteristic in common (e. g. the same lunar transit time, the same lunar distance, and so on). Such groups of cards, and sub-sets corresponding to a classification of the daily cards according to any desired number of daily characteristics, can be made and re-made any number of times, from the same pack. Further, the sums of the hourly data on the cards in the pack, thus divided into sets or sub-sets, can be made mechanically in a further (adding) machine, which also, if desired, can "print" the whole material on the cards in the original or any other chosen order. The sums of the hourly data, from groups of days all having the same lunar transit time, form the condensed material for the determination of the lunar (and also of the solar) diurnal variation, and of its probable error. The later stages of the work, on these sums, involves much harmonic analysis; special computing methods have been devised for such analyses of material derived from the adding machines.

5. The chief advantages of the mechanical over the manuscript methods of executing lunar geophysical computations are as follows:

(a) Speed, with resulting economy.

(b) Flexibility; the same original material can be used over and over again in different ways, and when entered upon the cards remains available for future use, either in conjunction with further material, or in new ways not yet recognized as practicable or desirable.

(c) Accuracy. The sorting and summation of the cards is performed with complete accuracy, so long as the machines are working properly; naturally they may get out of order, but a trained operator, using suitable checks, can quickly recognize and rectify this. The punching of the original date on the cards is the operation into which the human element enters most largely, and this part of the work has to be carefully checked, partly by means of special "verifying" punching machines designed for the purpose.

6. On account of these advantages it seems desirable that

any bureau specially devoting itself to lunar geophysical investigations should have such machines at its disposal*), to be operated by trained assistants under scientific direction. The principal costs of such a bureau, apart from the customary overhead charges would consist of the rent of the machines and the salaries of the operators and supervisors. The further running costs, for material (mainly cards and computing forms), are of lesser magnitude, though not by any means negligible if the program of work is extensive. The cards themselves cost about seven shillings per thousand, so that ten years' hourly data for one element at one station, involving two cards for each day, require 7300 cards, or (allowing 10 per cent for spoilt cards), 8000, costing about £ 3; if bihourly data are used, the cost of the cards is naturally halved. An installation of Hollerith machines, with adequate labour to keep them fully running**), can easily deal with 500,000 cards per year, costing £ 150 and representing about 60 decades of hourly observations. The subsequent stages of the work on such a mass of data, (i. e., the combination and harmonic analysis) would, of course, involve a large amount of time and labour.

7. The results of lunar geophysical investigations have hitherto been printed in the publications of the observations concerned, or as memoirs of scientific societies, or in scientific journals. If a scheme of international cooperation for the production of lunar geophysical results on a more extensive scale were drawn up, the most appropriate mode of publication should be considered, as a possible part of the scheme. The scientific journals which have hitherto published lunar geophysical results might not be able to give the necessary space for a largely increased production of results; if so, the publication might be spread over a larger number of journals, or the results might be collected into a special publication.

8. The work of a lunar geophysical bureau should consist partly of the reduction of the vast existing materiel accumulated at many observatories during past years, and also of collecting the current material and entering it on Hollerith cards, ready for investigation into its lunar diurnal periodicity at suitable intervals (e. g., annually, or every five years, or every ten years, according to the circumstances regarding different ele-

*) The British Tabulating Machine Company has generously lent such an installation, of Hollerith machines, without charge, to the Department of Mathematics, The Imperial College of Science and Technology, London, for demonstration and research purposes, and several lunar geophysical investigations have been carried out with its aid. Installations of such machines are rented, with maintenance, by their makers, and are not sold outright.

**) Owing to the limitation of the computing staff, the Hollerith installation at my own disposal, at the Imperial College, has not been worked to anything like its full capacity.

ments and stations). The number of elements to be examined should be increased, but not indiscriminately. In many cases, existing knowledge offers some guidance as to the order of magnitude of the lunar variation to be expected; it would be desirable to test such expectations in suitable cases, since our expectations of Nature are frequently falsified; but where a negative result was expected and found, that is, where the lunar variation in a particular element was likely, and verified, to be inappreciable, repeated checks at different stations would seem to be pointless. The main efforts should be devoted to improving our knowledge of the lunar phenomena that can be reasonably well determined. There is still much scope for improvement in our knowledge of well-established lunar geophysical phenomena, as well as for addition to their number.

9. The work of an international (or indeed any) lunar geophysical bureau must depend not only on its personnel and equipment, but also, to some extent, on cooperation between it and the observatories whose data it considers. This applies mainly to the observatoires that do not publish hourly (or bihourly) data, though having such data (or records from which such data can be obtained) in their archives; in such cases, of course, the data must be communicated to the bureau in manuscript, or by photographic or other reproductions of the manuscript tabulations of the observatory. If an observatory made it a regular part of its program to communicate its data to a lunar geophysical bureau, it could problably so arrange that the duplication of the tabulations at the time the latter were themselves made would involve scarcely any additional trouble or expense. Further, the bureau, through its mechanical equipment, might make some return to the individual observatories, which in many cases would not have the same expensive computing installation; the monthly hourly sums of the data supplied to the bureau by an observatory could be formed on the adding machines, and returned to the observatory, either for check on the similar sums formed there, or to check their sum against the sum of the 24 hourly values for each day, formed at the observatory itself; this should result in at least some saving of labour in addition, or in checking, at the observatory, to set off against the trouble involved in sending its results to the bureau; this naturally applies mainly to current or future work, and not to the communication and checking of data for past years.

10. In this connection some comments may be made regarding the preparation of hourly geophysical data, either for publication in full, or as a means of arriving at published monthly-hourly or daily means. In the course of much lunar geophysical work: I have been impressed by the large number of errors to be found in many published tables of hourly values with their

accompanying hourly and daily means. It seems likely that these could be avoided by checking the final tables directly against the original records, these being re-measured and compared with the final tabulations (e. g., in proof, if they are to be printed); naturally differences would be found in the last figure estimated on re-measurement, and the check could be made subject to certain limits of tolerance.

11. If, however, a regular practice were made of communicating the hourly tabulations, at once after the original measures, to a lunar geophysical bureau, the latter, after punching the data on to Hollerith cards, could re-print the material from the cards, and send a copy to the observatory, for check against the original records by re-measurement. Any errors thus found might be due either to a fault in the original measurements, or to a fault in the original copying, or to a fault in the punching of the cards at the bureau. In any case, the necessary corrections could then be sent to the bureau, which could correct (or replace) its faulty cards; it would then have a thoroughly accurate record of the original material, and could form monthly hourly sums, with scarcely any trouble, on the adding machine. The latter does not lend itself to the formation of daily sums: which moreover are not needed in lunar geophysical work; but the monthly hourly sums should be of value to the observatory, to which they could be communicated, in order from them to form monthly hourly *means,* (these also would be of little value to the bureau), and also for use as a check in forming daily sums and means.

12. In the case of past records which the bureau intended to utilize for lunar geophysical research, it would be of great advantage (in checking the punching of the data on the cards) if the observatory concerned would provide the corresponding monthly hourly sums existing in its archives, even where the hourly data and the corresponding hourly means are printed. If (as is rarely the case in printed records) the monthly hourly means are given to two more decimal points than the individual hourly values, the means provide a check, but even in this event, and still more when the means are given with less accuracy, the monthly hourly sums are much more convenient for checking.

13. In conclusion, I may be allowed to make a short statement regarding my own work in this field. For many years I have devoted part of my activity to lunar geophysical researches, at first while on the staff of the Royal Observatory, Greenwich — where, through the kindness, encouragement and interest of the then Astronomer Royal, Sir Frank Dyson, I had valuable facilities for such work — and later while professor of mathematics at Manchester University and the Imperial College. In recent years the Imperial College has placed a small

computing staff at my disposal for this and other work, and the production of lunar geophysical results has been accelerated, particularly since the Hollerith installation became available through the kindness of the British Tabulating Machine Company. This installation is operated by two trained computers, supervised by a well-qualified mathematician who controls the whole of the work under my direction. I hope to continue similar work in the future, with the facilities already provided, so long as these are avaiable to me. Should the Association of Terrestrial Magnetism desire to foster and accelerate such work, by devoting a part of its funds to this object, I could, if desired, undertake the charge of an additional assistant, and act as director of an international bureau for lunar geophysical researches; the expense of the increased number of cards then used would also have to be considered. Such an arrangement might prove of value for some years, though sooner or later it would probable be found desirable to transfer the work to some permanent geophysical institution, since it is unlikely that my successor as professor of mathematics at this College would share my own personal interest in the subject. I should add also that I have no desire to ask the Association to entrust me with the direction of a lunar geophysical bureau, if it should wish to institute one, and that I should give my best cooperation, if it should be desired, with any institution to whom such duties might be entrusted. A national magnetic and meteorological observatory or offices, or such an institution as the Department of Terrestrial Magnetism and Electricity of the Carnegie Institution of Washington, would provide a natural home for such work.

March, 1933.

ÉTUDES THÉORIQUES CONCERNANT LE MAGNÉTISME TERRESTRE

Voir la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting .... (Theoretical studies of terrestrial magnetism, by M. A. TUVE).

REPORT ON ION-COUNTERS, METHODS OF USE, AND RESULTS

By G. R. WAIT

A resolution passed at the Stockholm meeting expressed the wish that organizations especially occupied with ion-counting instruments should send information regarding their instruments and manner of use to Dr. Fleming. No organization has responded as yet to this request. In view of the extensive use made of the ion-counter by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, it seems desirable to report on the manner in which it has been used by this Department. It is also considered desirable to discuss briefly certain systematic errors to which the small ion-counter is liable. At the same time this will suggest the kind of information regarding ion-counters and their use, of particular value to those trying to evaluate results from any given instrument. Attention will be called only to four errors, all, except the first, common to the usual type of small ion-counter. Discussion of other errors possible with this instrument would go beyond the province of this report.

The usual method of measuring the small-ion content of the atmosphere is that due to Ebert. In this method, a stream of air is drawn through a cylindrical condenser, the outer cylinder of which is connected to earth, the inner is connected to an electrometer, and the cylinders are connected to opposite poles of a battery of potential from several to a few hundred volts. One of the chief defects of this method is that the time necessary to obtain a measurable change in deflection of the electrometer is necessarily long. To overcome this defect, two alternatives have been used. One is due to Swann, in which three cylinders are used. The inner cylinder is connected to a sensitive electrometer, which is kept near earth-potential, the outer cylinder is connected to earth and to one side of a battery, while the third cylinder is connected to the other side of the battery. The other alternative is to keep the inner cylinder near earth-potential, but to keep the outer cylinder at a higher or lower potential than earth, depending upon the sign of the ions to be measured.

With the outer cylinder of the ion-counter at a higher or lower potential than earth, ions coming into the instrument are subjected to an electric field which of necessity alters the number normally coming into the instrument. Thus an accurate measurement is not secured with this arrangement. It is possible, however, to overcome this difficulty by raising the inner cylinder and electrometer to the desired potential above earth, while the outer cylinder is kept at earth-potential. Thus the repulsion of ions coming into the instrument is avoided and an accurate measurement can be secured.

Radioactive matter tends to collect on those parts of the ion-counter subjected to potentials and air-flow. This radioactive matter adds to the number of ions caught by the instrument. At first thought it would seem only necessary to determine a correction-factor with the air shut off to make proper adjustment of the data. Tests indicate, however, that any correction-factor secured in this manner is not valid. The difficulty may be eliminated by polishing with fine emery paper the parts where radioactive matter may collect.

An earthed conductor when placed in an electric field has induced on it an electric charge that is determined in sign by the sign of the field and in amount by the strength of the field and the geometrical shape and dimensions of the conductor. A positive potential-gradient thus induces on the top of the ion-counter, if exposed to this field, a negative charge. This negative charge produces an error in the measured ionic content due to the negative small ions, but none in that due to the positive small ions. The per-cent error of the ion-count is proportional to both the induced charge and the mobility of the ions concerned, and inversely proportional to the volume of air entering the ion-counter per second. The error with an unshielded ion-counter has been observed to be as great as 27 per cent for a potential gradient of 115 volts per meter. Adequate shielding from the Earth's electric field should be provided to minimize this error. The interested reader may be referred to the investigations of Swann (Terr. Mag., v. 19, 205-218, 1914, and Phys. Rev., v. 21, 449-455, 1923), Norinder (Ark. Matem., v. 15, 1-19, 1921), and Mackell (Phys. Rev., v. 21, 436-448, 1923) for greater details.

In a determination of the small-ion content of the atmosphere, the ion-counter catches a certain proportion of the ions having smaller mobilities, as well as the small ions. Errors are produced in the small-ion content determination just to the extent that the other ions are caught. The magnitude of error introduced depends not only upon the number of other ions present and their mobility, but upon the instrument itself and upon the way it is used. In order to count all ions of a given mobility, sufficient voltage (so-called critical voltage) must be applied to the condenser-system of the ion-counter to catch all the ions before they can pass completely through the condenser. The magnitude of potential required depends upon the mobility of the ions concerned, upon the velocity of air passing through the condenser-system, and upon the geometrical shape and size of the condenser. Recent experiments made at the Department of Terrestrial Magnetism show that an additional factor is required when turbulence is present. Turbulence in the air-stream within the condenser acts in such a manner as to increase the critical potential. When turbulence is present, the experiments show it is not permissible to calculate the critical voltage in the usual manner, as in many cases a very large error would be introduced by so doing. Details regarding these experiments and results will be given in an early issue of the Journal of Terrestrial Magnetism and Atmospheric Electricity. For a given set of conditions (with the number of other ions present and their mobility and the rate of air-flow all fixed) the error in the observed number of small ions depends only upon the ratio of used potential to critical potential. Having determined by experiment for particular conditions and circumstances the critical voltage for his ion-counter, the investigator is in position to reduce the error in his measurement of small-ion content to the very lowest limit. In the present recording of small-ion content of the atmosphere at the Department, the critical potential is exceeded by only a small amount. The critical potential of the small-ion counter used on the *Carnegie* was only about one-tenth the potential actually used. Tests were made, however, and the results indicated that an inappreciable error was introduced due to this fact. This is as was to be expected in view of evident freedom of air over the ocean from contamination of industrial smoke—a very common source of ions of low mobilities. The location of the ion-counter on the *Carnegie* was such as to be practically free from the electric field of the Earth and consequently the data taken at sea aboard the *Carnegie* may be regarded as free from the effects of the potential gradient. The present recording of small ions at the Department has been confined to the positive rather than to the negative ions. The results consequently in general are not affected by the Earth's electric field. The recording in any case is being carried on inside a small building, with free ventilation to the outside, which should reduce the effect of the induced charge to a small amount. In addition, it is planned to stretch wires horizontally over the building, in order to further provide against possible effects from the Earth's field. In view of the low value for the radioactive content of the atmosphere over the oceans, little difficulty could be expected by deposit of radioactive matter on the walls of the ion-counter condenser. The walls of the ion-counter in use in Washington are cleaned occasionally with fine emery paper to insure that this source of error is removed.

The Swann modification of the Ebert ion-counter is employed for both the small-ion counter and the large-ion counter, and consequently sensitive electrometers are used and at the same time a field at the entrance to each counter that would affect the number of ions coming into the instrument is avoided. In the schematic diagram (Fig. 1) the large-ion counter is represented by the horizontal set of three concentric cylinders. These cylinders are about two meters long. Air is drawn at a constant rate between the central and intermediate cylinders, the adjacent surfaces of which are six mm apart. A potential difference of about 800 volts is applied between the intermediate and outer cylinders, the outer cylinder being earthed. The central, well-insulated cylinder is connected to the measuring-device, which is a single-fiber electrometer. During recording the charge coming to the central cylinder as a result of the collection of ions passes through a high resistance (10^{12} ohms), not shown in the diagram, to earth. The electrometer being connected across this high resistance, is caused to deflect as a result of the *ir*-drop. The deflections are measured from zeros produced by automatically shutting off once each hour the air-flow. All ions having a mobility greater than about 0.0004 cm per second per volt per cm will be collected by this large-ion counter. However, the small-ion counter shown as the vertical set of cylinders at the left in Figure 1 is of such dimensions and employs such potentials as will remove all ions with a mobility greater than about 0.8 cm per second per volt per cm, thus preventing the small ions from affecting the large-ion measurements. The number of small ions in the atmosphere in Washington is far too small to permit the use of the high

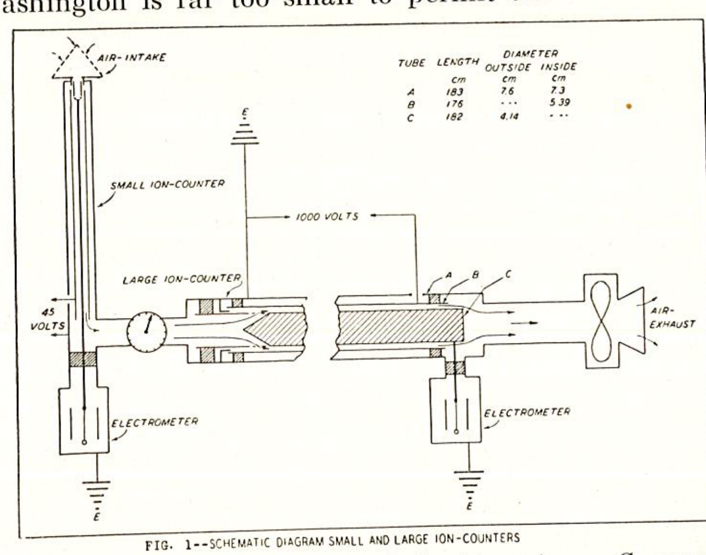


FIG. 1--SCHEMATIC DIAGRAM SMALL AND LARGE ION-COUNTERS

resistance as for the recording of the large-ions. Consequently the central cylinder and fiber of the single-fiber electrometer are allowed to charge up and the rate of charging up is recorded. Once each hour, before the charge is removed and a small opposite charge is placed on the inner cylinder (in order that the fiber may record through its zero-position and consequently diminish the effect of any insulation-leak) and the charging-up process repeated, a test of the insulators is made. The result of each insulation-test is shown at the upper end of each recorded line representing the small-ion count in Figure 2. Perfect insulation results in a horizontal line, and it is seen that all 24 values approach this condition very closely.

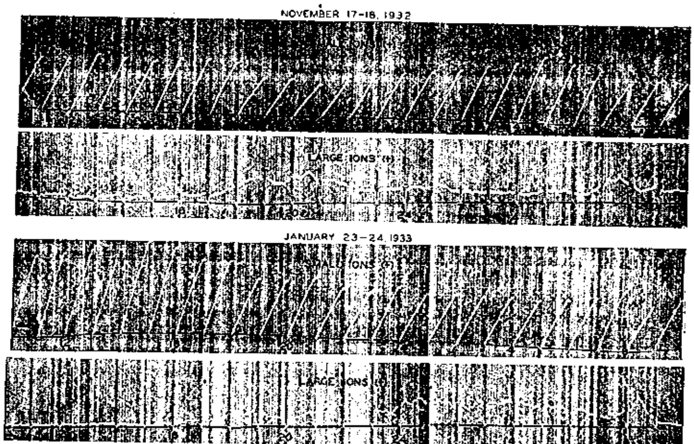


FIG. 2—TYPICAL SMALL-ION AND LARGE-ION RECORDS, WASHINGTON, D.C.
TIMES ARE 75° WEST MERIDIAN HOURS

Daily records for each of the two classes of ions (large and small) are reproduced in Figure 2 which gives a good idea of the character of the daily variation for each class. The mean large-ion diurnal-variation curve for 14 days during January, 1933, shows a sharp maximum between 8h and 9h (75° west meridian time) and a broad maximum of about the same amplitude between 18h and 23h. The mean small-ion diurnal-variation curve for the same days has a sharp minimum coinciding in time with the sharp morning-maximum of the large-ion curve and a broad minimum occurring at the same time as the broad evening-maximum of the large-ion curve. The principal maximum of the small-ion curve occurs at about noon and a secondary maximum, having about half the amplitude of the principal maximum, occurs at about 4h. The two minima of the large-ion curve occur at these times. Thus, except for minor details, one curve is a reciprocal of the other. The average counts per cc given by the small-ion counter and by the large-ion counter for the 14 days were 182 and 5,200, respectively.

Dep. Terr. Magn., C.I.W., July 29, 1933.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting .... (Ion-counters, methods of use, and results, by O. W. TORRESON).

RAPPORT DE M. STÖRMER SUR LA DISTRIBUTION DE L'ATLAS PHOTOGRAPHIQUE, DU SUPPLÉMENT, DES CIRCULAIRES, DES CARTES CÉLESTES EN 7 FEUILLES ET DES CARTES CÉLESTES DU TYPE CARLHEIM-GYLLENSKÖLD.

	Atlas	Supplément	Circulaire	Cartes		
				N.	S.	C. G.
Allemagne	6	4	1	1	1	
Amérique du Sud	2	2	2		2	
Autriche	1					
Canada	31	28	2	102		600
Danemark	27	27	1	1		
Danzig	1	1	1	1		
Espagne	4	4	2	2		
Esthonie	4	4	1	1		
Etats-Unis	46	45	13	1162	4	550
Finlande	7	2	1			100
France	11	10	2	102		
Grande Bretagne	70	25	3	153	1	
Hongrie	1	1	1	1		
Inde anglaise	1					
Italie	1					
Japon	3	1				
Norvège	56	48	5	316	2	10
Nouvelle-Zélande	20	20	1	1	500	80
Pays-Bas	10	10	1	1		
Pologne	5	5	1	1		
Portugal	1	1	1	1	1	
Suède	29	28	3	3	1	1000
Suisse	3	2	1	1		
U. R. S. S.	10	10	1	1		
	350	278	44	1851	512	2340

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la V^{e} partie: Comments on the agenda for the Lisbon meeting ... (Possible arrangements for amateur recording of auroral displays, by J. A. FLEMING).

SHORT PRELIMINARY REPORT ON THREE SUDDEN COMMENCEMENTS OF MAGNETIC STORMS

By A. TANAKADATE, Reporter

Mr. President,

At the last meeting of the Association in Stockholm 1930, the special Committee on Sudden Commencement of Magnetic Storms, urged me to continue the function of its reporter, so it became my duty to collect the available material up to date. But, since the reliable data could be procured only quite recently — too close to the session of this meeting for preparing a satisfactory résumé — I am presenting this report on the basis that something is better than nothing.

Allow me at this moment, to express my regret in having lost the opportunity of placing a report on this subject in the memorial publication of our last President Prof. Bauer who gave particular attention to this question and proposed to the Executive Committee to undertake its investigation.

The whole question of Sudden Commencements, interesting as it is, was rather obscure until reliable records from quick running magnetographs of sufficient sensitivity could be procured. The Association appointed a special committee which decided to install in selected observatories a set of instruments of similar construction, and, for the first trial, only one element (the horizontal intensity) was to be investigated. Prof. Mitchell designed an instrument for the purpose, but it was not realized for want of funds.

Fortunately, the Second Polar Year Commission took the question into its programme, and it is principally due to Dr. la Cour's happy idea of constructing a quick running magnetograph which can record all the variations needed with a great economy of photographic paper that so many stations were induced to take part in this international pursuit during the Polar Year. We will congratulate the Polar Year Commission for its success in having materially advanced the elucidation of this problem.

The Japanese Polar Year Committee took an intense interest in this question and made special preparations for the purpose in two stations, the one in Kakioka, not far from Tôkyô, and the other in Toyohara in Karahute, the northern island, furnishing them with magnetographs of the same type, sensitivity 1.5-1.7 gamma per mm, and time scale 12-15 mm/min. From the records of these magnetographs, three well marked sudden commencements in H were found, on Oct. 14: 17h. 47m. 03s. G. M. T. in 1932; April 30: 16h. 28m. 14s, and May 29: 6h. 26m. 22s, both in 1933. A careful measurement and comparison of the records of the two stations showed that the time difference between the time of S. C. of the two stations was nearly constant, about 8s. This constancy of time difference and the characteristic feature of the sudden change so convinced us of the worldwide nature of the phenomena, that it became very desirable to compare the results with other observations. Consequently, the present reporter with the kind consent of the Secretary, M. le Prof. Maurain, issued the circular on July 1st, 1933 to observatories where quick running instruments are in action, as well as to other important observatories, asking them to communicate their observations on these special times by the end of August, so that the result might be communicated to this Meeting.

The request was most courteously answered from all quarters, the number amounting to 29 including the one received yesterday afternoon from the French mission in Scoresbysund, 70° 29′ N, on the east coast of Greenland. I appreciate most profoundly the enthusiastic efforts of all those observers in sending their reports with such whole-hearted spirit.

The time of S. C. thus collected are arranged*) in alphabetical order of the names of the stations with their geographical coordinates. The alphabetical order is a mere matter of index; the stations could be arranged for any special purpose with other arguments such as geographical or magnetic latitude, local time etc.. It should be emphasized that the list is only a simple collection of data and is subject to corrections as the following considerations will show. It is, however, to be remarked that a certain number of widely distant stations agree in recording the S. C.s to within a few seconds, stations distributed from Watheroo in the south to Scoresbysund in the north. The S. C. of April 30th is the most pronounced of all. From the roughly sketched plates**), we see that the S. C.s occur under various magnetic conditions in different parts of the earth, nevertheless, a general characteristic is recognisable in all of them, so that we may be convinced that the same event is indeed being registered at all the stations along with their respective local variants.

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*) Voir p. 154-155.

**) *Note de la Rédaction:* Les planches en question ont été omises dans ce volume, vu qu'elles ne sont malheureusement pas appropriées à être imprimées.

Nature of Sudden Commencement and the Datum Instant of Reference

If the S. C. were truly instantaneous, there would be no question. But, like all other natural phenomena, when the time scale is expanded it appears as a smooth, gradual change, and which instant to take for the datum of reference becomes an important question. The Japanese Committee takes the minimum point which occurs just before the rate of change becomes fastest. In usual magnetographs this point looks like a knot in the graph, and may be looked upon as the commencement in the ordinary sense. In the literal sense of the word, however, this is certainly not the commencement. In the record of Kakioka, for example a careful examination will show that this minimum is preceded by a very flat swell. This earlier "maximum" is almost as much pronounced as the minimum in other stations e. g. Niemegk or Rude Skov, while in Julianehaab and Eskdalemuir it is rather flat.

Dr. la Cour proposes to take the point where any of the curves begin to show a deviation from the previous course (generally almost steady) as "the very beginning of the S. C. in question". This will have the advantage of eliminating instrumental peculiarities, provided the motion begins from rest without any frictional resistance. Practically, the determination of the point where the course of the curve begins to deviate from the preceding part is difficult in the case of Kakioka and Toyohara, because the deviation is so gradual that the time determination become very inaccurate. Similar conditions are observed in other stations especially where the magnetograph is of low sensitivity. However, it will be a good plan to compare the two times thus defined, as Dr. la Cour and others have already done. (See page 155 "Abstracts of Remarks").

From the records of Niemegk and others, the S. C. seems to appear in a manner not unlike seismic waves, with preliminary tremours and overtones of various periods, certain of which die away with distance, or degenerate in amplitude. This reminds me of the work we have done in Japan in 1910 and following years, when we observed rapid variations of the earth magnetic field with a quick running magnetograph of a high sensitivity, 0.15 to 0.17 gamma per mm.*) Prof. Terada analyzed the waves then found in different categories as spectra of magnetic waves. It may be useful to consider the results outlined in that paper in connection with the question of S. C.s.

In high latitude stations there are sudden changes which far exceed the selected S. C. but do not appear in low latitude. The importance of low latitude stations, it appears to me, is to filter

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*) See Vol. XXXVII Art. 9, Jr. of the Coll. of Science. Imp. Univ. Tôkyô.

out the local disturbances, thus leaving the *ground tone* which extends throughout the whole earth.

The quick running instrument loses much of its advantage when its sensitivity is not adequately increased. I may mention a simple device of reading the curve with a cylindrical lens to magnify the amplitude only — a glass tube of about 1 cm. diameter filled with water will answer. The minimum or maximum point is made much more apparent by this means.

Discrepancy in the time of S. C.

When we come to deal with seconds of time, there are two sources of error, beside the clock and index errors, 1. the local magnetic variants; 2. the instrumental error.

1. Whether we take the "very beginning" or the first "minimum point" as the datum instant of reference, the change is superposed with other variations; the unavoidable diurnal variations are in different phases in different longitudes, and of different amplitudes in different latitudes, and, in addition, local disturbance of limited extent are not unusual. These superposed effects will all tend to mask the datum point to a greater or less degree, whatever definition of S. C. is used.

2. The instruments have different capacities of responding to S. C. according to their proper period and degree of damping. Even if the S. C. occurs at a time when the needles are at rest, they will not begin to move until a sufficient force comes into action to overcome the frictional resistance. Most vertical variometers rest on knife-edges which certainly have friction. Some of the retardations observed in Z are very likely due to this cause.

The damper requires attention, when we are dealing with rapid or sudden change, the change of flux through the circuit set up by most damping arrangements, will generate currents, so that the magnetometer becomes a galvanometer and will be deflected in one sense or other according as the magnet is oriented W-E or E-W, that is to say, it will accelerate or retard the response to the S. C.*)

Conclusion

In conclusion, the material of this report, which is essentially preliminary, comes from observations made during the Second Polar Year, so that it will be the Polar Year Commission which

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*) In this respect the earth inductor will be a better instrument for the purpose. Seeing the large extent of ground needed in the Mitchell system, a laboratory instrument with three concentric coils in planes at right angles to each other was designed in 1928, but is not realized for the want of a galvanometer of sufficient sensitivity.

will reduce the results of these observations to the best advantage. However, as the reporter of this Association, and as a member of a National Committee on Polar Year Observations, I am glad of the opportunity of making some suggestions which may be accepted or rejected.

Suggestions

I. The coordinates of the stations, both geographical and magnetic should be listed.

II. The facsimilés of the part of the graphs should be published with the necessary time correction and scale values, as well as with the indication of the sense of time running and increase of force. The time marks are of width covering from 2 to 10 seconds, usually 4-5 seconds, so that it is necessary to indicate from which side of the mark the time is to be measured.

III. The maximum rate of time variation of the three elements should be measured.

IV. Instruments: *a,* Period and damping coefficient should be determined. In most cases the scale value determination can be carried out to include the determinations of these constants simultaneously. *b,* The shape and size of the magnet and of the damper should be stated, and also orientation of the suspended needle whether E-W or W-E.

V. Experiments by applying known field either electrically or with permanent magnets should be made to see how the instrument responds to changes of various degrees of suddenness.

Until these points are deliberately considered and taken account of, it will be unsafe to draw any definite conclusion as to the order of the event in different parts of the earth. This does not mean any hesitation on the part of theoretical studies under various possible hypotheses.

September, 17th, 1933.

SUDDEN COMMENCEMENT OF MAGNETIC STORMS IN G. M. T.

No.	Observatories	Mag. Coord.	Oct. 14, 1932 17h 40m+			April 30, 1933 16h 20m+			May 29, 1933 6h 20m+		
		Long. Lat.	H	Z	D	H	Z	D	H	Z	D
			m s	m s	m s	m s	m s	m s	m s	m s	m s
1	Abinger 0°23′ W 51°11′ N	83.3 54.0	7.0			8.2	6.5	7.6	4.0		4
2	Abisko 18°49′ E 68°21′ N	115.0 66.0	8 31		8 44	7 44 9 12	8 44	7 31 8 31	4 46 52	4 48	4 48
3	Bossekop 23°15′ E 69°58′ N	120.3 66.6									
4	Cape Town 18°28′ E 33°57′ S	79.9 —32.7	5 13			8 00			5 18		
5	College-Fairbanks 147°49′ W 64°51′ N	256.5 64.6			7 05			8 30	5 45		
6	De Bilt 5°11′ E 52°06′ N	89.4 53.8	5 56 6 56		5 56 6 56	7 46 8 46		7 46 8 46	4 21 5 21		4 21 5 21
7	Ebro 0°24′ E 40°49′ N	79.7 43.9	6 53			8 04			5 24		
8	Elisabethville 27°21′ E 11°40′ S	93.8 —12.7	6 56			7 56			5 05		
9	Eskdalemuir 3°12′ W 55°18′ N	82.9 58.5	6 25			7 31			4 42		
10	Fort Rae 115°44′ W 62°39′ N	291.5 68.9		6 54 8 11	6 45	7 33 8 10	7 47 8 29	7 23	4 45 5 27	5 28	4 48
11	Godhavn 53°30′ W 69°15′ N	32.5 79.9				7 34	7 31	7 33	5 06		
12	Huancayo 75°20′ W 12°03′ S	353.8 —0.6	6 28	6 43	6 44	7 37	7 38	8 16			
13	Julianehaab 45°58′ W 60°44′ N	35.6 70.8	7 03			8 14		7 37	5 22		
14	Kakioka 140°11′ E 36°14′ N	206.0 26.0									
15	Lovö 17°50′ E 59°21′ N	105.8 58.1									
16	Lycksele 18°41′ E 69°35′ N	116.4 67.1	6 44			7 40			4 52		
17	Manhay 5°41′ E 50°18′ N	88.9 52.0	4 37 7 06			5 02 7 39			0 22 5 35		
18	Meanook 113°20′ W 54°37′ N	301.0 61.8				8 33			5 30		
19	Niemegk 12°30′ E 52°04′ N	96.4 52.3									

Where two times are given for the S.C. the first is the "very beginning" and the second the "first maximal deviation".

No.	Observatories	Mag. Coord.	Oct. 14, 1932 17h 40m+			April 30, 1933 16h 20m+			May 29, 1933 6h 20m+		
		Long. Lat.	H	Z	D	H	Z	D	H	Z	D
			m s	m s	m s	m s	m s	m s	m s	m s	m s
20	Petsamo 31°13′ E 69°32′ N	125.7 64.9									
21	Ponta Delgada 25°41′ W 37°44′ N	50.9 45.6				6 24			0 43		
22	Reykjavik 21°45′ W 64°06′ N	70.9 70.2						7 34			4 48
23	Rude Skov 12°27′ E 55°51′ N	98.5 55.8	6 45 7 18	7 23 8 05	6 41 8 07	7 32 8 43	8 18 9 14	7 58 8 09	5 11 5 21	5 02 5 38	4 48 5 25
24	Scoresby Sund 22°19′ W 70°29′ N	81.4 75.8						7 44 8 04			
25	Simoda 138°56′ E 34°40′ N	205.0 24.3				8 13					
26	Toyohara 142°45′ E 46°57′ N	206.5 36.4	7 10			8 22			5 31		
27	Tromsö 18°57′ E 69°40′ N	116.7 67.1				9 08		8 33			
28	Val-Joyeux 2°01′ E 48°49′ N	84.5 51.3	6.0	6.0		7	7	8	5	5	6
29	Watheroo 115°52′ E 30°19′ S	185.6 —41.8						8 14	5 22		

ABSTRACTS OF REMARKS ON SUDDEN COMMENCEMENT OF MAGNETIC STORMS 1932-1933

1. Abinger: The times are taken from normal speed records to tenth of minutes.
April 30, typically sudden: May 29, traces not conspicuous.

2. Abisko: Two sets of values, the first minimum, the second maximum points. The ranges of the sudden changes are: April 30, H 123, E 29, Z 29 gamma. May 29, E —24, Z —5 gamma.

3. Bossekop: Deflections are so small that exact determination of time is impossible. So it is also in Bodö. On May 25, 1933, a distinct S. C. of D at 6h. 25 m. 08s, D preceeds H, in Bodö too.

4. Cape Town: The times for Oct. 14—15 are taken from slow running magnetographs. Two more S. C. in H at Oct. 15, 1932, 8h. 3m. 35s, August 5, 1933, 10h. 16m. 15s. Attention is drawn to the following data:

		Mag. Char.	Max. G.M.T.	Min. G.M.T.	Range Gamma	Mean Range for month
1932 Oct.	14	0.	8h 00m	11h 45m	34	
-	15	2.	6 55	17 25	166	
-	20	2.	7 25	18 00	105	Oct. 49 gamma
1933 Apr.	15	2.	9 50	20 25	90	
-	17	2.	0 33	13 00	100	Apr. 48 -
-	30	2.	16 3	22 05	75	
May	1	2.	8 15	17 53	224	
-	29	1.	7 25	16 55	75	May 53 -
Aug.	5	2.	10 49	19 17	143	

5. College-Fairbanks: Mitchell earth-inductor records on April 30.

6. De Bilt: Times taken from ordinary magnetographs of 15 mm/h. (miniature photo sent, rather small to copy) S. C. for X and Y are:

1932 Oct. 14, X 17h 45.0m Y 45.0m
1933 Apr. 30, X 16h 26.2m Y 16h 26.2 m
May 29, X 6h 24.0m Y 6h 23.0 m
June 25, X 10h 2.0m Y 10h 2.0 m ; H 10h 2m 6s to 3m 6s
D uncertain Scale values: for X Y 5.0 γ/mm, H 3 γ/mm, D 1'05/mm.

7. Ebro: May, 29, the time under H is not really that of H but it is taken from earth-current recorder.

8. Elisabethville: No special remarks.

10. Fort Rae: None of S.C. well marked except H on Apr. 30.

11. Godhavn: The times are the mean values of determinations by la Cour and Egedal agreeing within 2 or 3 seconds.

12. Huancayo: Earth-current records on the three days. May 29, D almost straight.

13. Julianehaab: Times are mean values of determinations by two persons.

14. Kakioka: Special quick running 12—15mm per min.

15. Lovö: Clear photographs sent, times not mentioned.

16. Lycksele: - - - - - -

17. Manhay: No particular remarks.

18. Meanook: Two time marks.

19. Niemegk: Minimum of H on Apr. 30 remarkably pronounced. Details of variation shown well due to the sensitivity 1.3 gamma/mm.

20. Petsamo: Pencil tracing of records sent, times not mentioned.

21. Ponta Delgada: Trace on Oct. 14 imperceptible (about 17h 45m).

23. Rude Skov: Two sets of times, the very beginning and the first maximum deviation.

24. Scoresbysund: Three points mentioned, D Debut 16h 27m 44s, Z 2 impulsions a: 27m 47s, and b: 28m 04s.

25. Simoda:	Earth-current record for Apr. 30. The time on Apr. 30, 16h 28m 10s—15s, the mean 13 is taken in the list.
26. Toyohara:	No special remark, except the magnetograph is of the same construction as that of Kakioka.
27. Tromsö:	Time correct within 5s. The S.C. of D preceeds that of H by 35s on Apr. 30, as is the case in Bossekop and Bodö.
28. Val-Joyeux:	Times are given to min. from ordinary magnetograph. The difference in S.C. of D and H attributed to uncertainty in photographic traces.
29. Watheroo:	Mitchell earth inductor records on Apr. 30 and May 29. Earth-current on Oct. 14 and Apr. 30.

REMARQUES DU P. RODÉS SUR LA COMMUNICATION DE M. TANAKADATE

Father Rodés after having congratulated Prof. Tanakadate for his interesting paper, expressed his opinion of the matter; — when several observatories have registered a sudden beginning within a few seconds of agreement, a difference of two or three minutes could not be accepted as real if data are homogeneous.

REMARQUES DE M. LA COUR SUR LA COMMUNICATION DE M. TANAKADATE

M. *la Cour* remercie également M. *Tanakadate* pour son rapport fort intéressant. Il dit que justement l'étude des débuts brusques et d'autres variations rapides du magnétisme terrestre est un des buts les plus importants du travail exécuté pendant l'Année Polaire. A son avis, la Commission Internationale de l'Année Polaire serait très contente de voir auprès de l'Association un Comité qui s'occupe de ce sujet et qui assisterait la Commission à organiser et à faciliter autant que possible les recherches sur ce domaine.

Il a lui-même examiné les enregistrements du début brusque du 30 avril 1933 faits aux stations de Danemark. Cet examen a montré: 1° que l'erreur moyenne de la détermination du temps est de 3 secondes environ, 2° que malgré la grande différence de latitude géographique et aussi géomagnétique des stations Godhavn, Julianehaab et Copenhague, les premiers commencements de ce début brusque ont été pratiquement simultanés à ces trois stations, et 3° que ces indications ne diffèrent que de quelques secondes des commencements à Huancayo (Pérou) et à Watheroo (Australie).

Il signale encore qu'il interprète une différence de temps entre les commencements des variations des divers éléments à une station quelconque, tout simplement comme suite de la direction de la force perturbatrice au moment du commencement.

Vu la forme différente des courbes des diverses stations, il trouve nécessaire que l'étude d'un début brusque soit faite par une seule personne en traitant tous les enregistrements ou de bonnes copies de ce début.

Il propose à l'Association de constituer le Comité suggéré plus haut.

RAPPORT SUR LA PUBLICATION DU CARACTÈRE MAGNÉTIQUE NUMÉRIQUE DES JOURS

Par G. van DIJK

Dans la séance de la Section de Magnétisme et Electricité Terrestres de l'Union Géodésique et Géophysique Internationale du 19 août 1930 à Stockholm, les recommandations suivantes de la Commission de la Caractérisation magnétique ont été adoptées (voir: Comptes Rendus de l'Assemblée de Stockholm, p. 206):

(1) That the Geodetic and Geophysical Union recommend to the International Meteorological Conference that the Magnetic Commission of the latter body should arrange for the extension of the present magnetic character scheme by inviting all observatories included in that scheme to forward to De Bilt, along with the usual magnetic character data, a statement shewing the value for each Greenwich day of $(HR_H + VR_V) : 10000$, or in the case of observatories which record N, W and V, of $(NR_N + WR_W + VR_V) : 10000$. (N, W, H, V are, respectively, the north, west, horizontal and vertical components; R_N, R_W, R_R, R_V are the absolute daily ranges of these components).

(2) That a list of these values, as from 1st January 1930, should be published along with the usual magnetic data for each quarter.

(3) That the Section of Terrestrial Magnetism make an annual grant not exceeding £ 100 to De Bilt Observatory to meet any additional outlay involved in clerical work or printing which may be required.

A la réunion de la Commission de Magnétisme Terrestre et d'Electricité Atmosphérique de l'Organisation Météorologique Internationale à Innsbruck, les 21-23 septembre 1931, on a discuté les conclusions sus-mentionnées; on a exprimé le désir de commencer le plus tôt possible la publication des quantités recommandées et de publier non seulement ces valeurs, mais aussi les quantités $HR_H : 10000$, $ZR_Z : 10000$ etc. séparément, en raison de l'intérêt à connaître ces quantités elles-mêmes et leurs relations mutuelles. On a adopté la résolution suivante (voir: Procès-verbaux des séances à Innsbruck, pp. 264 et 265):

Ayant pris connaissance des résolutions adoptées à Stockholm par l'Association de Magnétisme et Electricité terrestres relativement à la caractérisation numérique de la situation magnétique, la Commission charge son Bureau d'inviter tous les observatoires collaborants au «Caractère magnétique de chaque jour», publié sous les auspices de la Commission, à envoyer les valeurs

$\frac{H.R_H + Z.R_Z}{10000}$ ou $\frac{X.R_X + Y.R_Y + Z.R_Z}{10000}$ de chaque jour de Greenwich et de même les valeurs $HR_H : 10000$ et $ZR_Z : 10000$ ou $XR_X : 10000$, $YR_Y : 10000$ et $ZR_Z : 10000$ séparément, conjointement avec leurs rapports habituels des caractères 0, 1 et 2 des jours.

Après que cette résolution avait été approuvée par le Comité Météorologique International dans sa séance du 5 octobre 1931 à Locarno, le Président de la Commission, M. le Professeur Ch. Maurain, a, au commencement de novembre, envoyé une invitation à tous les observatoires collaborants au «Caractère magnétique de chaque jour».

En réponse à l'invitation, plusieurs stations magnétiques ont envoyé des données à l'Institut météorologique royal des Pays-Bas. Jusqu'ici on a fait imprimer six tomes de la nouvelle publication, intitulée: «Caractère magnétique numérique des jours», dont les tomes I—V se rapportent aux années 1930, 1931 et 1932, et le tome VI se rapporte au premier trimestre de 1933. Dans les premières pages des publications, on a inséré les coordonnées géographiques et les valeurs de H et Z, ou de X, —Y et Z des observatoires collaborants.

Pour les années 1930-1932 trente-deux stations magnétiques ont contribué à établir le caractère magnétique numérique des jours. Ce sont: Abinger, Abisko, Agincourt, Antipolo, Bombay, Cheltenham, Copenhague (Rude Skov), De Bilt, Eskdalemuir, Helwan, Honolulu, Huancayo, Kakioka, Kuyper, La Quiaca, Lerwick, Lovö (Stockholm), Lukiapang, Meanook, Pilar, San Fernando, San Juan, Seddin, Sitka, Sodankylä, Swider, Toolangi, Tortose (Ebre), Tucson, Val-Joyeux, Vienne (Auhof) et Watheroo.

Vingt-quatre stations ont envoyé les listes des trois années 1930-1932; on a reçu les listes de 1931 et 1932 de Helwan, celles de 1932 de Kakioka, Kuyper et Vienne (Auhof), de 1930, 1931 et des premier et second trimestres de 1932 de Pilar, de 1930, 1931 et du premier trimestre de 1932 de Seddin, de 1930 et 1931 de Swider*) et de 1930 de Toolangi.

La plupart des stations ont envoyé des listes avec les valeurs de HR_H : 10000, ZR_Z: 10000 et (HR_H + ZR_Z) : 10000; De Bilt a présenté en outre des listes avec XR_X : 10000, YR_Y : 10000, ZR_Z: 10000 et (XR_X + YR_Y + ZR_Z) : 10000. Eskdalemuir a envoyé pour 1930 et 1931 des listes avec XR_X : 10000, YR_Y : 10000, ZR_Z: 10000 et (XR_X + YR_Y + ZR_Z) : 10000, pour 1932 avec HR_H : 10000, ZR_Z : 10000 et (HR_H + ZR_Z) : 10000. Kakioka n'a donné que les valeurs de (HR_H + ZR_Z): 10000; Meanook, de janvier 1930 jusqu'à septembre 1931, a envoyé des listes avec les valeurs de HR_H : 10000, ensuite avec les valeurs de HR_H : 10000, ZR_Z : 10000 et (HR_H + ZR_Z) : 10000. San Fernando a présenté des listes avec les valeurs de HR_H : 10000 seulement; Seddin a donné les valeurs de XR_X : 10000, YR_Y : 10000, ZR_Z : 10000 et (XR_X + YR_Y + ZR_Z) : 10000.

D'après l'envoi des listes de l'année 1932, il semblait vraisemblable que, pour l'année 1933, on pourrait compter sur la collaboration régulière de 27 observatoires, dont 26, à savoir: Abinger, Abisko, Agincourt, Antipolo, Bombay, Cheltenham, Copenhague (Rude Skov), De Bilt, Eskdalemuir, Helwan, Honolulu, Huancayo, Kuyper, La Quiaca, Lerwick, Lovö (Stockholm), Meanook, San Juan, Sitka, Sodankylä, Tortose (Ebre), Tucson, Val-Joyeux, Vienne (Auhof), Watheroo et Zo-Sè (remplaçant Lukiapang) envoient des listes avec HR_H : 10000, ZR_Z : 10000 et (HR_H + ZR_Z) : 10000, tandis que San Fernando ne présente que HR_H : 10000 et De Bilt donne en outre les valeurs, se rapportant aux composantes astronomiques X, Y et Z. On espère que San Fernando présentera bientôt aussi les valeurs de ZR_Z : 10000.

Le tome VI, paru en août 1933, contient les données janvier-mars 1933 des 27 stations mentionnées ci-dessus, à l'exception de Meanook dont on n'a pas reçu de listes. On se propose de publier de la même manière les données des trimestres suivants de 1933; afin d'éviter un retard de la publication, il est très désirable que les observatoires collaborants envoient leurs listes le plus tôt possible. Après le dernier trimestre, on publiera toutes les communications reçues après la clôture des tableaux, c. à. d. en général les données qui ont été reçues à De Bilt après le trimestre suivant le trimestre où les données se rapportent (e. a. Swider, janvier-décembre 1932; Pilar, avril-juin 1932, dont les listes ont été reçues après la publication du Tome V).

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*) Les listes de Swider de 1932 ont été reçues en septembre 1933.

Les publications «Caractère magnétique numérique des jours» ont été expédiées, conjointement avec les publications «Caractère magnétique de chaque jour», par les soins du Secrétariat du Comité Météorologique International.

De Bilt, septembre 1933.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the Agenda for the Lisbon meeting .... (Publication of magnetic character of days, by J. A. FLEMING and H. F. JOHNSTON).

QUATRIÈME PARTIE

ANNÉE POLAIRE

RAPPORT DE M. STÖRMER SUR LA FABRICATION ET LA DISTRIBUTION DES APPAREILS PHOTOGRAPHIQUES POUR LES AURORES

Comme la Section magnétique a destiné une somme de 15.000 francs or pour des instruments à l'étude des aurores boréales, j'ai fait faire en tout 17 appareils photographiques des aurores.

Au mois d'avril 1932, les appareils photographiques avaient été distribués:

1 appareil avec objectif Meyer à Fort Rae,
2 appareils avec objectif Astro à Scoresbysund,
1 appareil avec objectif Astro à Angmagssalik.

Depuis lors il a été expédié:

5 appareils avec objectif Astro à M. la Cour pour être utilisés au Groenland: 2 à Thule pour mesurer la hauteur de l'aurore, 3 à Godhavn, avec stations auxiliaires Jacobshavn et Egedesminde, pour mesurer la hauteur de l'aurore.

2 appareils avec objectif Astro à la station suédoise au Spitzberg pour mesurer la hauteur de l'aurore.

5 appareils avec objectif Astro — dont 2 ont été achetés — au Canada pour être employés au Cape Hopes Advance, à Chesterfield, à Coppermine ainsi qu'à Saskatshewan où la hauteur de l'aurore sera mesurée.

2 appareils à Lerwick avec objectif Astro pour mesurer la hauteur de l'aurore. L'un de ces appareils a été acheté.

2 appareils avec objectif Astro à Tromsö, Norvège, à la condition que les deux appareils avec objectif Meyer qui s'y trouvent soient envoyés en échange.

2 appareils avec objectif Meyer, appartenant à Tromsö, ont été expédiés aux Etats-Unis pour être employés à Point Barrow et à Nome pour mesurer la hauteur de l'aurore conjointement avec College-Fairbanks.

2 appareils Astro en remplacement d'anciens objectifs Ernemann dans des appareils appartenant à deux de mes stations près d'Oslo.

Avec ces appareils et les appareils à disposition avant le vote des 15.000 francs or de l'Union, la hauteur et la position de l'aurore boréale pourront être mesurées photographiquement aux endroits suivants:

1. Oslo, Norvège, avec réseau de 6 stations.
2. Tromsö, Norvège, station double.
3. Abisko, Suède, station double.
4. Sodankylä, Finlande, station double.
5. Murmansk, Russie, station double?
6. Spitzberg, station double, mission suédoise.
7. Lerwick, Shetland, station double.
8. Jutland, Danemark, station double.
9. Scoresbysund, station double, mission française. } Groenland.
10. Godhavn, station triple, mission danoise. } Groenland.
11. Thule, station double, mission danoise. } Groenland.
12. Chesterfield Inlet, Canada, station double, mission canadienne.
13. Coppermine, Canada, station double, mission canadienne.
14. Saskatshewan, Canada, station double, mission canadienne.
15. Fort Rae, Canada, station double, mission anglaise.
16. College-Fairbanks, Etats-Unis, station double.
17. College-Point Barrow-Nome, Etats-Unis, station triple.

En outre l'aurore sera photographiée des stations suivantes:

1. Lökken Verk près de Trondheim, Norvège.
2. Ile des Ours entre la Norvège et le Spitzberg.
3. Station en Ecosse.
4. Angmagssalik, station hollandaise. } Groenland.
5. Godthaab, station danoise. } Groenland.
6. Julianehaab, station danoise. } Groenland.
7. Cape Hopes Advance, Canada, mission canadienne.

RAPPORT SUR LA FABRICATION ET LA DISTRIBUTION DES SPECTROSCOPES D'AURORES

Une série d'essais a été faite afin d'obtenir un simple spectroscope à grande dispersion. Les prismes à vision directe ont été faits en collaboration avec la Société *I. D. Moeller,* Wedel, Allemagne, et la dispersion de ces prismes pour la lumière jaune-verte est à peu près 3 fois la dispersion des spectroscopes de poche ordinaire à vision directe. A l'aide d'un tel appareil on peut apercevoir un arc d'aurore sur un ciel serein même si le crépuscule empêche de le voir à l'œil nu.

En tout il a été fabriqué 125 spectroscopes.

Conformément à la décision du Comité, des spectroscopes ont été prêtés à divers pays, et le procédé appliqué a été en principe le suivant: avec chaque spectroscope acheté un autre spectroscope a été prêté. La distribution des spectroscopes parmi les divers pays est donnée dans l'annexe ci-après qui indique que 72 spectroscopes sont prêtés pour emploi pendant l'Année Polaire, tandis que 47 ont été vendus.

Il n'est pas possible d'établir une liste complète des endroits où les spectroscopes sont employés, mais il y a lieu de croire que les spectroscopes sont employés selon le vœu exprimé par le Comité, à savoir que le Comité préférait que les spectroscopes prêtés soient employés en premier lieu:

aux stations où l'on pourrait faire, pendant toute la nuit, des observations régulières aux heures internationales préfixées

et

aux stations à bord des navires sur les mers où les aurores ne sont pas très rares.

Les institutions ou les expéditions qui ont emprunté des spectroscopes ont signé des reçus; il faut donc se mettre d'accord sur l'emploi de ces spectroscopes à l'avenir.

ANNEXE

DISTRIBUTION DES SPECTROSCOPES

Pays	Emprunté	Acheté
Algérie	1	
Allemagne	7	8
Canada	10	10
Danemark	13	13
Esthonie	2	2
Etats-Unis (U. S. Weather Bureau)	5	5
» » (Carnegie Institution)	4	
Finlande		5
France	3	
Grande Bretagne	2	
Islande	1	
Norvège	10	
Pays-Bas	2	2
Pologne	1	
Suède (Commission Année Polaire)	4	
» (Institut Hydro-Météorologique)	3	
Suisse		2
Expédition de Pan American Airways	2	
» de l'Université de Michigan	2	
	72	47

Le soussigné en a disposé de : 2.
Reste : 4.

Copenhague, le 12 Décembre 1932.

D. la COUR.

COMMUNICATION SUR LES TRAVAUX DE LA COMMISSION INTERNATIONALE DE L'ANNÉE POLAIRE 1932-1933

Par D. la COUR

Depuis l'Assemblée de Stockholm, la Commission Internationale de l'Année Polaire 1932-1933, instituée par l'Organisation Météorologique Internationale, a tenu 3 réunions, soit à Leningrad en 1930, à Innsbruck en 1931 et à Copenhague au mois de mai 1933, chacune de ces réunions fut suivie de la publication d'un rapport imprimé sur les travaux d'organisation de l'Année Polaire. Chaque volume contient un rapport présenté par le Président de la dite Commission à la réunion en question et montre en grandes lignes comment les préparatifs à l'Année Polaire ont avancé et quels sont les projets futurs de la Commission. Des informations ultérieures sur la mise en œuvre de l'Année Polaire se trouvent dans une série de lettres circulaires envoyées par la Commission à tous ses membres et correspondants.

En me référant ainsi aux rapports imprimés et aux circulaires, je me bornerai à dire, au sujet des préparatifs à l'Année Polaire, que j'interprète le fait que l'Année Polaire a été réalisée malgré les temps les plus difficiles au point de vue économique comme une reconnaissance générale de la valeur des hauts buts qu'on s'est proposés. Ce bon accueil a été rencontré *non seulement* chez des géophysiciens actifs et auprès des institutions qui se sont adonnés au travail avec beaucoup d'énergie et qui ont procuré les moyens nécessaires, *mais aussi* auprès de plusieurs institutions qui ont prêté une assistance précieuse.

Il est tout naturel d'indiquer ici que le Président de notre Association, conjointement avec les Présidents de la Commission Internationale de Magnétisme terrestre et d'Electricité atmosphérique et de la Commission Internationale de l'Année Polaire, a envoyé une demande de collaboration à tous les observatoires magnétiques et à d'autres institutions susceptibles de pouvoir participer au programme des recherches magnétiques, électriques et d'aurores polaires, et que l'Association a subventionné l'achat de chambres photographiques d'aurores et de spectroscopes, tandis que l'Association de Météorologie a subventionné l'achat de radiosondes. C'est surtout l'Institution Rockefeller qui a soutenu les efforts de la Commission pour organiser les observations magnétiques et électriques en lui accordant (outre 10.000 $ pour des radiosondes) une somme de 30.000 $ américains pour l'achat d'instruments magnétiques et électriques; de ces 30.000 $, 5.000 $ pouvaient être versés pour les exercices des observateurs. (Pour quelques détails de l'emploi de cette subvention, voir le IIIe Rapport p. 21 et p. 24-25). Je suis persuadé que cette assistance précieuse à l'Année Polaire se montrera d'une importance considérable, aussi pour les travaux qui se feront à l'avenir, puisque l'Année Polaire, grâce à la subvention de l'Institut Rockefeller, a laissé à la postérité de nouveaux observatoires magnétiques et électriques et de nouveaux appareils à plusieurs observatories déjà existants, et qu'également plusieurs observatoires tireront profit à l'avenir des expériences acquises. Je me permets de proposer que l'Association exprime sa haute appréciation à la Fondation Rockefeller pour son appui généreux qui a été d'une valeur extrême pour les recherches magnétiques et électriques de l'Année Polaire et qui le sera aussi pour les observations ultérieures.

Quoique je ne connaisse actuellement qu'une partie relativement minime de toutes les nombreuses données recueillies, je n'hésite point à dire que les travaux exécutés pendant l'Année Polaire sont d'une si grande importance pour la Géophysique que l'Année Polaire a fait progresser notre science d'un bond formidable — ainsi que nous l'avions tous espéré. Des enregistrements magnétiques et électriques des phénomènes étendus sur tout le globe n'ont jamais existé dans une étendue aussi grande que pour l'Année Polaire et — j'ose aussi ajouter, du moins pour ce qui concerne les régions polaires — jamais avec autant d'exactitude. L'extension des enregistrements magnétiques à marche rapide et l'enregistrement des courants telluriques est d'une telle étendue que nous sommes arrivés à une nouvelle période de nos recherches. A côté de ceci, les recherches météorologiques et celles sur des aurores polaires, sur l'ionosphère et la radiation cosmique ont été faites comme jamais auparavant.

Un souvenir spécial et de reconnaissance est adressé aux nombreux observateurs qui, pendant l'Année Polaire, ont effectué un travail soigné et souvent avec de grandes difficultés. Pour les hauts degrés comme pour les bas degrés de latitude, on possède des communications sur un travail énorme et bien fait.

A sa réunion à Copenhague, la Commission Internationale de l'Année Polaire s'est principalement occupée de la question suivante: Comment la Commission, de la meilleure manière et pour tirer le plus grand profit scientifique possible du travail exécuté, prêterait-elle son assistance à la réalisation du traitement des nombreuses données de l'Année Polaire? La Commission avait antérieurement déjà fait des propositions pour la publication des observations faites par chaque pays individuellement (IIe Rapport p. 182 et suivantes), mais, outre les traitements nécessaires des observations pour donner les résultats obtenus par chaque pays individuellement, il y a des problèmes importants pour l'étude desquels les observations d'un seul pays ne sont qu'une partie et dont l'investigation effective dépend d'un traitement d'ensemble.

Comme on le verra surtout des résolutions XI et XII adoptées à Copenhague (IIIe Rapport p. 42-43), la Commission a établi un programme pour ce travail. Ce programme comporte l'organisation par la Commission d'un bureau central provisoire dont la mission serait d'organiser l'échange des observations et des enregistrements ainsi que le traitement des questions spéciales par des experts, et de soutenir des recherches ultérieures en faisant un catalogue de toutes les séries d'observations et enregistrements utilisables. — Pour atteindre ce but, la Commission recommande qu'il soit rassemblé dans des archives des copies de tous les enregistrements faits pendant l'Année Polaire et qu'un duplicata des données magnétiques soit déposé au Département de Magnétisme Terrestre de l'Institution Carnegie de Washington.

Il va sans dire que pour la réalisation de ce programme dans l'étendue proposée et exigée, il faut des fonds à la Commission, et elle a exprimé l'espoir le plus vif que «des fonds nécessaires pour l'exécution de cette œuvre très importante puissent être obtenus.» Je me permets de demander à l'Association de bien vouloir exprimer son opinion à ce sujet.

C'est avec le plus grand plaisir que j'ai déjà reçu, de quelques pays, des rapports préliminaires sur leurs travaux faits pendant l'Année Polaire. Je mentionne le joli rapport sur les travaux de la Mission polonaise à l'Ile des Ours; mais, par exemple, les enregistrements et les tableaux complets des valeurs diurnes et même des valeurs horaires mentionnés dans le rapport sur les travaux des stations magnétiques de Danemark prouvent aussi une activité et une énergie considérables. Cependant, je ne vais pas rendre compte aujourd'hui des résultats de l'Année Polaire — ce serait chose prématurée, car ce que j'en connais n'est qu'une petite fraction de l'œuvre entière.

Pour terminer, j'espère vivement que la Commission de l'Année Polaire trouvera aussi dans l'avenir les moyens nécessaires pour pouvoir prêter une assistance effective au recueil des résultats du grand travail exécuté pendant l'Année Polaire, et j'espère aussi que le Bureau Central de cette Association pourra soutenir ces efforts d'une manière utile.

LETTRE DU SECRÉTAIRE GÉNÉRAL DE L'UNION AU PRÉSIDENT DE L'ASSOCIATION DE MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES

25th July, 1933.

My dear Colleague,

The following resolution has been received from the "Commission de l'Année Polaire 1932-33", having been passed at the recent Meeting of that Commission at Copenhagen.

«*Résolution IV*. La Commission Internationale de l'Année Polaire 1932-1933 exprime sa profonde reconnaissance pour l'aide précieuse qui lui a été apportée par l'Union de Géodésie et de Géophysique Internationale. La subvention que l'Union a mise à la disposition de son Comité Polaire a été de la plus grande importance pour le succès des recherches relatives aux aurores pendant l'Année Polaire.»

I should be grateful if you would bring this resolution to the notice of any of your colleagues who are interested.

Yours faithfully,

H. St. J. L. WINTERBOTHAM.
Brigadier, General Secretary.

PARTICIPATION DE DIVERS PAYS A L'ANNÉE POLAIRE

Quelques pays ont présenté à l'Assemblée de Lisbonne des informations et des notes préliminaires sur leur participation à l'Année Polaire; ces notes font partie des Rapports Nationaux publiés plus haut.

CINQUIÈME PARTIE

COMMUNICATIONS SUR DIFFÉRENTS SUJETS

A. NOTE GÉNÉRALE ET COMMUNICATIONS DU DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON

REPORT BY THE DEPARTMENT OF TERRESTRIAL MAGNETISM CARNEGIE INSTITUTION OF WASHINGTON TO THE LISBON ASSEMBLY ON WORK DONE SINCE THE STOCKHOLM ASSEMBLY

By J. A. FLEMING

Introductory

Since the Stockholm Assembly in 1930, the Department of Terrestrial Magnetism has lost by death two of its outstanding investigators. The death April 12, 1932, of Louis Agricola Bauer, Director from 1904 and Director Emeritus from 1930 of the Department, removed from science an internationally recognized authority on geophysics. Largely through his enthusiasm and organizing ability, based on his earlier work in the magnetic survey of the United States Government, the systematic magnetic survey of the whole Earth, sponsored by the Carnegie Institution of Washington upon his initiative, was accomplished. This survey established the empirical basis of required accuracy for theoretical discussions of the origin and behavior of the Earth's magnetic field. Bauer was among those foremost in the discussion of terrestrial magnetism and of related geophysical problems, as is evidenced by his many scientific contributions. No small part of the international coordination of research in geophysics during the past 40 years may be attributed to Bauer's devoted efforts. His was an increasingly important directive influence in the progress of terrestrial magnetism throughout the period of his active labors. From the formation of the International Union of Geodesy and Geophysics at Brussels, he took active part in its development, and particularly in the development of its Association of Terrestrial Magnetism and Electricity, of which he was Secretary and Director of the Central Bureau from 1919 until the Prague Assembly, when he was elected President of the Association for the period 1924-1927.

In the death of Harlan Wilbur Fisk December 26, 1932, our fields of activity were deprived of the services of an outstanding investigator. Since joining the Department in October 1906, he had centered his activities chiefly on land magnetic-survey work, taking part in the field as well as in the office and in training many of the Department's most successful observers. In his later years as Chief of the Section of Land Magnetic Survey, he had charge of the extensive magnetic operations effected by the Department in all continents. His principal contribution came from his investigations of secular changes and of the shifting of isoporic foci disclosed by the magnetic survey on land and sea. His last work was devoted to the investigation of the possibility of determining changes within the Earth's crust or interior through the study of magnetic observations obtained on its surface. As a member of the American Geophysical Union and Secretary of its Section of Terrestrial Magnetism and Electricity during 1929-32, he contributed valuable service to national and international geophysics.

Since 1930 the efforts of the Department have been continued along the various lines reported to the Stockholm Assembly. Chief attention has been given (1) to the study of the extensive observational material in hand, including results of the survey on land and sea and from the observatories of the Department, and (2) to the development of the laboratory-attack on problems in our fields. It has been the Department's privilege to cooperate in both of these with workers in all parts of the world—cooperation which it is believed has made for material progress.

Investigational and experimental work

The investigational and experimental programs since the Stockholm Assembly may be briefly summarized as follows:

(1) The investigations of correlations between magnetic activity and the Earth's magnetic and electric fields were continued. The study of magnetic correlations with other geophysical, solar, and cosmic phenomena received great impetus through the connection as Research Associate of the Department since April 1931

of Dr. J. Bartels. From the discussion of magnetic and solar correlations it is concluded that there must exist in the Sun's surface certain restricted areas (*M*-regions), the lifetime of which is limited (up to a year), though generally longer than that of sunspots. They cause terrestrial-magnetic disturbances, very likely by emitting well-defined corpuscular streams. These solar regions, as individuals, escape the usual astrophysical means of observation (visual, photographic, and spectrohelioscopic); they can as yet only be traced in terrestrial-magnetic activity. Terrestrial-magnetic records have therefore obtained a purely astrophysical interest, beyond their well-known geophysical aspect, namely, the indication of the times when the Earth is actually under the influence of solar streams.

The determination and analysis of the magnetic lunar diurnal-variation from data for the Watheroo (from 1919) and the Huancayo (from 1922) magnetic observatories are now well under way, and a preliminary report on some of the results will be presented to the Association at Lisbon in a communication from Dr. Bartels.

The study of stereographic projection was taken up as a means of more effectively interpreting and demonstrating terrestrial-magnetic phenomena. A paper on this method was published by Bartels (see list of publications), and a preliminary communication on the stereographic representation of disturbance-vectors for several magnetic storms being investigated by W. J. Peters has been prepared for this Assembly.

(2) Investigation of the magnetic secular-variations has been continued and the areas examined were extended. The gradual accumulation of reliable data from various parts of the Earth, notably from magnetic observatories, permits a progressive refinement of the distribution of rates of secular variation. Progress in our investigations indicates how desirable it is to approach the problem from a somewhat different standpoint than heretofore adopted. Attempts to derive a satisfactory picture of the phenomenon by harmonic analysis have been disappointing, and the results of more abundant observations, with a more widely scattered distribution and covering a longer interval of time, are clearly indicating the reasons for this lack of earlier success. It now appears that superimposed upon a gradual change in the direction of the magnetic axis and the steady alteration in the magnetic moment of the Earth as a whole, which may be considered as the "true secular variation," there are other fluctuations of temporary character or having a shorter period, which should be evaluated and so far as possible eliminated before an analysis of the true secular variation can be profitably undertaken. For example, conditions associated with the cycle of solar activity indicated by the variations in

the abundance of sunspots apparently affect the annual mean value of the intensity-components derived from continuous values at observatories, and may also produce abnormal results when secular variation is obtained from single values at field-stations. Then there are other changes which have the appearance of being confined to restricted regions and which seem to run their course in a period of years; there is no present evidence that they are cyclical in character, or that the changes in one region are definitely connected with similar changes taking place in other remote regions. Obviously these changes should also be examined closely and their effect eliminated so far as possible before undertaking an analysis of the changes which presumably have their origin in causes affecting the entire Earth, and therefore constitute the true secular variation as assumed above.

Secular change for a given locality is most effectively determined from the continuous registrations obtained at that place by a standard magnetic observatory. The evaluation of the effect produced by the solar cycle can be fairly well determined for much of the Earth's surface from the present distribution of magnetic observatories, but that distribution is far from adequate to furnish the information necessary to outline the areas of regional activity. Only after there had been an accumulation of observations at widely scattered field-stations, an accumulation to which this Department had contributed very substantially, was it possible to make any approximate picture of what has been taking place over the Earth as a whole, or to obtain a comprehensive idea of this extremely important aspect of the problem. While the apparent changes in the annual rates of secular change clearly indicate that the regional activity is far from constant, the time over which sufficiently accurate data have been gathered is much too short to state what the period may be through which the phenomenon runs its course. The nature of the problem is such that substantial progress toward its solution demands that periodical observations be made at stations scattered over the whole surface of the Earth, and since in addition to the areas covered by the oceans there is much of the land-surface which is under jurisdictions wholly unable or at present indisposed to provide the means for work of this character, there still remains an urgent demand for the continuance of the work which the Department has carried on since its organization. Because of this inherent characteristic of the problem it can not well be approached by any agency or organization under governmental control of a single country whose activities are necessarily restricted by national boundaries, nor by investigators working only in laboratories, no matter how well equipped. For this reason the organization of the Department is most fittingly adapted to carry on the work in the field and is regarded as a mobile agency for correlating and coordinating the otherwise detached operations by the different countries or within limited areas.

(3) Investigations of the variability of magnetic diurnal-variation are under way. The important bearing of the magnetic diurnal-variation upon phenomena in the upper atmosphere has been recognized and investigated, in the past, by discussing nothing but the average diurnal-variations as calculated from a number of days, for example, all quiet days in a certain month. This restriction to averages, however, blocks the way to a full understanding. Generally speaking, the basis for a theoretical explanation of a geophysical phenomenon is a complete summary of the observations; such summary is incomplete if the statement of the average value or appearance is not supplemented by an account of the variability of the phenomenon. Adequate expressions and modes of description for the variability have long been derived in general statistics, and applied in geophysics. They are, however, mostly applicable in such cases only, in which each observation can be expressed by one quantity (frequency-curves) or two quantities (theory of correlation), while these methods are not readily transferred to research on periodical variations, for instance, those with the period of a solar day.

General statistical methods for research on diurnal variations, together with schemes for numerical and graphical work suitable for handling the largest possible amount of material, have been developed. The procedure has been applied to magnetic diurnal-variation at Watheroo and Huancayo observatories and has already yielded convincing results. Thus, the diurnal variation of declination at such an equatorial station as Huancayo is found to vary considerably even on very quiet days. At Watheroo, on quiet days in southern summer, the horizontal intensity has, on the average, a small diurnal variation, because Watheroo is situated in the transitional zone between the equatorial and the polar types of the variation; individual days, however, exhibit either the equatorial or the polar type quite markedly, indicating that the focus of the diurnal atmospheric current-system passes on some days several degrees of latitude south, on other days north of Watheroo. Furthermore, the passage of the focus is retarded or accelerated on some days by a few hours, and the intensity of the current varies by a large fraction of its average value; these features are indicated in simultaneous changes of the diurnal variations of declination and of vertical intensity.

(4) In the laboratory much attention was given the characteristic features of terrestrial-magnetic research, which are com-

mon to other branches of geophysical research, in comparison with those of laboratory physics. While the impossibility of keeping the relevant conditions of observation constant leads naturally to the use of statistical methods in geophysics, the policy of the Department, adopted over 15 years ago, of effecting laboratory approach to its problems finds increasing justification in the rapid development of physics and astrophysics. The Department's program in the laboratory on the basic phenomena of magnetism has been directed toward a study of the simplest interactions of the fundamental material particles of which all matter is composed. By 1931 beta- and gamma-rays had been artifically produced with energies equivalent to most of those emitted by radioactive substances using equipment previously reported upon at the Prague and Stockholm assemblies. In view of the development of the comparatively inexpensive Van de Graaff electrostatic generator in air as a source of high voltages for this type of work, the previous method of using the spark-excited Tesla coil, which involves considerably greater expenditure of effort and has not the great advantage of steady direct-current of the Van de Graaff generator, was superseded. Thus the deliberate attempt to provide a new method of attack on some of the most basic problems in magnetism by development of artificial (high-voltage) sources of high-energy particles and radiations undertaken by the Department in 1926 has been carried to a point where the technical difficulties have been overcome and its development as a research-tool has been largely completed.

A conference on this research-program was held at the Institution in October 1932 giving the Department the benefit of the suggestions and advice of a group of outstanding investigators both in the United States and abroad. The basic constituents of matter are now known to have important magnetic properties which supplement the electric forces by which they were previously known to interact. Tightly bound together to form the nuclei of atoms of the chemical elements, large energies (on an atomic scale) are required to separate these basic particles in a study of their interactions and the high-voltage methods have been used to disintegrate some of the lighter atomic nuclei yielding information on the energies involved in these particular configurations of the primary particles. A one-meter (600-kilovolt) electrostatic Van de Graaff generator was used with the cascade-type high-voltage tube developed in the Department. A laboratory specially designed to house a two-meter generator for higher voltages was completed August 1 and the generator is now being installed.

Experiments which verified the existence of the "neutron", which may be a new type of fundamental particle, were made several months after its discovery was announced in England. It is expected that the two-meter generator can be used to produce a comparatively strong source of neutrons, which will make possible a study of the properties of this new particle. Search is under way for the one-quantum isolated magnetic poles predicted by Dirac in 1931. Proof of the existence of isolated magnetic poles would be of transcendent importance in physics; obviously nothing could be more fundamental to the study of magnetism.

A study of the factors which limit the measurement of very small electric currents showed that the FP-54 vacuum-tube attains the theoretical limit of accuracy which is set by the thermal agitation of electric charges (in all materials) at room-temperature.

(5) The study of terrestrial-magnetic variations and the possible effects of such variations on radio waves and their relation to ionizing agents are sources of great promise for information about the physical state of the outermost layers of our atmosphere and thereby about cosmical influences on the Earth. The compilation of lunar diurnal-variations must be expected to give data bearing upon the ionized regions of the upper atmosphere. Observational data on the variation in height of these ionized regions following the development of the echo-method of determination in this Department in 1925 will be productive in such study. Equipments to record the heights of the upper ionized regions of the atmosphere, developed at Washington by the Department in conjunction with the United States Bureau of Standards and constructed in the Department's instrument-shop, have now been supplied to our two observatories. The installation at Huancayo is completed, and that at Watheroo is well under way. In utilizing the echo-method, radio-frequency pulses are transmitted at the rate of 90 per second and the time-delay between the echo or echoes and the ground-pulse is measured directly in kilometers by means of a synchronous oscillograph-unit. This work is especially desired at Huancayo because of the unique conditions set up by present theories on the ionized and auroral phenomena in the equatorial belt. The United States Bureau of Standards is obtaining records of variations in height of the ionized regions regularly at Washington. The original experimental equipment first used in 1925-26 by the Department was reassembled with the addition of a new oscillograph-unit and was forwarded to the Director of the Meteorological Service of New Zealand at Wellington, where it is to be used for investigations of the ionosphere by Professor Florence of the Victoria University College. It is expected Professor Florence will have the assistance of Professor Barnett, well known by reason of his work with Dr. Appleton, the actual work to be done by two postgraduate students.

(6) A photographic method has been developed for the purpose of reproducing magnetograms or other continuous photographic records made at different observatories on the same scales as regards both time and value of magnetic or other recorded element with all the minutiae of detail. In making photographic exposures of the photographic record and the resulting negative, the sensitized paper is inclined at predetermined angles depending upon the modifications required of the abscissae and ordinates, respectively, and upon the condition that the respective scales be uniform throughout the final positive. While there is no limit theoretically to the choice of ratio desired between the scale of ordinate and the scale of abscissa, the limit is fixed in practice by the depth of focus available, and the smallest stop usable, or by the number of repetitions of the operation of two exposures. Actual tests and photographic prints were made, using an experimental set-up in which the final ordinates were made about three times as long as the original with respect to the abscissae in one operation of two exposures and which fully demonstrate the feasibility of the method. The final designs of this apparatus were made and the construction of the first permanent instrument is now over 90 per cent completed.

(7) Investigations of various measures of magnetic activity have been undertaken, and in particular of the measure adopted at Stockholm in 1930 — the so-called numerical magnetic character of days. The results indicate this measure is not an altogether satisfactory one for world-wide investigation of activity, as seasonal effects of varying magnitudes influence the values obtained by this method for stations differing in geomagnetic latitude. Measures of activity derived from the sums of changes in ordinates by the ordinate-integrator developed in the Department indicate that a high degree of similarity at different observatories may be expected, particularly if through theoretical considerations relations between ordinate-change measures for observatories in greatly differing geographical locations may be obtained.

(8) Important results have been obtained experimentally in the study of the factors and laws determining ionic balance in the atmosphere and its relation to atmospheric pollution. In our atmospheric-electric studies during the past 15 years, measurements of potential gradient and of conductivity received greatest attention. Emphasis has been placed on the character of the variations in these elements and upon securing some idea of their absolute values, rather than on procuring answers to the question of why the variations behave as they do. The small ions in the atmosphere are responsible for the conductivity. The change in the number of small ions is caused by variations

either in their rate of production or in their rate of removal. Variations in the rate of removal of small ions from the atmosphere may result when they become attached to large ions and to condensation-nuclei and, therefore, studies were begun on the number and nature of these nuclei or particles. From observations at the Department in Washington, it was found that, in general, the mobility of the large ion here is greater than that found by other investigators. It appears that all condensation-nuclei are capable of becoming large ions.

The first results were based upon eye-observations, but later results were based upon continuous registrations obtained with photographically recording-apparatus. From these a full year's automatic records of large ions, eight month's records of small ions, and two month's records of intermediate ions have been obtained in the studies of atmospheric pollution. These data represent the only known series of continuously recorded measurements of these elements. The character of the diurnal-variation of large ions is shown to change with the season of the year. Comparison of simultaneous period during January 1933 of diurnal variation of small ions with that of large ions shows a remarkable reciprocal relationship between the two elements indicating that a knowledge of the large-ion content of the atmosphere is important to an understanding of the phenomena of terrestrial electricity.

Rates of ionization in a thin-walled vessel recorded continuously during the past six months in Washington indicate variation in the daily rate as much as twofold, with evidence also of a regular diurnal-variation. The rate may increase several times during a thunder-storm. Screening of the vessel shows that a greater part of the ionization is due to radiations more penetrating than alpha-particles.

(9) Good progress has been made in the investigations for improvements of instrumental design for work at sea. Upon the completion of an automatic swing for recording photographically, numerous experiments have been made for the study of dynamic deviations. These experiments have led to improvements for the marine collimating-compass, having in mind the reduction of dynamic deviations so troublesome in observations at sea. The possibilities of securing automatic registration of magnetic elements below the surface at sea or in the air away from the ship have been given much study, but a practical solution is yet to be reached. Theoretical consideration has been given to applying earth-inductor methods to measure magnetic intensity at sea, and the design of experimental equipment for investigation of this matter was completed. Some attention was given also to the design of an electromagnetic magnetometer for use on land and sea for determination

of total intensity, declination, and inclination, as well as the design of a simple device to test the sensitivity of this proposed method. These studies and those on dynamic deviations it is hoped will result in helpful suggestions for the solution of the problem of making precise magnetic determinations from a moving support under tow at sea.

Land work

Additional data much needed for the extension of the Gaussian spherical harmonic analyses of the Earth's magnetic field have been made certain by the provisions of numerous governments and private organizations to participate in the International Polar Year program of 1932-33, in the realization of which the Department has assisted. It is taking part in the operation of two special stations, namely, the College-Fairbanks Station in Alaska provided by an act of the United States Congress and a station established at Point Barrow, Alaska; the latter is practically a reoccupation of the station occupied by the United States during the first International Polar Year of 1882-83.

The College-Fairbanks Station is under the direction of the United States Coast and Geodetic Survey, and was made possible by the united efforts of the State Department, the Department of Commerce through its Coast and Geodetic Survey and Bureau of Standards, the War Department through its radio station at Fairbanks, the Navy Department through its Naval Research Laboratory, the Department of Agriculture through its Weather Bureau, the Carnegie Institution of Washington through its Department of Terrestrial Magnetism, the Alaska Agricultural College and School of Mines, the International Polar Year Commission, and contributions from individuals. Despite unavoidable delays, the buildings were constructed, the instrumental equipment was installed, and continuous registrations were begun October 1, 1932. The program is most comprehensive, including magnetic variation (sensitive, insensitive, and quick-running magnetographs) and absolute measurements, earth-current records, auroral observations, measurements of variation in magnetic vertical-intensity by the Mitchell loop-method, atmospheric potential-gradient, air-conductivity, ionic content, Aitken nuclei-counts, measurements of the height of the ionized regions of the upper atmosphere, and meteorological observations of a first-order station.

The observatory at Point Barrow, Alaska, was established by cooperation of the Department, the United States Weather Bureau, and the International Polar Year Commission. Complete instruction at Washington in the use of absolute instruments and the la Cour magnetograph was given the Observer-in-Charge, and the necessary additional equipment and appurtenances were provided. Copies of magnetograms (insensitive regular speed) and radio advices from Point Barrow indicate the magnetic program has been fully realized, as also the meteorological and auroral programs, and that the data obtained will make valuable contributions to the International Polar Year.

The Department cooperated also with other International Polar Year observatories. A magnetometer-inductor was supplied for control-observations at Cape Town, and some aid was obtained to assist the University authorities to construct the necessary building for the variation-instruments. Earth-current equipment designed by the Department was supplied to the Meteorological Service of Canada for use at Chesterfield Inlet, and a member of the Department's staff was furloughed upon the request of the Meteorological Service of Canada so that he might establish and operate the observatory at Chesterfield Inlet. One of the Department's observers spent some time at Magallanes upon the request of the Director of the Meteorological Service of Chile and instructed the observers at the Polar Year station there in certain details of control and absolute observations. Through simultaneous comparison-observations with the Department's magnetometer-inductor and the Kew magnetometer and inductor used at Magallanes, relative constants for the Observatory's absolute equipment were determined.

On account of economic conditions, curtailment of field-operations has been necessary during the past few years, but the accumulation of data by the Department has been continued through limited expeditions sent from Washington and through cooperative work with other organizations being done in South Africa, in British East Africa, and in China. During the interval since the Stockholm Assembly, observations have been secured at many of the stations on the proposed list of international repeat-stations recommended by the special committee of the Association on secular variation. Thus, two of these stations in Africa and four in China have been reoccupied. Through Department field-expeditions three have been reoccupied in Central America including the Canal Zone, and 43 of a total of 57 stations proposed have been occupied during the past three years in South America.

The cooperative arrangements with the University of Cape Town for field-work in Africa have been continued, as have also those arrangements for cooperative field-work with the British East African Meteorological Service.

The Department is also taking part in the proposed second Byrd Antarctic Expedition, which is to proceed to Antarctica late in September 1933. Observers are being trained at Washington and at the Cheltenham Magnetic Observatory, the United

States Coast and Geodetic Survey extending its facilities for this purpose. An insensitive la Cour magnetograph with necessary appurtenances has been provided by courtesy of the International Polar Year Commission, and the necessary absolute instruments both for observatory- and field-work in Antarctica by the Department.

Observatory work

The magnetic, atmospheric-electric, earth-current, and meteorological programs at the Watheroo and Huancayo observatories, and the cooperative work in atmospheric electricity with the Apia Observatory and in atmospheric electricity and earth-currents with the Tucson Observatory of the United States Coast and Geodetic Survey have been maintained. The earth-current work at Tucson was added with the cooperation of the Mountain States Telegraph and Telephone Company in 1931. As stated elsewhere, the apparatus for studies of height-variations in the ionized layers of the ionosphere was installed at Huancayo, where regular observations began in June 1933.

The preliminary values of the magnetic elements as derived from magnetograms of all days for the years 1930 to 1932 are as follows:

Year	Declination	Inclination	Horizontal intensity	Vertical intensity
(Watheroo Magnetic Observatory, 30°19′.1 S, 115°52′.6 E, 800 feet above sea-level)				
			c. g. s.	c. g. s.
1930	4°08′.0 W	64°17′.7 S	0.24633	—0.51174
1931	4 03 .2 W	64 18 .0 S	0.24646	—0.51215
1932	3 58 .5 W	64 19 .2 S	0.24652	—0.51267
(Huancayo Magnetic Observatory, 12°02′.7 S, 75°20′.4 W, 11,000 feet above sea-level)				
1930	7 36 .5 E	1 42 .7 N	0.29614	0.00885
1931	7 30 .8 E	1 50 .3 N	0.29622	0,00951
1932	7 25 .6 E	1 58 .4 N	0.29617	0.01021

Reduction and discussion of observatory-data

The compilation and preparation for publication of the magnetic data for the Watheroo and Huancayo observatories were continued. Because of an improvement in the formula for variation of horizontal-intensity scale-value with ordinate, the mean hourly values at Watheroo during 1919 to 1930 were recomputed and retabulated, thus delaying publication of the volume of the Department's *Researches* giving Watheroo results for 1919-30.

These recomputations, retabulations, and redrafting of numerous graphs requiring change were finished and final manuscript is now complete. Good progress has been made on the corresponding manuscript covering the data obtained at the Huancayo Magnetic Observatory from 1922.

Pending the completion of the work on solar and lunar magnetic variations at Watheroo, 1919-30, according to the original scheme, similar work was begun for declination at Huancayo, 1922-30. Using the experience obtained in compiling the data for Watheroo, a new scheme was devised starting with a simplified harmonic analysis for each individual day. In this way much material will be available for research on the variability of the solar diurnal-variations, its relations to the lunar variations, and its bearing on the ionization in the high atmosphere. Preliminary calculations were begun to obtain, in the manner proposed by Adolf Schmidt, the deviations of consecutive daily means from their normal values for horizontal intensity of Watheroo. They will be used in a study of the post-perturbation.

The reduction and tabulation of the magnetic results (May 1928 to Februar 1929) from the first Byrd Antarctic Expedition were completed, and the preparation of final manuscript for accompanying text and discussion was well under way. A study of the relationship between aurora and magnetic disturbance as recorded at Little America was made, involving an attempt to correlate the directions and intensities of auroral displays with the directions and intensities of simultaneous magnetic disturbing-forces; apparently the series of observations during the season of maximum auroral display — June, July, and August — was too short to establish a definite correlation. Some progress was made using the Expedition's results in an investigation on a relation between magnetic disturbances and a hypothetical ring or vortex of electrified matter circulating above the auroral zone, the probability of the existence of such a ring or vortex being suggested by the fact that magnetic disturbances are usually most violent in the regions near the auroral zones. A beginning was made on a comparison of particular magnetic disturbances as recorded at Little America and at other observatories distributed over the Earth.

The preparation of atmospheric-electric records for publication has progressed steadily. The method of electric classification or characterization of days has been discussed, and communications have been prepared for presentation before the Lisbon Assembly. Based on certain findings made while working on the calibration-data, it appeared that errors caused by variation in temperature are not sufficiently large to warrant the labor involved in applying temperature-corrections.

The compilation of reduction-factor data for Watheroo through 1930 was completed. Studies of the special potential-gradient observations obtained at Watheroo were made in connection with the discussion of reduction-factor data. In adopting values for January 1, 1934 to December 31, 1932, it was concluded that the reduction-factor observations, while generally satisfactory, do not warrant using a factor to two decimal places. This study, taking account of changes in environment and apparatus used, indicated that valuable information would be obtained from observations of space-charge at the standardizing station and that such observations should be made.

A good beginning has been made on the study of conductivity calibration-data for Huancayo for the years 1924, 1925, and 1926.

The data on earth-potentials from Watheroo, Huancayo, Tucson, and College were checked and examined when received, that a close control might be kept on factors which might escape the routine control at the observatories. The tabulation by groups as intended for publication has been kept practically current with the magnetic classification for the several observatories. The groupings of earth-current data are made on the basis of the magnetic characterization. This method was adopted some years ago after a study had showed that an independent classification, based wholly upon the character of the earth-current records, agreed so closely with magnetic classification that apparently nothing was to be gained by independent classifications of the data for these two closely related phenomena. The comparison of the diurnal variation in earth-currents on the five international quiet and the five international magnetically disturbed days was extended to include data from Huancayo for the years 1930 and 1931 and that from Tucson for the year July 1931 to June 1932. The small but definite difference found in the similar comparison of data from Watheroo and Ebro for the common five-year period, 1924-28, is apparently borne out by the Tucson data. Those for Huancayo, however, show a departure which may be perhaps associated with other peculiarities of that station.

On account of the voluminous data and great amount of computational work in the reductions of observatory-data, there is a pressing need to simplify some of the operations involved in the computations. To this end, graphical aids have been devised which have been helpful and expeditious without making any sacrifice from the standpoint of accuracy. These devices, if not to be depended on for the original computations, serve as excellent and independent checks on computations by the usual methods. Among these aids may be mentioned (1) horizontal-intensity scale-value and daily range determinations utilizing the formula $h\gamma = h\ (a + bh/2)_{mm}$ and (2) diurnal-variation determinations of ΔX, ΔY, ΔZ and ΔF from the usual differential formulae.

Magnetic standards and comparisons

Intercomparisons with the standard instruments at Washington of those instruments used in the field have been made as heretofore, both before and after field-work. The constancy of the standard instruments at Washington, upon which the provisional magnetic standards of the Department are based, has been controlled by redeterminations from time to time, and particularly by redeterminations of the moment of inertia of the oscillating magnet of the magnetometer. These determinations have again shown that the standards have been maintained with an accuracy well within the limit of error of observation.

Cooperative arrangements have been made with the United States Coast and Geodetic Survey to obtain the construction of a comparison and test building, as well as rebuilding of the absolute instruments and the provision of added facilities for intercomparisons of instrumental equipment, at the Cheltenham Magnetic Observatory. The C. I. W. standard sine-galvanometer will be installed permanently at Cheltenham for comparisons.

Since the Stockholm report, intercomparison of observatory-instruments has been obtained by the Department at the following observatories: San Juan Observatory (Puerto Rico) September 1931, Vassouras Observatory (Brazil) January 1932, Pilar Observatory (Argentina) March 1932 and July 1933, La Quiaca Observatory (Argentina) March 1932, Lukiapang and Zosé observatories (China) February 1933, and Magallanes (Chile) April 1933. Arrangements have been made for intercomparisons of standards at Cheltenham, Maryland, and at Toronto, Canada, during September and December 1933. Additional intercomparisons for the standards of the Huancayo Observatory have been obtained by comparison there of the field-equipment used by Department parties in 1931 to 1933 operating in South America.

Ocean-work

The results obtained on the last cruise of the *Carnegie* are in preparation for publication. The physical, chemical, and biological oceanographic data, in addition to those in terrestrial magnetism and atmospheric electricity, are to be published in several volumes of the *Researches* of the Department. The manuscript for the first volume, containing the physical, chemical, and meteorological results, together with numerous graphs for their interpretations, has been advanced rapidly and should be in press by the end of 1933 or early in 1934.

The charts and graphs prepared show the vertical and horizontal distribution of physical, chemical, and sounding-velocity characteristics, and also the mean relations of salinity to temperature in 14 regions of the Pacific. The current-systems at various levels down to 1,500 meters in the Pacific are illustrated by charts. Graphs have also been prepared showing the direction and velocity of the wind as based on pilot-balloon observations on the *Carnegie* at 171 stations in the Pacific. The harmonic analyses of air-pressure, air-temperature, sea-surface temperature, and relative humidity have been completed. The discussion of the barometric data indicates the differences in amplitude and phase of the waves of air-pressure over oceans, islands, and continents, and their relation to temperature-conditions. The discussion of the gravity-determinations obtained with the Vening-Meinesz apparatus during September to November 1929 from San Francisco to Apia on the *Carnegie* indicates that with minor modifications of mounting the use of this apparatus for accurate gravimetric determinations on surface-vessels is feasible.

The examination of bottom-samples collected by the *Carnegie* has been practically completed by the Scripps Institution of Oceanography and the Geophysical Laboratory. The manuscript on the investigation of the radium-content of these samples has been completed at the Geophysical Laboratory. The mechanical analyses and chemical analyses have also been completed by the Scripps Institution of Oceanography, and further physical analyses, including X-ray spectograms, will be completed in 1933.

The narrative account "Last Cruise of the *Carnegie*" of the seventh cruise of the vessel, including popular descriptions of the scientific work, by J. Harland Paul, who was surgeon and observer on board, was published by the Williams and Wilkins Company of Baltimore. This profusely illustrated volume was favorably received and widely distributed, over one thousand copies having been sold.

Publications

The publications issued by the Department since the report presented at the Stockholm Assembly include (a) annual or progress-reports covering the years ending June 30, 1931, 1932, and 1933, appearing in Year Books Nos. 30, 31 and 32 of the Carnegie Institution of Washington, and (b) over 275 articles on investigations and on special subjects contributed to scientific journals by members of the staff. A bibliography of recent publications pertaining to cosmical and terrestrial magnetism and electricity and allied subjects is regularly maintained. Reviews and abstracts of outstanding contributions to geophysics have also been published by members of the staff. A general idea of the scope of the publications issued through the Department and its personnel is indicated in the following bibliography containing some titles of interest to the Association selected from the papers published since the Stockholm Assembly.

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COMMENTS*) ON THE AGENDA FOR THE LISBON MEETING OF THE ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

III-a—*New observatories for terrestrial magnetism and electricity*

It is to be hoped that the "Commission for the selection of sites of new observatories for terrestrial magnetism and electricity" will propose several locations for *electric observatories,* and that facilities for observing will become available as promptly as possible at these sites. The work of these new stations will be especially valuable if they undertake a diversified program of work. A program which would include continuous records of condensation-nuclei, large ions, small ions, potential gradient, and detailed meteorological observations would be of the greatest value in forwarding our understanding of terrestrial electricity. With such a diversified program, furthermore, observations during disturbed periods would be at least as important as the results obtained during quiet periods. — O. W. T.

It would certainly be of great aid to the science of terrestrial magnetism could some of the Polar-Year observatories be continued. However, it is suggested that in addition to giving careful thought to the selection of suitable locations for continuing observatories, the minimum equipment that such observatories should have also ought to be thorougly canvassed. It is considered that all should have both rapid and insensitive magnetographs. In addition, it is considered that careful consideration should be given to the proper world-distribution of all rapid and insensitive sets. With optimum placement of these magnetographs much valuable information would be obtained on sudden commencements during the approaching period of increasing numbers of magnetic disturbances and also, should as magnificent a storm as that of May 1921 be repeated, instead of only a *single* complete record as happened then, we would have many complete magnetograms furnishing material for the first possible study of a severe magnetic storm. — H. F. J.

III-e—*Theoretical studies of terrestrial magnetism*

The Carnegie Institution and its Department of Terrestrial Magnetism for many years have taken the position that the

*) The initials following the various paragraphs indicate the members of the Department making comments as follows: C. R. Duvall, J. A. Fleming, S. E. Forbush, O. H. Gish, H. F. Johnston, A. G. McNish, O. W. Torreson, M. A. Tuve, G. R. Wait, and W. F. Wallis.

problems of terrestrial magnetism will never reach a really satisfactory solution until we possess an adequate understanding of the basic phenomena of magnetism itself. Dr. Barnett's work at the Department on the so-called "gyro-magnetic ratio" was undertaken at a time when perhaps no more fundamental problem in magnetism could have been enunciated. In recent years the Department's laboratory-program has been directed toward a study of the simplest interactions of the fundamental particles of which all matter is composed. These basic constituents of matter are now known to have important magnetic properties which supplement the electric forces by which they were previously known to interact. Most of the electrons, protons, neutrons, and other primary "building-blocks" of the universe are tightly bound together to form the nuclei of atoms of the chemical elements, and large energies (on an atomic scale) are required to separate them in a study of their interactions. The Department undertook in 1926 the pioneer development of high-voltage methods for fundamental studies of this type, and the progress of this work, which has begun to bear fruit, is recorded in our Annual Reports.

As an illustration of the way in which such sub-atomic studies may have very important bearing on the complex problems of geophysics and terrestrial magnetism, mention may be made of one of the investigations now under way in our laboratory. In the search for proper equations to represent the interaction of electrons with radiation, the young English physicist Dirac was led several years ago to a set of formulas which was satisfactory in most respects but which had the glaring "fault" of inherently requiring the existence of an unknown kind of particle, the "anti-electron," which would be essentially a *positive* electron. These same equations also predicted the existence of isolated magnetic poles of a certain size. To the surprise of most physicists, a new particle, corresponding almost exactly (as far as can be said from the experiments to date) to the "anti-electrons" of Dirac's theory, has been discovered during the past year. This discovery evidently lends weight to Dirac's prediction (1931) of isolated magnetic poles, and we have undertaken certain experiments, closely related to the nuclear physics program we already have under way, seeking evidence for the existence of such poles. Dirac calculates the "magnetic charge" or pole-strength of a one-quantum pole to be 3.28×10^{-8} electromagnetic unit. Dr. Tuve, of the Department's staff, has pointed out that if Dirac poles exist in nature a mechanism for the production of single particles of extremely great energy is at once obvious. The kinetic energy acquired by such a unit-pole in falling one centimeter in a field of one gauss is 20,600 electron-volts, and if it fell one meter down the field inside a solenoid producing 200 gauss such an isolated pole would acquire an energy of 410,000,000 electron-volts, and would probably produce radiation, and high-speed primary particles of all types, of a similar order of magnitude of energy, by recoil and by secondary processes. A dirac isolated pole falling from "infinity" (a few Earth-diameters) to the surface of the Earth at one of the magnetic poles would acquire an energy of 4×10^{12} electron-volts, an energy well in excess of that of the highest energy particles yet measured in studies of the so-called "cosmic rays." The trajectories of such Dirac magnetic poles in the Earth's magnetic field have not yet been considered in detail, but it appears that if Dirac's isolated magnetic poles exist, perhaps an explanation of very high energy particles striking the Earth more or less uniformly over its surface may be made along these lines without introducing the whole cosmos. The accelerations of Dirac poles by the magnetic field of the Sun and of a sunspot are among the further possibilities of interest. It may also bear mention that the possibility of a residual magnetic charge of one sign on the Earth would be of importance in the Gaussian analysis, as was in fact pointed out by Gauss himself in his original memoir.

Dirac's equations may be wrong, and isolated magnetic poles may not exist in nature, but these considerations are presented simply as an example from our current work of one type of thing we are thinking about in connection with our laboratory-program on the basic phenomena of magnetism. There can be no question but that fundamental studies, in which a given type of problem is reduced to the simplest conceivable terms, have very great importance in providing a basis for our understanding of the vastly complex world in which we live, including the problems which are the subject of our mutual efforts in the field of terrestrial magnetism. — M. A. T.

III-f—*Ion-counters, methods of use, and results*

The interpretation of measurements with small-ion counters has up to the present been a somewhat controversial matter. It is to be hoped that the report by Wait will assist toward dispersing some of the existing confusion. Measurements of small ions, whatever the design of the small-ion counter, must include a *conductivity* due to intermediate and large ions, and this may be a large part of the finally computed ion-content, unless care is taken to choose a potential for operation which is low enough to make the conductivity-effect negligible. Too often the potential is chosen a rather high value merely to assure that all small ions will be captured. — O. W. T.

III-i—*Publication of magnetic character of days*

The publication of magnetic character of days by the Meteorological Institute at De Bilt for the International Commission of Terrestrial Magnetism and Atmospheric Electricity it is hoped may be continued, since it serves a most useful purpose. That this tabulation may be of greater value, it is suggested that all observatories cooperating be asked to supply a detailed statement giving the exact significance of the character-numbers as assigned, and that this information be published. Judging from the sums of compiled activities for each month at the various observatories, there must be a wide divergence in the definition of magnetic activity for the scale used. Thus, the mean value of magnetic activity obtained from the 44 observatories which supply character-numbers may not be as representative really of the world as a whole as might be inferred. This is the case because a great majority of the observatories reporting are within a limited region in Europe and any great divergence in the significance of the three classifications adopted must necessarily influence these means. — J. A. F. and H. F. J.

V-b—*New determination of the Gaussian constants*

If there is any indication that the inclusion of new data will in any way alter the conclusions of Schmidt and Bauer that the line-integral $\int H\cos(H\mathrm{ds})\,\mathrm{ds}$ does not vanish for most selected closed lines on the Earth's surface, the new determinations should by all means be made. It seems quite possible that the inclusion of new *polar* data can hardly affect the line-integrals for well-known land-areas and for circles of middle latitude to an extent sufficient to alter the older results. This indication of a non-potential component of horizontal intensity, leading to an air-earth current of a wholly unverified and almost unreasonable magnitude, is one of the major discrepancies in our understanding of the Earth's field. Even the discovery of isolated magnetic poles would not immediately remove this difficulty, since the field of a unit-pole is a potential field, although such a possibility of "unbalanced magnetic charge" would undoubtedly alter the adjustment of the observations used for computing the Gaussian constants, and thereby might very well alter the line-integrals for circles of latitude used by Schmidt and Bauer for drawing their conclusions. — M. A. T.

The recent observations made in connection with the Polar-Year program and with data obtained on the last cruise of the *Carnegie* supply, in connection with earlier observations, better data than have ever been available for the determination of the Gaussian constants. Their more precise determination may serve to establish or discount the "non-potential" portion of the Earth's field, a phenomenon which is at present fairly well established by observation though no satisfactory physical explanation of the phenomenon has yet been offered. Furthermore, the present knowledge of corrections to be applied to field-observations, for example, correction for post-perturbation which has been pointed out adequately by Bartels (Terr. Mag., *37*, 4, 1932), will improve accuracy of existing data. — A. G. McN.

V-c—*International repeat-stations*

In addition to the broad aspect of the selection of a list of stations for regular reoccupation to obtain better knowledge of secular variations, intensive work in the vicinity of the more active isoporic foci should assist in the solution of some of the special problems involved. It is suggested that such intensive study of one of the *most active foci* be made the subject of continuous investigation on the part of a number of governments in some definite program, dividing the responsibility from year to year, thus stimulating international cooperation and avoiding excessive expenditure by any one nation. — H. F. J.

V-e—*Annual and diurnal distribution of sudden commencements*

Previous notions as to the non-simultaneity of sudden commencements have been discounted by the more accurate time-determinations made possible in recent years. It would be distinctly advantageous to their investigation were well-distributed observatories to supply regularly the following particulars for each sudden commencement observed: Time, individual changes in the several elements, and comments on unusual associated phenomena. The need of a more exact difinition of sudden commencements is apparent. Accurate times of occurrence of such features demand most careful time-control for all registrations so suitable photographic enlargements may be utilized for determination of time and where possible the use of equipment with high-speed recorder. To avoid effects due to induction in conducting media, it appears time should be reckoned at the instant the element begins to change. — J. A. F. and A. G. McN.

V-f—*Magnetic activity and characterization*

It is suggested that the divisor 100,000 be used instead of 10,000 in the computation of the numerical magnetic character-numbers. This will amount to reducing the number of figures by one, a substantial saving in time and effort, with little if any loss of value. The monthly means of these reduced numbers should be carried to tenths, as is already done at most of the observatories for numbers ten times as large. — C. R. D.

In a communication to the Assembly at Stockholm, C. R. Duvall reported on some magnetic measures using an ordinate-change integrator. Using this device on the records obtained at Watheroo (Australia) and Huancayo (Peru), he determined the sum, in gammas, of the absolute changes in the horizontal and vertical components and in the component at right-angles to the magnetic meridian, for each Greenwich mean date in March 1927. For each day and each observatory two numerical measures of activity were given, each depending on the measured changes in the three elements. The correlation-coefficient between the 31 values at the two observatories was found to be 0.94 for one measure and 0.93 for the other. Using as a measure of activity only the data obtained from Duvall's measurements on the horizontal-intensity trace, the correlation-coefficient between the 31 values at the two observatories is found to be 0.92. The close agreement with Duvall's values indicates that apparently little gain is effected by deriving an activity-measure from all three elements instead of from the horizontal intensity alone. — S. E. F.

The absence of a definition of magnetic activity complicates the formulation of a measure of it. As has been frequently pointed out, a regularly progressing diurnal-variation is not regarded as activity, nor is the absence of a regularly progressing diurnal-variation to be so regarded. The following definition is proposed: Activity is a characteristic of the diurnal magnetic variations which prevents the curves from being closely fitted by a few harmonics and a linear trend. A further definition of the words "few" and "closely" is required, but these may be derived from actual experience. The measurement of activity according to this definition would be a complicated process. However, such approximations to it as the method of ordinate-integration (see C. R. Duvall's paper presented at the Stockholm meeting) should fully satisfy the requirements. Most of the measures of activity already in use are based upon the thought underlying the above difinition. Unfortunately, some of them are very susceptible to changes in the regular diurnal-variations from day to day and season to season. — A. G. McN.

V-j—*Equipment for study and for recording of cosmic rays at fixed stations and possible relations to terrestrial magnetism and electricity*

Although there appears to be no relationship between fluctuations of the cosmic radiation and fluctuations of the terrestrial-magnetic field, the assumption that no such relationship exists is unwarranted. It is quite inconceivable that the magnetic diurnal-variations could appreciably alter the cosmic-ray intensity on the basis of the Lemaître-Vallarta hypothesis. However, the fields about the Earth during a magnetic storm are generally assumed to be such that an effect on the cosmic-ray intensity is to be expected which should be revealed by statistical investigations. The proof of the presence or the absence of this effect would have an important bearing on the validity of cosmic-ray and magnetic-storm theories. This feature is of sufficient significance to warrant the continuous recording of cosmic-ray intensity by institutions interested in the furtherance of terrestrial magnetic investigations. — A. G. Mc N.

V-k—*Possible arrangements for amateur recording of auroral displays*

Now that the Association has published auroral atlases, it seems that the long experience of scientific observers of auroral lights might be furthered by encouraging observations and records of such displays by amateur observers. Such work, if systematically planned, should go far towards giving needed material for a catalogue of aurora. Such a catalogue would be of use in correlation-studies of other geophysical and cosmical phenomena. — J. A. F.

V-l—*Ionization and diurnal-variation of the conducting regions of the high atmosphere and their relations to terrestrial magnetism and electricity*

It is suggested that nomenclature in regard to the ionized regions of the upper atmosphere should not be crystallized definitely as yet. It would seem advisable to place this matter in the hands of an international committee for discussion before any resolutions are adopted. As a provisional expedient it appears satisfactory to refer to the Earth's atmosphere in problems relating to its behavior as an ionized medium as the *ionosphere* and to continue, and to expand if necessary, Appleton's designation of certain regions by the letters "E", "F", etc., but the facts at present indicate a degree of unknown complexity which might make any international conventions on the subject very much of a hindrance rather than a help.

The term "region" seems preferable to the term "layer" when referring to a considerable range of virtual heights, regardless of whether names or letters are used. The term "layer" might be used only in connection with the apparent and sharp increases of ionization with respect to virtual height which are observed. — M. A. T.

Possible advances in knowledge of the causes of diurnal-variation in the Earth's magnetic and electric fields promise to be extended enormously by the application of radio waves to determine the heights and existing ionization of the conducting regions of the high atmosphere. Following its original development and researches made in 1925, the Department has felt it desirable to provide its two observatories with suitable equipments for such investigations. The pulse-retardation method devised by Breit and Tuve is utilized in these with improvements later developed at the United States Bureau of Standards. Two communications from the Department give brief notes regarding the designs used. The first 24-hour run obtained at Huancayo shows interesting results. As was reported to the International Electrical Congress at Paris in July 1932, the diurnal-variations in the north, east, and vertical components of the Earth's magnetic intensity at this station are unusually large—several times as large as those computed from the coefficients deduced by Chapman in 1919 from an analysis of the data from 19 observatories. It is hoped that the ionized-layer observations to be made at Huancayo in the coming year will assist in solving this outstanding anomaly; it is felt of importance that records from stations in other latitudes (Washington, Watheroo, Tromsoe, etc.) should be maintained and that the Association may lend any assistance possible to accomplish this, for example, by a suitable resolution emphasizing the desirability of so doing. — H. F. J.

V-m—*Correlation of the terrestrial-electric field with conductivity of the air*

This item is of particular interest to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington as it appears to deal directly with results on the two identical elements which have been recorded for several years at its observatories. Recent discussion of potential-gradient and conductivity results at Watheroo gave some indication, on inspection, of the nature and extent of the correlation that might be obtained by mathematical treatment of those Watheroo data, and it will be illuminating to have Mr. Smosarski's treatment of his data and to learn the nature and extent of his correlation. — O. W. T.

V-n—*Numerical characterization of electric field*

The numerical characterization of electric field has been dealt with in several separate communications from the Department. It seems desirable that representatives of all electric observatories should submit a discussion of their local problems in relation to the atmospheric-electric elements which they are recording or measuring. Such discussions, presented to an international committee, would be of the greatest value in assisting toward the formulation of international character-figures for the electric field. Not until a considerable group of observatories has thus provided a basis for considering the world-wide aspects of characterization, should any code of character-figures be adopted for international use. — O. W. T.

In the preliminary compilations that have been furnished by the observatories at Watheroo and Huancayo, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, hourly values are scaled from the continuous photographic records. As is the practice at some other observatories, the days are characterized electrically and divided into three classes. Those days of no negative potential-gradient are designated "0", those with less than three hours of negative potential-gradient "1", and those with more than three hours of negative potential-gradient "2". The observatory-staffs also select those "0"-days which in their estimation should be meaned in order to obtain hourly values which would be a first approximation to the representative curve for the particular month. Such a system of classification and selection is useful to other investigators and serves as a guide in their studies of particular atmospheric-electric problems. It is considered that observatories which have classified the days from the electrical point of view should publish their classification giving full information concerning their method of carrying out the characterization.

While local conditions at the various atmospheric-electric observatories are so different as to make difficult the selection of a system of classification that will suit all locations, yet it should be possible to devise one universally applicable, which if selected and sponsored by the Association of Terrestrial Magnetism and Electricity would be of great advantage. While the system mentioned above is simple and easily applicable, and withal corresponds somewhat to the magnetic classification of days, yet further information would be advantageous. Most of the "0"-days are included in the mean, yet some are so much disturbed that they must be discarded; on the other hand, some "1"-days are so slightly disturbed that they should be included in the selected days. Hence, days satisfactory for selection should be indicated by a common symbol, for instance, an asterisk, and the amount of disturbance that limits the selection should be published. The characterization above indicated is substantially in effect at Ebro, where four classes of days are employed (0, 1, 2, and 3), and also at Eskdalemuir by the suffix of the letter *a* to the character-numbers 0, 1, and 2.

When selecting days for the monthly mean, not only should all available "0"-days be examined but also the "1"-days. This is necessary particularly for a station where during certain seasons of the year few "0"-days are available. For example, at Huancayo (Peru) during January to April and September to December, 1932, there were only 16 "0"-days. An examination of the "1"-days showed 33 of them were suitable for selection, thus bringing the total to 49 days. The resulting values for the electric elements for the 16 days are 47 volts per meter, 4.31×10^{-4} electrostatic unit, and 4.25×10^{-4} electrostatic unit, against values for the 49 days of 49 volts per meter, 4.42×10^{-4} electrostatic unit, and 4.32×10^{-4} electrostatic unit, for potential gradient, positive conductivity, and negative conductivity, respectively. The result might also be adduced in support of a recommendation that in monthly tabulations of hourly values two means be shown, one for all complete days irrespective of classification and the other for the days as selected by the compiler.

The meteorological elements such as rain, fog, mist, haze, dew, clouds, and thunder-storms, and artificial disturbing-elements such as smoke, affect the atmospheric-electric elements to a large extent. It is suggested that a careful meteorological log should be kept at all atmospheric-electric observatories. Such a detailed log written up at two-hour intervals would be invaluable in analyses of the results. — H. F. J.

The two communications (1) by O. H. Gish and (2) by O. W. Torreson on electric characterization are submitted by the Department in the hope that the two view-points may stimulate any discussion of the Association in formulating a method which will meet the needs satisfactorily. The first is based solely on an inspection of the electrograms, while the latter is based according to the cause of the recorded degree of disturbance as regards prevailing meteorological conditions for the day, with the reservation that any two hours of disturbed record may be interpolated over if the record is otherwise undisturbed. There is agreement that the system of characterization tentatively adopted by the Department several years ago is not satisfactory in that it totally neglects large positive departures from the so-called normal. The first is a modified system which characterizes such departures "exceeding twice the mean of day" as "1" or "2" according to duration. This is a helpful change as regards records typical of Watheroo but does not seem applicable to those typical of Huancayo, and presumably of other high-altitude stations. Thus, at Huancayo the so-called normal day nearly always has a positive departure exceeding twice the mean of day, and there would therefore in this system be no "0"-days. Therefore, to make a definite standard for characterizing large positive departures that will meet world-wide conditions may be difficult unless we go back to the source of the departures and base characterization according to the cause of departure rather than according to the departure itself. On the other hand, a characterization based on perturbations may be representative of the normal conditions for a given station. It might be well before giving a definite basis of perturbation-characterization to make sure that the type of perturbation is not really to be attributed to some particular cause not really electrical in nature, for example, possible wind-effects in the case of the symbol suggested for "r"-perturbations. At Watheroo there would be apparently few if any "s"-days. The "p"- or "q"-definitions would probably be rare. — J. A. F.

V-o—*Study of storms and lightning*

Because of its comparatively low damping, the la Cour magnetograph at the Huancayo Magnetic Observatory shows in its records marked effects of lightning-discharges. Assuming that the variometers behave as suspended-magnet type ballistic galvanometers, computation of the charges passing during the lightning-flashes are found to be of approximately the same magnitude as obtained by other methods of investigation. Theoretical considerations lead to the view that Maxwellian displacement-currents also are to be taken into account in the calculations. This offers apparently a unique means of determining the charge passing during a lightning-flash. — A. G. McN.

It is a matter of considerable regret among magneticians that the details of many of the most severe magnetic storms of the past have been lost on the records through failure to provide sufficiently insensitive instruments. Similarly, students of atmospheric electricity are beginning to regret the lack of records during thunder-storms occasioned by the failure to provide sufficiently insensitive instruments. There is no doubt that very valuable results would be obtained if every observatory which measures potential gradient would have, in addition to its usual sensitive instrument, an extremely insensitive recorder which would record during thunder-storms. Our knowledge of storms and lightning would thereby be greatly assisted. — O. W. T.

Dep. Terr. Magn., C. I. W., August 30, 1933.

MULTI-FREQUENCY MEASUREMENT OF VIRTUAL HEIGHTS OF THE IONIZED REGIONS OF THE IONOSPHERE

By L. V. BERKNER

A continuation of the studies of the reflections of radio waves has yielded much additional information regarding the electrical structure of the upper atmosphere. Recently the method of these studies has tended advantageously toward a procedure of rapid changes of transmitted frequency at which the measurements are made, throughout the frequency-range returning reflections. Such investigations result in curves giving virtual heights and critical frequencies of the various ionized regions, together with additional information of the structure of the ionosphere. When the critical frequency is known to be the frequency which just penetrates a layer, as is the case with all but the highest layer, it can be used to compute the maximum ionization of the layer. These values are of great importance in the study of correlations in the fields of terrestrial magnetism and atmospheric electricity and in determining the magnitude of changes that may be expected from the effects in various layers.

The results over a period of years obtained at Washington by this method have recently been presented (see Kirby, Berkner, and Stuart, Studies of the ionosphere and their application to radio transmission, Bur. Stand. J. Res., vol. 9, Oct. 1933). An interpretation of the critical frequencies and virtual heights indicates that during the summer day three regular major layers are present — the E-layer at about 100 km virtual height, the F_1-layer at about 180 km virtual height, and the F_2-layer at about 250 km virtual height. During the winter noon and summer afternoon the critical frequency for the F_1-layer becomes indistinct, disappearing at night, and indicating that the F_1- and F_2-layers may merge into a single F-layer under these conditions. The regular maximum ionizations of the E- and F_1-layers are found to vary seasonally and diurnally with the incidence of the Sun's rays, which leads to the conclusion that the major source of ionization is due to ultraviolet radiations of the Sun. This is shown more conclusively in the results of the solar eclipse, 1932 (see Kirby, Berkner, Gilliland, and Norton, Radio observations of the ionosphere at the U. S. Bureau of Standards during the Solar Eclipse of 1932, Bur. Stand. J. Res., vol. 9, Oct. 1933), in which the maximum ionization of these layers was found to vary inversely with the phases of the eclipse. The E-layer is found to have occasional sudden high ionizations which do not appear to be associated directly with the Sun. The retardations characterizing the F_1 critical frequency appear to be associated with magnetic activity, with such retardations much greater and absorption higher during magnetically disturbed periods. Additional layers are found to appear at irregular intervals. The critical frequency of the F_2-layer does not vary directly with the incidence of the Sun's rays, but is found to be higher in winter than in summer, to have a diurnal characteristic with the maximum shifting from noon in the winter to evening in the summer, and to be subject to rapid variations not evident in the lower layers. No unusual variation of this critical frequency was found during the solar eclipse of 1932. It is evident that additional factors must be introduced to explain these phenomena. Such changes suggest an ion-distribution which would cause complete absorption in this layer before penetration occurs, during part of the day at least. In general, these variations are so complex as to require statistical study of a long series to disclose any relation to other geophysical phenomena. The average winter maxima of F_2 critical frequency during the past four years, however, show a continual decrease.

Preliminary ionosphere-observations by H. W. Wells at the Huancayo Magnetic Observatory indicate that the general character of the F-region is to some extent similar to the character of this region at Washington, as shown by the results of the Bureau of Standards during a time of equal incidence of the Sun's rays. First results indicate that what appear to be the two rays due to magnetic double refraction from the F_1-layer are returned with more nearly the same order of magnitude than is usually the case at Washington. The location of this station at the magnetic equator and its relation to the chain of stations established and being established at other strategic positions will make its observations of unusual interest.

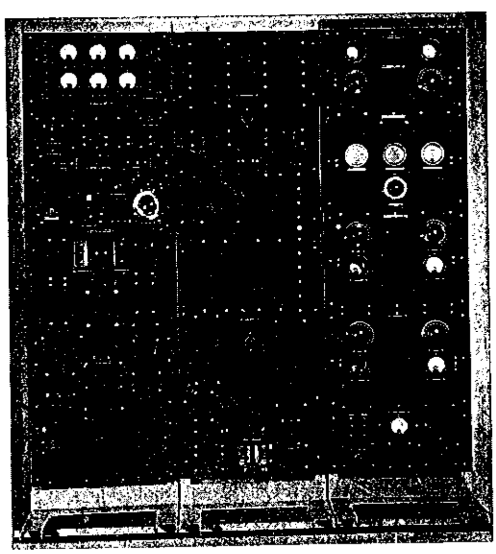


Fig. 1 — Manually operated multi-frequency radio receiver and transmitter at Huancayo Magnetic Observatory, Peru

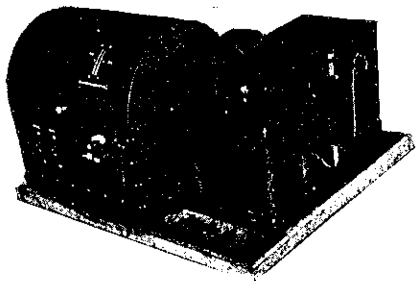


Fig. 2 — (a) Direct measuring oscillograph for ionosphere virtual heights with screen for manual measurements (the screen may be replaced with special camera for continuous recording)

The equipment (see Figs. 1 and 2) for these observations at the Huancayo Magnetic Observatory has recently been placed in operation by the Carnegie Institution of Washington through its Department of Terrestrial Magnetism. A second similar equipment is being installed at its observatory at Watheroo, Western Australia. The equipment was designed in collaboration with the Radio Section of the United States Bureau of Standards around the design which they have used for manual measurements for a number of years. The detailed design and construction of the equipment was under the supervision of C. Huff of the instrument-shop of this Department and include such features as have been found desirable in the maintenance of such equipment operating at isolated observatories. It is assembled of individual units in panel-form, mounted on relay

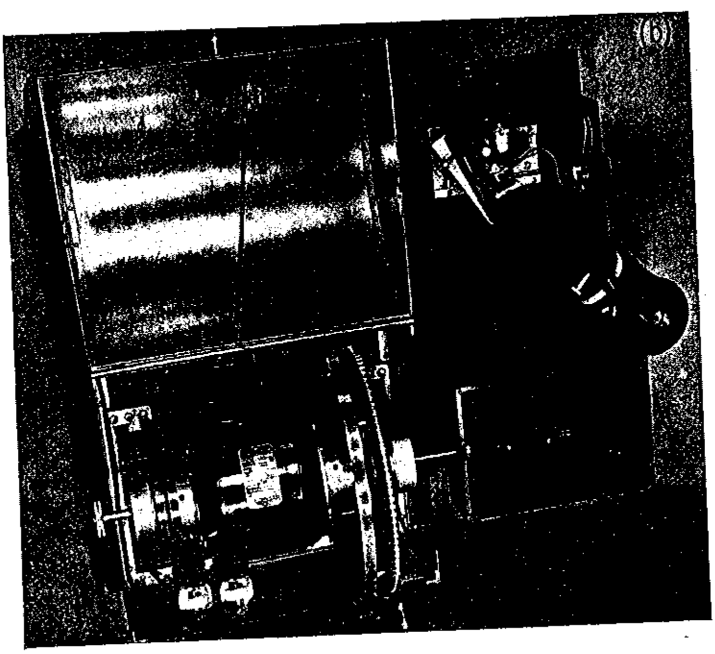


Fig. 2 — (b) Same with covers opened and screen removed

racks for accessibility, and is arranged for easy modification with changing requirements such as may be encountered in problems of continuous recording.

This equipment consists of a radio transmitter, receiver, and direct-measuring oscillograph. An engine generator-unit furnishes power to the equipment. The transmitter consists of a lightly loaded oscillator, an intermediate, and a power-amplifier, in which either the intermediate amplifier or oscillator can be pulsed. The multi-circuit transmitter limits the frequency-band of the emitted wave to the fundamental and such side-bands as are necessary to the formation of a sufficiently short pulse. Pulse-distortion and scattering due to frequency-dispersion, which is especially noticeable at critical frequencies, is thus largely avoided, and interference is reduced. The receiver is a superheterodyne with the intermediate amplifier tuned as sharply as is consistent with the necessary sharpness of the pulse. Excessive sharpness of tuning is avoided because of spurious lengthening of the pulse due to lack of proper circuit-damping. A linear detector drives a direct-current amplifier which is arranged in the form of a bridge, of which the oscillograph galvanometer-element is one leg. The galvanometer-element is normally under an electrical bias, so that during deflection it is accelerated electrically, during both its rise and fall. With this arrangement, the element executes a forced oscillation of a period determined by circuit-constants of the receiver. The oscillograph consists of a small synchronous motor driving a mirror which distributes the light-beam from the galvanometer to the screen. The power for this unit is obtained from a constant-frequency tuning-fork controlled source, which also pulses the transmitter. As a result, the reflection-pattern is stationary on the screen, A micrometer-screw calibrated directly in kilometers meshes a helical gear which rotates the frame of the motor so that each reflection is measured directly as it is brought to a reference-line. The addition of a camera

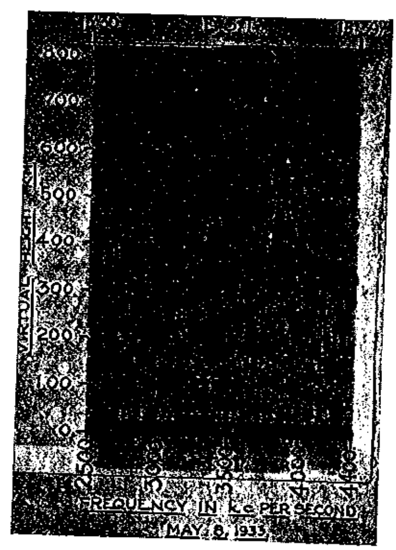


Fig. 3 — Multi-frequency virtual-height record at Washington with continual variation of frequency through range shown (Reproduced by permission of the United States Bureau of Standards)

with a film moving slowly along the axis of the deflections allows the continuous recording of virtual height.

There has been recently developed and described (see T. R. Gilliland, Note on multi-frequency automatic recorder of ionosphere virtual heights, Bur. Stand. J. Res., vol. 9, Oct. 1933) by the United States Bureau of Standards at Washington an experimental apparatus which records the relation of virtual

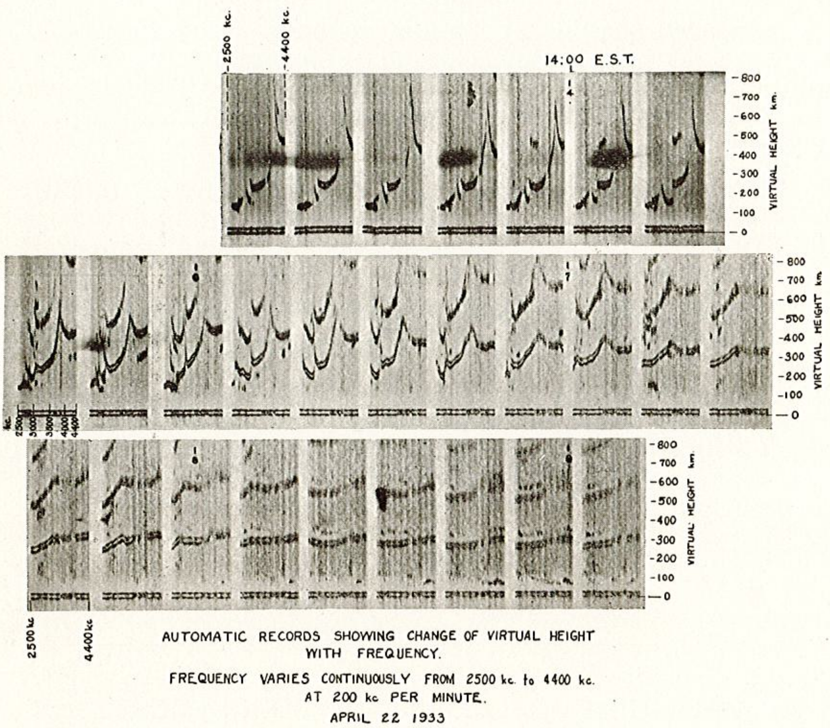


Fig. 4 — A sequence of multi-frequency virtual-height records during an afternoon (Reproduced by permission of the United States Bureau of Standards)

height to frequency through a band of frequencies. The method of Breit and Tuve, consisting of the transmission of a pulse which is short compared to the time required for the return of the reflection, is applied to a radio transmitting equipment whose frequency varies continuously and uniformly throughout the desired range. The transmitting and receiving equipment is in the same building. The resonant frequency of a radio receiver is varied with the transmitted frequency by means of a common driving shaft and causes the reflections from the ionosphere to deflect an oscillograph which records the virtual height of the reflections on a slowly moving film. This results in a record, as shown in Figure 3. A sequence of such records during a day is illustrated in Figure 4. The pulsing-frequency is chosen below a noise-frequency so that the interference created is negligible, while the transmitted frequency changes a few hundred cycles between each pulse to obtain records of sharply defined phenomena. Such records delineate changes in the features of the ionosphere very much more completely than has been possible by manual methods, and with comparative ease, leaving nothing to the judgment of the observer. Similar records obtained in this manner at strategic locations can be made available for comparison over an extended period of years.

It is planned that in the near future the necessary modifications will be made in the radio equipment at the Huancayo and Watheroo observatories to obtain a continual sequence of records in a manner similar to that just described. The present sequence is to be continued by the United States Bureau of Standards at Washington. The frequency-range will be extended to include a larger part of the range returning reflections. A properly arranged series of such determinations over an extended period offers the opportunity of statistical investigation which will result in a better understanding of the relation of this region of the atmosphere to geophysical and cosmic phenomena.

Dep. Terr. Magn., C. I. W., July 17, 1933.

MEMORANDUM ON THE USE OF FIXED-FREQUENCY VIRTUAL-HEIGHT RECORDS IN CORRELATIONS WITH OTHER GEOPHYSICAL PHENOMENA

By L. V. BERKNER

Since the developments of methods for the study of the ionosphere, a great deal of interest has been evinced in the correlation of ionosphere-changes with other geophysical phenomena. Methods of observation are largely classified into two types, namely, (1) continuous observation at one frequency and (2) rapid observation at a large number of frequencies during a short period of time.

Both methods are capable of use for automatic recording, and, while the latter method gives by far the most complete and useful picture of the structure of the layer, the former method has been adopted by many observers because of its greater simplicity and convenience, particularly in isolated locations.

It is of interest to examine the information obtained in fixed-frequency records of the ionosphere and the extent to which these records can be interpreted in the absence of other data, and to determine the precautions which must be observed in the valid correlation of such records with other physical data. The curves of virtual height against frequency shown in Figure 1 are drawn for an average day in spring or autumn according to the present available information at Washington, D. C. From these may be deduced an approximate layer-structure as shown beside each curve. The actual heights of the layers given in the approximate structure are only roughly estimated as about the value of the lowest virtual height of each layer when such heights are observed to be quite constant within a band of several hundred kilocycles. The relative positions of the layers, however, can be more closely estimated from the shape and variations of the multi-frequency virtual-height curves. The diurnal variation of the virtual height at a single frequency can now be obtained from Figure 1, together with the approximate variation in actual height. These are plotted in Figure 2 for two frequencies ($f_1 = 4{,}100$ kc and $f_2 = 4{,}250$ kc). The curves in Figure 2 show the form of record that would be obtained on a single frequency compared to the approximate actual heights which this record represents. The comparison of the records of virtual heights on two adjacent frequencies (in this case differing by 150 kc) shows them to be quite different.

The non-proportionality between virtual and actual height exists because of the movement of the critical frequencies with ionization and recombination in the layers. For the cases chosen in the morning the reflections of the ordinary ray are returned from the F_2-layer, while very small reflections of the extraordinary ray are returned from the F_1-layer. As ionization of the F_1-layer increases as the morning progresses, the F_1 critical frequency for the ordinary ray increases, causing abnormal retardation on the recorded frequency, though the actual height from which the reflections are returned is decreasing during this period. As the critical frequency passes above the recorded frequency as noon is approached, the virtual height falls toward F_1-layer virtual height. In the afternoon the process is approximately reversed. The two cases selected for frequencies spaced by only 150 kc show that the two records may appear quite different although the variations are caused by essentially identical layer-changes. (Note: The symbols used have the following significance: E = height of reflections ordinary ray from E-layer; F_1 = height of reflections ordinary ray from F_1-layer; F_1 = height of reflections extraordinary ray from F_1-layer; F_2 = height of reflections ordinary ray from F_2-layer; F_2 = height of reflections extraordinary ray from F_2-layer; f_E = E-layer critical frequency; f_{F1} = F_1-layer critical frequency for ordinary ray; f_{F1} = F_1-layer critical frequency for extraordinary ray; f_1 = fixed recording-frequency 4,100 kc; and f_2 = fixed recording-frequency 4,250 kc.)

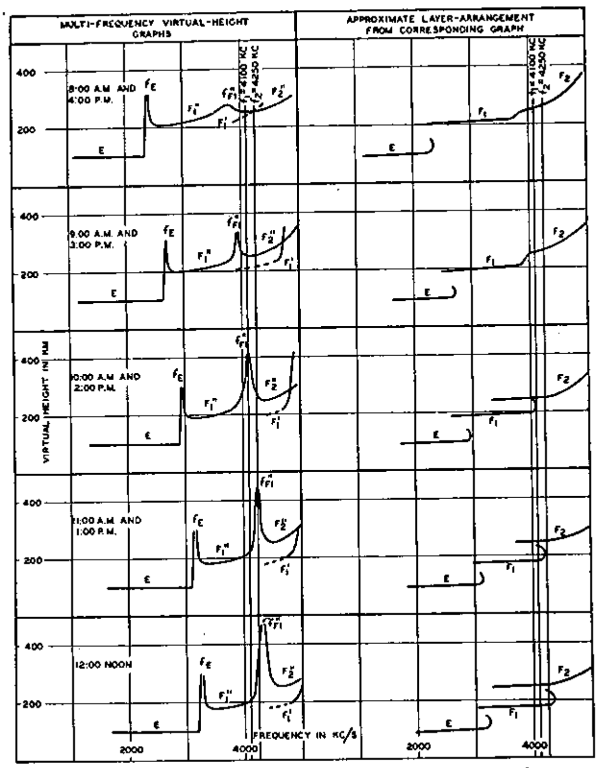


FIG. 1 — MULTI-FREQUENCY VIRTUAL-HEIGHT GRAPHS IONOSPHERE FOR CERTAIN DAYLIGHT HOURS ON NORMAL SPRING OR AUTUMN DAY AND DEDUCED APPROXIMATE LAYER-STRUCTURE WHICH THEY REPRESENT

These comparisons show that any assumption that the virtual height is a direct function of the actual height may be seriously in error. An increase in virtual height on a fixed frequency may represent either an increase or decrease in actual height of the layer returning reflections depending upon the relation of the recorded frequency to the adjacent critical frequencies. Neither can it be said that the virtual height on a fixed frequency, during a period in which no rapid virtual-height fluctuations are taking place, is necessarily an approximate measure of the actual height.

If the normal location and movement of critical frequencies adjacent to the recorded frequency are known for a certain place and season, the movement of such critical frequencies together with the retardation-phenomena occurring with them can be deduced from the fixed-frequency record. During periods of erratic height-variation, however, it is impossible to determine from single-frequency records whether abnormal heights are due to (1) fluctuation of a normal critical frequency due to

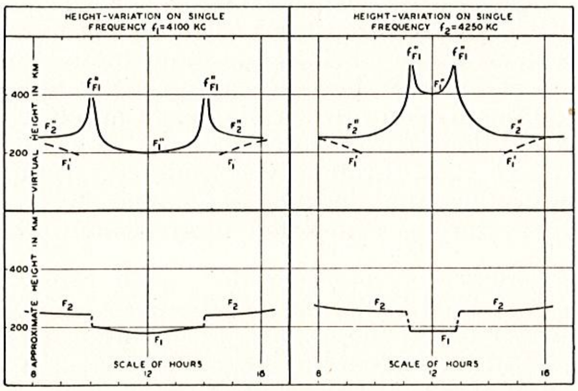


FIG 2—DIURNAL VARIATION VIRTUAL HEIGHT RECORDED ON SINGLE FREQUENCY TAKEN FROM FIGURE 1 FOR FREQUENCIES f_1=4100 KC AND f_2=4250 KC, COMPARED TO APPROXIMATE ACTUAL HEIGHT-VARIATION OBTAINED FROM APPROXIMATE LAYER-STRUCTURE

varying ionization, (2) the appearance of a new critical frequency due to an unusual additional layer, (3) abnormal group-retardation due to a changed ion-distribution, or (4) an actual increase in the height of the layer. Unusual erratic height-variations therefore only indicate the existence of some unusual condition, at least until such time as it is possible to determine which of these conditions is most likely to occur.

It must be concluded, therefore, that in attempting a correlation of ionosphere-measurements or records at a fixed frequency with other phenomena, certain precautions must be observed. These are: (1) The actual height cannot be assumed a direct function of the virtual height; (2) the rate of change of actual height is ordinarily not a function of the rate of change of virtual height; (3) a partial interpretation of actual layer-conditions can only be made if the relation of the recorded frequency to the normal adjacent critical frequencies has been determined by a periodic procedure of sweeping through the frequency-band returning reflections; (4) during periods of unusual height-variation, no interpretation can be made other than the assumption of unusual general conditions, in the absence of multi-frequency data during the disturbed period.

Dep. Terr. Magn., C. I. W., August 7, 1933.

NUMERICAL MAGNETIC CHARACTER-NUMBERS

By C. R. DUVALL

In the Journal of Terrestrial Magnetism and Atmospheric Electricity (vol. 37, 261-267, 1932) the seasonal change of numerical magnetic character-numbers was examined by means of a Fourier analysis. The first and second terms of an analysis were tabulated for the 12 monthly means of these charater-numbers for each of the years 1930 and 1931 at 17 observatories. Dr. Egedal's communication for Lisbon on the numerical magnetic character-numbers brings up some interesting questions in this connection, and therefore a further analysis has been made of additional data now available. "Caractère Magnétique Numérique des Jours," Tome III, makes it possible to add ten observatories to those originally considered. Tome IV is also at hand, giving results through September 1932, but no additional observatory is completed for 1930 and 1931.

For convenience of reference the results already published have been combined with the new analyses in Table 1. The observatories added in the analyses are Abisko, Lerwick, Lovö, Eskdalemuir, Meanook, Seddin, Świder, San Fernando, Antipolo, and Pilar. The results at Eskdalemuir and Seddin are computed from ranges in the three rectangular components X, Y, and Z, and those at Meanook and San Fernando from H-ranges only. To get some idea of what differences might be expected in the analyses of numbers derived in these three ways, the (XYZ)- and (H)-values were also analyzed for De Bilt and the coefficients are placed beneath those for the usual (HZ)-analysis in Table 1.

The question arises here whether the numerical character-numbers based on H-ranges alone might not be sufficient for all purposes. Judging from the results of the analyses at De Bilt and Meanook, one might be led to believe that they would, but San Fernando would give rise to some doubt. In view of the great saving in work, an investigation of this question using the data already at hand might well be undertaken.

The monthly means were analyzed as given in the De Bilt publications, rounding off to the units place and disregarding non-cyclic change and inequality in length of month. The unit of the amplitudes is accordingly the unit given in the publications. Before discussing the results in Table 1, it will be well to call to mind that the monthly means of the international character-numbers reach maximum values in April 1930 and October 1931. With few exceptions this is true of the monthly means, at the different observatories, of the numerical character-numbers.

It is believed that the results in Table 1 justify the assumption, made in subjecting the monthly means to a Fourier analysis, that there is an annual period in these numbers. For nearly all the observatories in the north the first term reaches its maximum early in June in 1930. Nearing the equator the time becomes earlier, and precedes the vernal equinox for all points south. That is, in 1930 the first term reaches its maximum at all observatories when the Sun is on the same side of the equator as the observatory. In 1931 there are nine exceptions to this, all in the north, and mostly in the far north. The distance on the opposite side from the Sun is most at Antipolo, about a month, nearly as much at the far northern observatories of Abisko and Sodankylä, and only a few days at the other six. It seems rather striking that a point near the equator, like Antipolo, should be so different from other points of roughly the same latitude, but for the year 1931 there is a remarkable change in the time of the first term from that of 1930.

Table 1 — *Amplitudes and phase-angles for monthly means of numerical magnetic character of days*

Observatory	Latitude north	Year 1930				Year 1931			
		c_1	c_2	φ_1	φ_2	c_1	c_2	φ_1	φ_2
Abisko	68.4°	769	387	289°	272°	655	322	160°	262°
Sodankylä	67.4	548	476	296	269	590	295	160	244
Lerwick	60.1	382	225	298	256	240	154	177	253
Lovö	59.4	198	178	298	236	137	100	175	239
Sitka	57.0	507	337	281	261	341	137	182	244
Rude Skov	55.8	146	101	293	259	110	77	182	227
Eskdalemuir (XYZ)	55.3	176	109	295	249	110	74	189	245
Meanook (H)	54.6	222	120	293	270	139	42	181	234
Seddin (XYZ)	52.3	97	55	293	257	60	39	204	228
Swider	52.1	87	59	295	266	52	53	222	216
De Bilt (HZ)	52.1	100	55	291	252	62	40	198	228
De Bilt (XYZ)	52.1	101	64	292	257	68	49	194	237
De Bilt (H)	52.1	50	25	285	261	26	14	186	222
Abinger	51.2	107	54	288	253	55	39	217	228
Val Joyeux	48.8	67	47	284	250	39	24	235	225
Agincourt	43.8	363	106	271	210	58	36	210	251
Tortosa	40.8	69	52	295	258	43	32	197	211
Cheltenham	38.7	150	58	286	238	57	27	235	236
San Fernando (H)	36.5	10	28	223	296	31	22	166	233
Tucson	32.2	46	18	291	290	32	8	240	261
Lukiapang	31.3	38	38	296	246	15	25	230	250
Honolulu	21.3	22	15	310	283	18	15	282	277
Bombay	18.9	11	16	0	279	18	25	207	258
San Juan	18.4	15	39	309	274	7	13	281	296
Antipolo	14.6	55	44	5	310	35	45	158	267
Huancayo	—12.0	83	67	28	298	50	56	93	297
La Quiaca	—22.1	46	25	43	267	33	22	102	278
Watheroo	—30.3	25	47	34	273	94	35	118	282
Pilar	—31.7	29	14	49	265	24	3	117	295

A similar analysis of the international character-numbers gave the time of maximum of the first term for 1930 as about the end of May, and for 1931 as near the middle of October. These times are not greatly different from those of most of the northern observatories. This may be regarded as an argument in favor of the general applicability of the new measure of activity, and it may also be looked upon as showing the predominance of northern stations in the determination of the international character-numbers.

It is to the second term — the 6-month period — that one must turn for the strongest evidence of a seasonal variation. The time of first maximum of this term varies in 1930 from a little before the middle of March at Antipolo to about the first of May at Agincourt. In 1931 the variation is from about the middle of March at Huancayo to about the first of May at Tortosa. The mean of all observatories is April 3 in 1930, and April 10 in 1931. The dates of maxima of the second terms of the analyses of the international character-numbers are about March 21 in 1930 and April 18 in 1931. These dates are given merely for comparison, without any assumption that there is an annual or semiannual period in the international character-numbers.

An analysis has been made of Egedal's numerical character-numbers at Rude Skov for quiet days, for international character-numbers less than 0.5, and also for his values of these numbers reduced to international character-number 0.20. Table 2 below gives the results together with those of Rude Skov repeated from Table 1.

Table 2 — *Amplitudes and phase-angles for monthly means of numerical magnetic character-numbers at Rude Skov*

Group	Year 1930				Year 1931			
	c_1	c_2	φ_1	φ_2	c_1	c_2	φ_1	φ_2
Quiet days (Egedal)	73	7	266°	355°	64	31	257°	232°
Quiet days, reduced (Egedal)	57	3	276	321	60	24	264	221
All days	146	101	293	259	110	77	182	227

The most striking thing, perhaps is the loss by the second term of its relative importance, as shown by the amplitudes of the quiet-day analyses. This is especially true for 1930. The next most striking fact brought out is the close agreement in the times of maximum of the first term for the two years. This occurs early in July in 1930 and 1931, both for the quiet days and for the reduced quiet days. Perhaps it would be sufficient to use only the quiet days in a further investigation of this question of whether this well-marked period of a year is also present in the quiet-day results of other observatoires.

The time of maximum of the second term in 1931 for quiet days differs only two or three days from the corresponding value for all days. In 1930 the difference is more than a month, which large difference may be partly due to uncertainty in phase arising from small amplitude. It would be well worth while to extend this discussion to other observatories.

Dep. Terr. Magn., C. I. W., July 31, 1933.

LATEST ANNUAL VALUES OF THE MAGNETIC ELEMENTS AT OBSERVATORIES[a)]

Compiled by J. A. FLEMING and C. C. ENNIS

Observatory	Latitude	Longitude	Year	Declination (*D*)	Inclination (*I*)	Intensity Hor. (*H*)	Intensity Ver. (*Z*)
						c. g. s.	*c. g. s.*
Matotchkin Shar	73°16′N	56°24′E	1924	20°37.5′E	80°05.4′N	.09491	.54326
Godhavn	69 15 N	53 30 W	1927	58 28.4 W	81 34.7 N	.08259	.55788
Sodankylä	67 22 N	26 39 E	1927	2 10.6 E	75 54.7 N	.12357	.49238
			1928	2 18.9 E	75 57.2 N	.12316	.49228
			1929	2 27.4 E	75 59.8 N	.12273	.49219
			1930	2 35.5 E	76 02.4 N	.12228	.49216
			1931	2 45.0 E	76 05.0 N	.12188	.49220
Lerwick	60 08 N	1 11 W	1928	14 37.1 W	72 39.4 N	.14585	.46702
			1929	14 23.6 W	72 40.3 N	.14556	.46651
			1930	14 11.2 W	72 41.6 N	.14528	.46625
			1931	13 59.6 W	72 42.3 N	.14517	.46623
Pavlovsk (Sloutzk)	59 41 N	30 29 E	1928	3 50.2 E	71 38.6 N	.15630	.47106
			1929	3 57.4 E	71 42.3 N	.15586	.47145
Lovö	59 21 N	17 50 E	1929	3 08.3 W	71 24.9 N	.15584	.46344
Sitka	57 03 N	135 20 W	1930	(30 15.6 E)	(74 22.8 N)	(.15448)	(.55255)
			1931	(30 13.1 E)	(74 23.5 N)	(.15454)	(.55190)

a) See also tables for previous and intermediate years in *Terr. Magn.*, v. 4, 135; v. 5, 128; v. 8, 7; v. 12, 175; v. 16, 209; v. 20, 131; v. 22, 169; v. 23, 191; v. 25, 179; v. 26, 147; v. 27, 157; v. 29, 149; v. 31, 27; v. 32, 27; v. 33, 95; and v. 35, 165. Unless otherwise indicated, values are from continuous magnetograph records. Preliminary values, pending final reductions, are indicated by parantheses. Observatories marked by an asterisk *) are in regions of local disturbance.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
						c. g. s.	c. g. s.
Katharinenburg*) (Swerdlovsk)	56° 50′ N	60° 38′ E	1928	10° 58.5′ E	72° 16.7′ N	.16335	.51117
			1929	10 57.2 E	72 20.3 N	.16285	.51145
Rude Skov	55 51 N	12 27 E	1929	6 11.3 W	69 16.2 N	.16924	.44718
			1930	6 00.4 W	69 19.0 N	.16893	.44747
			1931	5 50.4 W	69 20.5 N	.16879	.44767
Kasan (Saimistsche)	55 50 N	48 51 E	1928	9 04.5 E	70 27.4 N	.17091	.48148
			1929	9 05.2 E	70 31.6 N	.17033	.48168
			1930	9 06.8 E	70 36.3 N	.16982	.48238
			1931	9 07.3 E	70 39.1 N	.16953	.48279
Koutchino	55 46 N	37 58 E	1927	6 36.1 E	68 59.5 N	.17875	.46545
Eskdalemuir	55 19 N	3 12 W	1928	15 10.5 W	69 41.2 N	.16619	.44894
			1929	14 58.9 W	69 41.9 N	.16603	.44878
			1930	14 47.1 W	69 43.2 N	.16585	.44881
			1931	14 34.8 W	69 43.7 N	.16583	.44898
Meanook	54 37 N	113 20 W	1928	26 48.5 E	77 54.6 N b)	.12790 b)	.59719 b)
			1929	26 42.9 E	77 55.1 N b)	.12781 b)	.59709 b)
			1930	26 39.2 E	77 56.1 N b)	.12755 b)	.59675 b)
			1931	26 33.3 E	77 54.9 N b)	.12758 b)	.59587 b)
Stonyhurst	53 51 N	2 28 W	1930	13 51.1 W	68 47.8 N b)	.17190	.44311 b)
			1931	13 39.4 W	68 47.3 N b)	.17181	.44271 b)
Wilhelmshaven	53 32 N	8 09 E	1900	12 27.7 W	67 44.0 N	.18095	.44193
			1905	12 08.2 W	67 40.2 N	.18169	.44235
			1910	11 37.0 W	67 30.5 N	.18124	.43773
			1911	11 28.2 W	67 30.7 N b)	.18110	.43747
Irkutsk*) (Zouy)	52 28 N	104 02 E	1928	0 30.6 E	71 17.8 N	.19061	.56303
			1929	0 20.2 E	71 19.2 N	.19038	.56310
Potsdam	52 23 N	13 04 E	1929	5 47.8 W	66 48.6 N	.18442	.43049
Seddin	52 17 N	13 01 E	1929	5 49.1 W	66 45.6 N	.18480	.43034
			1930	5 38.6 W	66 48.3 N	.18456	.43072
			1931	5 28.9 W	66 49.8 N	.18450	.43108
Swider	52 07 N	21 15 E	1925	2 46.6 W	66 45.0 N	.18620	.43339
			1926	2 35.1 W	66 48.3 N	.18584	.43369
			1927	2 25.2 W	66 50.3 N	.18563	.43390
			1928	2 15.3 W	66 54.2 N	.18536	.43464
			1929	2 06.3 W	66 57.6 N	.18507	.43517
			1930	1 49.1 W	67 03.2 N	.18463	.43608
De Bilt	52 06 N	5 11 E	1929	9 37.3 W	66 58.6 N	.18300	.43063
			1930	9 26.3 W	67 00.4 N	.18282	.43084
			1931	9 15.7 W	67 00.8 N	.18278	.43089
			1932	9 04.2 W	67 02.3 N	.18264	.43107

b) Values from absolute observations only.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
						c. g. s.	c. g. s.
Valencia[b)] (Cahirciveen)	51° 56′ N	10° 15′ W	1928	17° 48.0′ W	67° 59.3′ N	.17826	.44096
			1929	17 37.3 W	67 59.6 N	.17821	.44094
			1930	17 27.6 W	67 59.8 N	.17813	.44081
			1931	17 16.8 W	67 58.7 N	.17815	.44048
Bochum[b)]	51 29 N	7 14 E	1927	9 08.5 W	....	....	....
			1928	8 57.4 W	....	....	....
			1929	8 46.0 W	....	....	....
			1930	8 35.2 W	....	....	....
			1931	8 23.8 W	....	....	....
Abinger[c)]	51 11 N	0 23 W	1930	12 24.6 W	66 38.2 N	.18542	.42924
			1931	12 13.7 W	66 38.1 N	.18543	.42923
Uccle[b)]	50 48 N	4 21 E	1927	10 26.9 W	....	....	....
			1928	10 16.0 W	....	....	....
			1929	10 05.4 W	....	.19234	....
			1930	9 54.6 W	....	....	....
Hermsdorf	50 46 N	16 14 E	1915	6 37.8 W	....	....	....
			1920	5 53.1 W	....	....	....
			1925	4 54.3 W	....	....	....
			1926	4 39.6 W	....	....	....
			1927	4 29.3 W	....	....	....
			1928	4 19.6 W	....	....	....
			1929	4 10.6 W	....	....	....
Beuthen-Mikilow	50 09 N	18 54 E	1925	3 37.8 W	....	....	....
			1926	3 26.7 W	....	....	....
			1927	3 16.0 W	....	....	....
			1928	3 06.2 W	....	....	....
			1929	2 56.6 W	....	....	....
			1930	2 46.7 W	....	....	....
Val Joyeux	48 49 N	2 01 E	1928	11 20.4 W	64 39.9 N	.19648	.41502
			1929	11 10.1 W	64 41.0 N	.19641	.41519
			1930	10 59.3 W	64 42.0 N	.19631	.41529
			1931	10 49.0 W	64 43.4 N	.19636	.41584
Maisach[b)]	48 12 N	11 15 E	1927	6 52.5 W	63 32.5 N	.20314	.40817
			1928	6 41.6 W	63 35.2 N	.20298	.40867
			1929	6 29.9 W	63 35.8 N	.20292	.40872
			1930	6 20.2 W	63 39.7 N	.20279	.40963
			1931	6 12.2 W	63 41.1 N	.20288	.41022
Vienna[b)] (Auhof)	48 12 N	16 14 E	1931	3 53.2 W	63 30.5 N	.20480	.41092
Munich	48 09 N	11 37 E	1920	8 03.8 W	....	....	....
			1925	7 06.7 W	....	....	....
			1926	6 54.7 W	....	....	....
O'Gyalla (Stará Dala)	47 52 N	18 11 E	1929	3 27.4 W	....	....	....
			1930	3 18.8 W	....	....	....

c) Succeeding Greenwich.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity	
						Hor. (H)	Ver. (Z).
						c.g.s.	*c.g.s.*
Nantes[d]	47°15′ N	1°34′ W	1928	12°23.6′ W	63°41.2′ N	.20220	.40886
			1929	12 13.5 W	63 43.1 N	.20222	.40950
			1930	12 04.6 W	63 43.3 N	.20226	.40965
			1931	11 54.6 W	63 43.3 N	.20241	.40995
Otomari[b]	46 39 N	142 46 E	1930	8 35.5 W	....	....	....
			1931	8 36.2 W	....	....	....
Agincourt	43 47 N	79 16 W	1930	7 28.1 W	74 46.4 N	.15544	.57103
			1931	7 31.9 W	74 46.3 N	.15520	.57010
Karsani	41 50 N	44 42 E	1926	4 12.3 E	58 03.0 N	.24694	.39595
(New site)			1927	4 15.5 E	58 08.1 N	.24673	.39693
			1928	4 18.8 E	58 13.5 N	.24646	.39788
			1929	4 19.7 E	58 19.0 N	.24627	.39901
Tashkent	41 (12) N	68 (52) E	1928	5 38.5 E	....	.25332	.43538
			1930[e]	5 30.8 E	....	.25276	....
Ebro	40 49 N	0 31 E	1929	10 28.0 W	57 25.8 N	.23383	.36605
(Tortosa)			1930	10 20.1 W	57 25.3 N	.23401	.36621
			1931	10 11.7 W	57 24.1 N	.23415	.36616
Coimbra	40 12 N	8 25 W	1928	14 10.3 W[b]	58 02.5 N[b]	.23172[b]	.37142[b]
			1929	13 59.7 W	57 57.9 N[b]	.23176	.37026[b]
			1930	13 55.3 W[b]	57 56.4 N[b]	.23179[b]	.37001[b]
			1931	13 45.5 W[b]	57 52.2 N[b]	.23196	.36931[b]
Cheltenham	38 44 N	76 50 W	1930	6 55.9 W	71 08.0 N	.18591	.54402
			1931	(7 00.2 W)	(71 09.3 N)	(.18539)	(.54317)
			1932	(7 03.8 W)	(71 11.2 N)	(.18485)	(.54247)
San Miguel*)	37 46 N	25 39 W	1928	18 40.5 W	59 52.6 N[b]	.23324[b]	.40197[b]
(Ponta Delgada)			1929	18 35.0 W	59 48.0 N[b]	.23309[b]	.40046[b]
			1930	18 29.4 W	59 46.6 N[b]	.23310[b]	.40004[b]
			1931	18 23.1 W	59 41.1 N[b]	.23351[b]	.39936[b]
Zinsen[b]	37 30 N	126 38 E	1930	6 03.8 W	53 08 N	.29831	.39779
			1931	6 03.9 W	53 12 N	.29866	.39923
San Fernando	36 28 N	6 12 W	1930	12 32.8 W	53 29.9 N[b]	.25072	.33881[b]
			1931	12 25.9 W	53 27.9 N[b]	.25106	.33885[b]
Kakioka	36 14 N	140 11 E	1924[f]	5 31.6 W	49 29.5 N	.29708	.34774
			1925	5 34.4 W	49 27.8 N	.29716	.34749
			1926	5 36.6 W	49 27.7 N	.29694	.34721
			1927	5 39.6 W	49 27.6 N	.29702	.34727
			1928	5 40.5 W	49 27.0 N	.29707	.34721
			1929	5 41.9 W	49 26.0 N	.29704	.34698
			1930	5 42.4 W	49 27.9 N	.29713	.34746

d) Electrical disturbances, especially, in Z.
e) Means eleven months February to December.
f) Means eleven months February to December.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
						c.g.s.	c.g.s.
Tsingtao	36° 04′ N	120° 19′ E	1928	4° 26.1′ W[b)]	52° 06.7′ N[b)]	.30839[b)]	.39713[b)]
			1929	4 33.0 W	52 06.6 N	.30870	.39669
			1930	4 32.8 W	52 06.8 N	.30868	.39673
			1931	4 32.1 W	52 05.1 N	.30880	.39646
Tucson	32 15 N	110 50 W	1929	(13 45.8 E)	(59 34.8 N)	.26488	.45112
			1930	(13 47.7 E)	(59 37.0 N)	.26432	.45081
			1931	(13 49.5 E)	(59 37.5 N)	(.26398)	(.45038)
Lukiapang	31 19 N	121 02 E	1928	3 35.3 W	45 26.1 N[g)]	.33233	.33737[g)]
			1929	3 37.2 W[b)]	45 24.9 N[b)]	.33278[b)]	.33763[b)]
			1930	3 37.4 W[b)]	45 25.1 N[b)]	.33264[b)]	.33753[b)]
			1931	3 37.0 W[b)]	45 22.5 N[b)]	.33313[b)]	.33751[b)]
Dehra Dun	30 19 N	78 03 E	1928	1 18.5 E	45 31.8 N	.32940	.33554
			1929	1 15.5 E	45 35.9 N	.32946[h)]	.33601[h)]
			1930	1 11.9 E	45 34.5 N	.32963	.33631
			1931	1 08.6 E	45 35.9 N	.33001	.33698
Helwan	29 52 N	31 20 E	1924	0 52.3 W	41 22.1 N	.29979	.26400
			1925	0 44.8 W	41 25.7 N	.29986	.26463
			1926	0 37.7 W	41 30.4 N	.29998	.26545
			1927	0 30.4 W	41 33.8 N	.30013	.26612
			1928[b)]	(0 24.0 W)	(41 36.3 N)	(.30039)	(.26775)
			1929[b)]	(0 19.3 W)	(41 39.1 N)	(.30067)	(.26743)
			1930[b)]	(0 14.7 W)	(41 43.8 N)	(.30078)	(.26827)
			1931[b)]	(0 10.5 W)	(41 45.6 N)	(.30126)	(.26898)
Taihoku[b)]	25 02 N	121 31 E	1930	2 09.4 W	....	....	....
			1931	2 09.6 W	....	....	....
Au Tau	22 27 N	114 03 E	1930	0 43.6 W	30 37.3 N	.37485	.22187
			1931	0 43.3 W	30 34.4 N	.37522	.22164
			1932	0 43.3 W	30 33.1 N	.37545	.22161
Honolulu	21 19 N	158 04 W	1930	10 04.4 E	39 29.2 N	.28542	.23516
			1931	10 04.3 E	39 24.4 N	.28551	.23458
			1932	10 05.0 E	39 21.0 N	.28545	.23405
Teoloyucan	19 45 N	99 11 W	1930	9 25.4 E	46 54.2 N	.31199	.33343[i)]
			1931[b)]	9 27.2 E	46 57.7 N	.31162	.33375
Alibag	18 38 N	72 52 E	1928	0 03.8 W	25 28.3 N	.37152	.17698
			1929	0 05.9 W	25 29.1 N	.37209	.17736
			1930	0 08.0 W	25 30.6 N	.37253	.17777
			1931	(0 10.5 W)	(25 30.3 N)	(.37323)	(.17806)
San Juan	18 23 N	66 07 W	1930	(4 50.5 W)	(52 29.2 N)	(.27493)	(.35813)
			1931	(4 58.8 W)	(52 30.2 N)	(.27451)	(.35780)
Antipolo[b)]	14 36 N	121 10 E	1928	0 26.9 E	15 50.4 N	.38228	.10846
			1929	0 26.5 E	15 47.9 N	.38231	.10817

g) Means five months June to September and December.
h) No values for August and September.
i) For eleven months February to December.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
	° ′	° ′		° ′	° ′	c. g. s.	c. g. s.
Antipolo[b)]	14 36 N	121 10 E	1930	0 26.7 E	15 47.2 N	.38244	.10812
			1931	0 27.3 E	15 48.2 N	.38270	.10832
Palau	7 20 N	134 29 E	1930	2 00.8 E	....	....	....
			1931	2 02.2 E	....	....	....
Batavia (Kuyper)	6 02 S	106 44 E	1928	0 53.0 E	32 14.9 S	.36834	−.23239
			1929[b)]	0 54.0 E	32 16.6 S	.36815	−.23252
			1930[b)]	0 55 E	32 18 S	.36820	−.23280
			1931[b)]	0 57.8 E	32 19.8 S	.36862	−.23330
Huancayo	12 03 S	75 20 W	1930	7 36.5 E	1 42.7 N	.29614	.00885
			1931	7 30.8 E	1 50.3 N	.29622	.00951
			1932	7 25.6 E	1 58.4 N	.29617	.01021
Apia	13 48 S	171 46 W	1929	10 33.5 E		.35209	−.20418
			1930[j)]	10 34.2 E	30 07.9 S	.35196	−.20428
			1931	10 35.2 E	30 09.3 S[b)]	.35171	−.20434[b)]
Mauritius	20 06 S	57 33 E	1930	12 05.5 W	52 39.6 S	.22697	−.29750
			1931	12 17.2 W	52 38.3 S	.22673	−.29696
La Quiaca	22 07 S	65 35 W	1929	4 49.0 E	12 24.0 S	.26295	−.05781
			1930	4 40.7 E	12 23.8 S	.26266	−.05774
			1931	4 31.7 E	12 22.8 S	.26256	−.05763
Watheroo	30 19 S	115 53 E	1930	4 08.0 W	64 17.7 S	.24633	−.51174
			1931	4 03.2 W	64 18.0 S	.24646	−.51215
			1932	3 58.5 W	64 19.2 S	.24652	−.51267
Pilar	31 40 S	63 53 W	1928	6 42.0 E	25 46.8 S	.24818	−.11987
			1929	6 34.4 E	25 48.2 S	.24763	−.11973
			1930	6 26.8 E	25 50.6 S	.24695	−.11961
			1931	6 18.9 E	25 51.2 S	.24661	−.11950
Toolangi	37 32 S	145 28 E	1928	8 14.7 E	67 49.4 S	.22891	−.56159
			1929	8 17.5 E	67 50.4 S	.22883	−.56183
			1930[b)]	8 21.6 E	67 52.4 S	.22851	−.56198
			1931[b)]	(8 24.5 E)	(67 51.1 S)	(.22890)	(−.56232)
Amberley[k)]	43 10 S	172 44 E	1929	17 45.0 E	67 57.8 S	.22365	−.55252
			1930	17 51.0 E	67 58.4 S	.22351	−.55246
Christchurch[l)]	43 32 S	172 37 E	1929	17 42.4 E	68 17.6 S	.22123	−.55575
			1930	17 48.3 E	68 18.3 S	.22108	−.55570

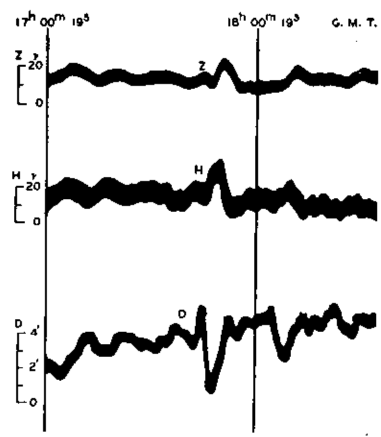
j) Means for six months January to June.
k) Succeeding Christchurch.
l) From Amberley values.

PHOTOGRAPHICALLY ENLARGED MAGNETOGRAMS FOR STUDY OF SUDDEN COMMENCEMENTS

By J. A. FLEMING and C. C. ENNIS

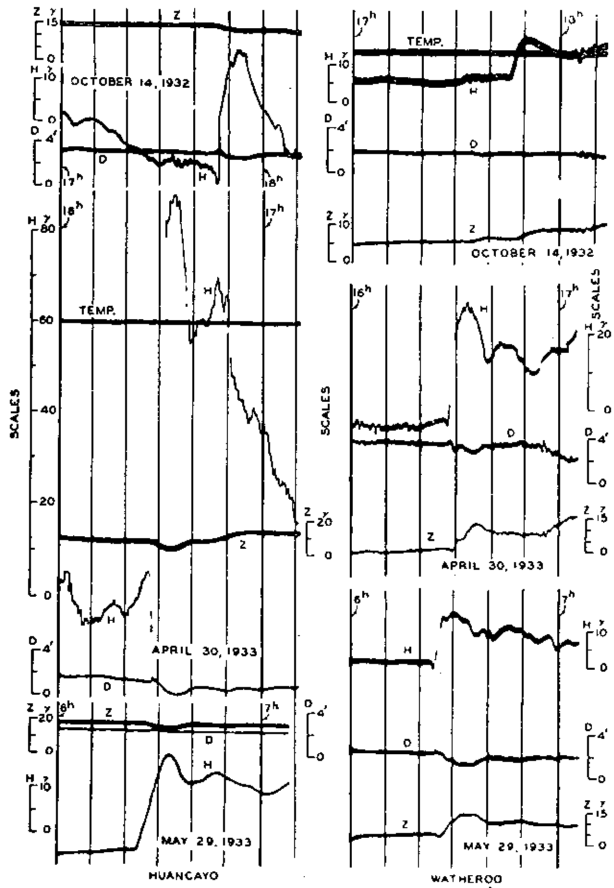
The study and investigation of magnetic disturbances and of their "sudden commencements" have been pursued most intensively, especially with respect to the times of the sudden commencements as scaled from magnetograms obtained at observatories throughout the world. As is well known, a magnetic disturbance as recorded on magnetograms has varying characteristics at different stations, the variation in some cases being from a decidedly abrupt beginning to a condition where it is quite difficult, if not impossible, to select points of commencement. Naturally under such conditions there has been discordance in the times of sudden commencements as reported by different observatories, a difficulty still further aggravated by the limits in accuracy of the time as scaled from magnetograms obtained on the usual time-scales with a speed of record of 15 to 20 mm per hour.

At the majority of functioning observatories the equipment has been such so far that in economical maintenance only records with a time-scale of 15 or 20 mm per hour have been made because the arrangements for high-speed records such as, for example, on the Eschenhagen instrument in use at some of the observatories, requires frequent attention and a considerably increased quantity of photographic paper.



COLLEGE-FAIRBANKS, OCTOBER 14, 1932
ENLARGED MAGNETOGRAMS FOR STUDY OF SUDDEN COMMENCEMENTS
ORIGINAL TIME-SCALE 15 MILLIMETERS TO THE HOUR

This difficulty has been largely overcome through the design of the high-speed registering magnetograph by Dr. D. la Cour for use particularly during the International Polar Year of 1932-33. The sensitivity of this apparatus, however, as installed is generally considerably less than that usually maintained with the older equipment at most of the observatories. Thus, while the time-difficulty is obviated by this high-speed recorder, there is the important question as to whether the use of this apparatus may not in some cases defeat the major aims by obscuring, because of the lesser sensitivity, a considerable amount of detail which appears in the regular traces and the lack of which thus renders it more difficult to select points of sudden commencements. It seems that wider use might be made of magnetograms obtained on the usual time-scale of 15 or 20 mm per hour by photographic enlargements of the portions of



ENLARGED MAGNETOGRAMS FOR STUDY OF SUDDEN COMMENCEMENTS
ORIGINAL TIME-SCALE (G M T) 20 MILLIMETERS TO THE HOUR

the magnetograms which record disturbances of the type to be investigated including, of course, sudden commencements.

In this connection, there are attached two figures which are photographic reproductions of regular-speed magnetograms and which are enlarged almost four times over the original for the College-Fairbanks record and almost three times over the original for the Watheroo and Huancayo records.*) With some improvements in the lighting and optical systems of the regular

*) *Note de la Rédaction:* Prière remarquer l'échelle indiquée sur les reproductions imprimées.

type of magnetograph and with the greatly improved rapid photographic papers now available, it would seem that records could be obtained regularly which might be enlarged satisfactorily from five to ten times, particularly if more painstaking care were given in the development of the magnetograms. It would be necessary that each observatory determine quite carefully its parallax correction for time-marking system used. It is believed that a time-marking system such as is used at the Huancayo and Watheroo magnetic observatories with automatic and photographic registration of time every ten minutes — with occasional like registrations for every minute throughout the day to test any inequalities in the clock movement — would make it possible to determine times of particular features of disturbance with a precision of at least one-tenth of a minute through the use of photographically enlarged copies.

It is felt that this possibility is worthy of serious consideration, particularly as many of the functioning observatories do not have equipment with which to make high-speed records.

Dep. Terr. Magn., C. I. W., August 25, 1933.

ELECTRIC CHARACTER-NUMBERS AND MEANS OF ATMOSPHERIC-ELECTRIC DATA FOR PUBLICATION.

By O. H. GISH

Doubtless everyone who has to deal with atmospheric-electric data desires some form of classification, either for use in forming mean values corresponding to some selected set of conditions whose effect on the electric field is to be investigated, or else for expressing certain aspects of the registrations which are not adequately or conveniently presented by such published numerical data, as hourly means, daily means, and daily ranges.

In the first instance, certain typical meteorological conditions may be the basis of classification. In the second, the classification may be based wholly on characteristics of the electrograms. Reasons for desiring some classifications made according to either or both of these schemes are not far to seek. Many special groupings of data will be required in the investigations which must yet be made in order to definitely ascertain to what extent and in what manner various suspected factors affect the electric state of the atmosphere, especially over land-areas. It is, of course, not within the capacity of any one individual or organization either to foresee all these requirements or even to supply in publications of extensive data all those groupings for which need can be seen. The group-means which are published should, therefore, be those of interest to the majority of investigators.

If the extent to which some electric characteristic occurs during a day may be expressed on a scale of numbers, then these numbers may be designated electric character-numbers. The electric character-number may serve in part as a basis for forming the group-means, but it should be especially designed to serve as an additional datum for use in the more general studies, after the manner in which the magnetic character-number is employed. In order to be serviceable in this way, it is of course obvious that some common basis of classification must be employed at all atmospheric-electric observatories. The desirability of such a means of expressing electric character is perhaps not so great as is that for magnetic character, because characteristics which are highly localized are far more conspicuous in the electric than in the magnetic field of the Earth. One can, however, think of lines of investigation in which a uniform system of electric character-numbers would be serviceable when a mass of data of sufficient extent in both time and geographical distribution is available. Such electric character-numbers should be designed to convey, either in a rough quantitative way or by classifying attributes, information which is not readily, if at all, obtainable from the published tables of data. For example, the mean of the day and the range, together with an inspection of the hourly means, cannot be expected to disclose the degree of variability as well perhaps as suitably chosen character-numbers. Neither would very brief but pronounced occurrences, for example, of negative potentials — a feature of special interest — be adequately disclosed by those data. These are examples of the sort of information which should be given by electric charater-numbers, which as already implied are obtained wholly by inspection of the electrograms.

Another quite different type of classification sometimes used is based on meteorological or other auxiliary observations. A number of meteorological conditions are more or less definitely known to affect the electrical state of the atmosphere. The chief of these are thunder-storms, general rains, snow, dust- and snow-storms, smoke, and other forms of atmospheric pollution, all of which may be expected to disturb the electrical state of the atmosphere, even at somewhat indefinite distances from the storm, etc. Other meteorological circumstances which doubtless come into account at some places and times are as follows: Type and intensity of air-movement or circulation; wind-direction; barometric tendency; temperature-distribution (for example, lapse-rate); and amount, form, and distribution of water in the atmosphere and in the surface-layers of soil (for example, whether soil is filled with water, liquid or solid, or covered with snow). These factors, sometimes acting independently but more often in combinations, are thought to affect the general values and also the variations of the atmospheric-electric elements. This applies especially to land-areas. At sea, the number of combinations of meteorological with other factors which may come into account is obviously considerably less than over land. In this discussion, however, we are principally concerned with conditions which prevail over land, for, unfortunate though it may be, no continuous registration of the electric elements is now being obtained under typical oceanic conditions. Various groupings of the electric data according to different meteorological conditions will doubtless be desired for use in studying the relationships between the meteorological and the electric phenomena. However, it is thought that any class-numbers assigned to these should not be designated "electric character-numbers", for to do so tacitly implies too much *a priori* knowledge regarding the relationships between these phenomena. "Meteorological classes" would seem a better term to use.

It seems desirable that the following questions be thoroughly considered by all persons who are concerned with the publication of atmospheric-electric data, and that the opinions reached be made known:

(1) Are electric character-numbers, as distinguished from meteorological classes in the foregoing paragraphs, required?
(2) Should the classification used for forming general group-means be based on features of electrograms or on certain specified meteorological conditions?

Both types of classification have been used here and there, and even hybrids of the two types have appeared. However, in what follows it will be taken for granted that such mixed classifications are to be scrupulously avoided, because of the obscurities which are generally thereby introduced into the results of analysis. The writer's response to these questions follows:

Perhaps one feels at the start that the answer to question (2) depends somewhat on the decision in respect to question (1). That is, if character-numbers are employed, these should also serve as a basis for the general group-means which are to be given in publications of extensive data. It is believed, however, that one should admit the possible desirability of publishing character-numbers even though these are not used as a basis for the published group-means. Magnetic character-numbers have been found useful for various statistical studies, such, for example, as to bring out the correlation between magnetic activity and sunspot-numbers. Electric character-numbers should serve for a similar comparison between electric and solar activity. Also, in studies of other variations with time and of the geographical distribution of electric activity, such electric character-numbers should be found useful. One should, of course, expect that a considerably greater mass of such data will be required here than in similar studies in terrestrial magnetism, because of the highly localized character of many electric perturbations. A uniform practice at all atmospheric-electric observatories is, of course, necessary in order to provide adequate data for such studies.

Question (2) amounts in essence to a request for a choice between electric character-numbers and meteorological criteria as a basis for forming general group-means. The making of such a choice is not altogether easy, but when one comes to plan the publication of extensive results obtained at observatories some decision is imperative and the writer thinks this resolves itself into a choice between the alternatives just mentioned. The choice will, of course, finally depend considerably on the particulars of the system of character-numbers and of the meteorological classification which is considered.

The system of character-numbers which evolved in the British Meteorological Office (London, Met. Office, Hourly values from autographic records, or Observatories' Year Book, any recent year, e.g., p. 328, 1928) was recommended by S. J. Mauchly in 1922 for "tentative" adoption by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and, has been continuously employed ever since. Mauchly used the qualifying term "tentative" in the expectation that the International Union of Geodesy and Geophysics would shortly give the matter consideration and make recommendations. Naturally the Department of Terrestrial Magnetism would welcome an early decision on this matter before publication of atmospheric-electric results at its observatories. Discussion by members of the Department's staff on the merits and demerits of this as well as other schemes of characterization or classification has not developed any strong common preference.

The recommendation which the writer would make is one which has slowly grown from disfavor into favor with him. He would now favor the general use of a system of character-numbers similar to that of the British Meteorological Office.

In this system one of the three character-numbers 0, 1, 2 is assigned to each day in accordance with the following:

"0" for days on which no negative potential was recorded.

"1" for days on which negative potential was recorded for at least one short period, but for an aggregate duration of less than three hours.

"2" for days on which negative potential was recorded for an aggregate duration of three hours or more.

The outstanding advantage of this scheme is that it is so simple and definite that anyone can apply it and without a chance of introducing personal bias. The definiteness would be appreciated also by the investigator who may use the data. These merits go far toward offsetting some demerits of the scheme. This system was begun at the Kew and Eskdalemuir observatories at least 20 years ago, and beginning with the year 1922 the character-number for each day at these observatories — later that for Lerwick — has been published. It was adopted by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in 1922 and has been in use at the following observatories of the Department or at observatories in the work of which the Department actively cooperates: Washington (D. C.) and Apia (Samoa) since 1922; Watheroo (Australia) and Huancayo (Peru) since 1924; Tucson (Arizona) since 1929, and College (Alaska) since 1932. The long experience had in the use of these character-numbers at the British Meteorological Office observatories would enhance the interest in a statement from that Office regarding the full purpose and the merits of the scheme.

Some apparent shortcomings of this system of character-numbers are as follows: (1) Perturbations having amplitudes averaging less than the mean of day are not taken into account and (2) positive departures are not given consideration comparable with that given the negative ones. It would seem desirable that some scheme be found for reporting these features. In assigning character-numbers at the Ebro Observatory (Bol. Obs. del Ebro, vol. 22, No. 1, 9, 1931), perturbations do receive some consideration. Sverdrup in his discussion of the electric data obtained on the *Maud* Expedition used character-numbers based largely on the degree of perturbation; thus he says "The character-numbers here used depend only upon the appearance of the curve, 2 meaning a very rugged, 0 a very smooth curve (Res. Dept. Terr. Mag., vol. VI, 437, 1927). In fact, during two winters of continuous registration at the *Maud* stations negative potentials occurred on only one day! Under such circumstances, character-numbers based on the occurrence of negative potentials are obviously inadequate for expressing changes in electric features from day to day, although they may be of value in comparing stations and in describing the geographical distribution of the characteristics comprehended by the numbers. Thus, for example, there is noticed a distinct contrast between the percentage of "zero-days" observed at sea and that observed on land in middle and lower latitudes, the percentage being considerably greater at sea and also in the polar regions than at land-stations.

It would seem feasible to so modify the scheme as to give equal consideration to both positive and negative departures, without any loss in definiteness. A modification is suggested which is based on the following considerations. A negative potential corresponds, on the average, to a negative departure greater than the mean of day. Hence, if positive and negative departures are to be given equal consideration, potentials which are greater than double the mean of day should be taken as equivalent to negative potentials when assigning character-numbers. The definition of the character-numbers modified so as to take account of positive departures would be as follows:

"0", days with no negative potentials nor with positive potentials exceeding twice the mean of day.

"1", days with negative potentials, or positive potentials exceeding twice the mean of day, for at least one short period, but for which the aggregate duration of such occurrences is less than three hours (perhaps this time-limit should be extended, say to six hours).

"2", days for which the aggregate duration of the negative and (or) positive potentials in excess of twice the mean of day is three (six?) hours or more.

The taking into account of positive departures would, of course, add to the time required in assigning the character-number. However, devices may be used which will facilitate this. It is believed that the mean deflection for the day can be estimated adequately for this purpose by setting a line, or a rule, so that when parallel with the line of zeros the areas between the trace and the line appear to the eye to be distributed equally above and below the line, the ordinate of the line, referred to the zero-line, of course being the estimated mean deflection. Or it may be satisfactory to use the mean deflection, from zero-line, for the month. If the monthly mean ordinate be used, the work would doubtless be facilitated by using an adjustable parallelogram which can be set so that the distance between the long edges (somewhat longer than the record-sheet) is twice the mean ordinate. With this laid upon the record-sheet, one edge coinciding with the zero-line, any positive departures which must be considered can be seen at once. The time required to assign the character-numbers by the plan thus modified would be somewhat increased but probably not doubled. Even at that, the time-requirement would be relatively small.

As already intimated, it is difficult, and perhaps not possible, to devise a correspondingly simple and clear-cut means of reporting the more rapid perturbations or oscillations, and yet it would often be desirable to have information regarding these features. For example, one should like to know whether a "zero"-day was quiet or disturbed; wheter the trace on a "one"-day was relatively smooth, the change to and from negative (or large positive) values occurring gradually or whether there were numerous oscillations, some of which extended beyond the limits which define a "zero"-day. Similar distinctions may also be made between days of character "2". Not infrequently negative potentials may be recorded over periods of hours but without conspicuous oscillations. It is believed that such aspects as these are of sufficiently general interest to justify the publication of information regarding them.

It is thought that such information should be presented by symbols which are independent of the character-numbers (as defined above), for it is feared that an attempt to so define character-numbers as to include these perturbation-features would result in a melange of uncertain significance. It is not without some misgivings that the following suggestions for expressing such features are offered.

In this discussion, a perturbed condition is considered as being one in which the registered values (say, of air-potential) fluctuate rather rapidly through at least several oscillations, and the degree of perturbability depends on the mean amplitude of the perturbations and their aggregate duration. Variations having periods of such length that the mean value of the hour may be appreciably influenced by them should not be considered as perturbations. Intercomparison of the published hourly values will usually present evidence of such occurrences. It is then suggested that each day one of four degrees of perturbability be noted, according to the following scheme:

"p", days on which the predominant perturbations have a mean amplitude greater than the mean of day.

"q", days on which the predominant perturbations have a mean amplitude not exceeding the mean of day but greater than one-fifth of that mean.

"r", days on which the predominant perturbations have a mean amplitude not grater than one-fifth of the mean of day.

"s", days comparatively free from perturbations.

Despite some unavoidable vagueness, it is thought that such a classification of the perturbability would be a valuable adjunct to tables of hourly means. One might elaborate the scheme by placing after the symbol (or as a subscript) a number to indicate to the nearest hour the aggregate duration of the characteristic perturbability. However, it is realized that the acceptability and effectiveness of such devices are generally directly proportional to their simplicity. Furthermore, if these perturbability-symbols should be used along with the character-numbers, some rough indication of the duration would be shown, as part of the more complete description which could be thus effected.

Some combinations of the character-numbers with perturbability-symbols would, of course, be excluded, for although a "zero"-day may have a "q", "r", or "s" perturbability, yet it could not be of character "p". On the other hand, a day of character "l" may be any one of the four perturbability-types, but in case it is of type "p" it follows that the aggregate duration of the perturbations was less than three hours.

With the publication of the character-numbers, the perturbability-symbols, the hourly means, and possibly the absolute range, it is thought that a fairly satisfactory description of the outstanding electric characteristics of a day would be given. Even the character-numbers and perturbability-symbols above would give information which should be of value for comparing stations and for investigating certain features for possible systematic variations either in time or in space. Thus, for example, it would seem important to know the location and extent of regions for which the perturbability is generally great (such as Huancayo), as well as of those where it tends to be relatively small. It is not intended that there should be in the electric characterization any connotation of "electrically good" or "electrically bad" days (designations sometimes used), for the quality of goodness of the data for a given day depends upon the specific purpose for which it is used.

It is, of course, the purpose in publication of data such as that for atmospheric electricity to make available in so far as feasible all information which is likely to be required in any analysis to which the data may be subjected. By means of character-numbers and symbols, one endeavors to amplify the numerical data which are obtained from the registrations.

However, many investigations in atmospheric electricity, in addition to the electric data, require information regarding other phenomena which are known to, or at least are thought to, affect the electric phenomena. Meteorological data and general information fall in this category. In order to carry out the various investigations which will be required to satisfactorily ascertain the manner and extent to which the electric phenomena are influenced be meteorological and allied factors, rather extensive information regarding the latter is required. There is here again a limit to the amount of information which can be published; however, the goal should be high. Much valuable qualitative information can be supplied even though complete tables cannot be published. For this a system of character-symbols may be found useful. These should be so selected and presented that investigators may use them as criteria in forming such grouping as may serve the purpose. It seems unlikely, however, that any uniform practice in this aspect of publication can be expected in the near future. Hence, published group-means, based on meteorological criteria, are not likely to be comparable from place to place.

In view of these circumstances, it is believed that group-means based on a system of character-numbers, somewhat like that suggested, may be more generally useful than attempts to group according to more or less inadequate meteorological data. However, it is not thought that a mean should be published for each character-group. The mean of the "zero"-days or a well-defined selection therefrom, and that for all classes of days, are thought to be most generally useful groupings. In any case, if dates for which data are used in forming group-means are indicated and character-numbers and symbols somewhat like those here suggested are published, the investigator would know fairly definitely the nature of the selection.

It is hoped that the International Association may give careful consideration to this subject and that it may adopt definite recommendations or resolutions.

Dep. Terr. Magn., C. I. W., July 31, 1933.

PRELIMINARY NOTE ON THE LATEST SECULAR-CHANGE VALUES IN THE CARIBBEAN AREA AND SOUTH AMERICA

By J. W. GREEN

Previous data pertaining to magnetic secular-changes in the Caribbean area and South America have been discussed by Fisk for the epoch 1920-25. The data obtained by observers of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington during 1931 to 1933 provide material for the epoch 1925-33.

In general, the trend indicated during 1920-25 has continued, especially in the regions of the foci of rapid change, but in most of the area this has been accompanied by a change in the annual rate. This emphasizes the need for more frequent observations at secular-variation stations in these regions and, in order to define more closely the locations and limits of the focal centers, a closer grouping of repeat-stations.

Over the whole of South America, including the Caribbean Area, the north end of the needle is drifting toward the west, with the exception of the extreme western part of the island of Cuba where there is still an eastward movement. This eastward movement, however, has a decreasing rate since the zero-isopor has moved from some little distance east of Havana to a position just west of that City, thus reversing the eastward trend which existed in the neighbourhood of Havana during the former epoch.

The isoporic center for declination, formerly central over northeastern Brazil, is moving slightly northward with a tendency toward enlargement. On the other hand, the changes in inclination indicate that the isoporic center covering Colombia, Ecuador, and western Venezuela has remained fairly stationary but is contracting sharply while an increase in the negative rate at Pernambuco indicates that the large mid-Atlantic focal area between the tropics is either moving westward or expanding. The zero-isopor for inclination continues to move westward as was the case during 1920-25.

The strongly marked negative isoporic center of the horizontal intensity component in the northern Caribbean area seems to be contracting and has a westerly movement. The small area of positive change which penetrated Brazil from the eastward in the Amazon Region has receded toward the east so that at the present time there is no area of positive change in horizontal intensity on the Continent of South America. The southerly negative focal center in this element also has moved westward and apparently has lost none of its intensity since the average annual rate during 1925-33 was nearly 100γ at Puerto Montt, Chile. In general, the annual rates of change in magnetic horizontal intensity have decreased in the northern part of the area, have increased slightly in the southern part, and have remained practically stationary along the west.

Annual changes in total intensity have increased somewhat over the entire area except along the west coast where the values have remained practically stationary during 1925-33. The increase in the negative rate in the extreme south has been quite marked — about 150γ per year at Punta Arenas, Chile — while the small focal area of positive change in the northwesterly part has practically disappeared, the only station still showing a positive change being Puerto Cabello, Venezuela. This station has had an average rate of +5γ during the epoch. It is probably zero or negative at the present time.

Dep. Terr. Magn., C. I. W., August 10, 1933.

SUBCRUSTAL CONVECTION-CURRENTS AND MAGNETIC SECULAR-VARIATION

By J. W. GREEN

(A communication suggested for discussion under item III-c *of the agenda for the Lisbon Assembly)*

In considering theoretical studies of terrestrial magnetism no one phase of the problem is more likely to throw some light on the probable cause of the main phenomenon than is the study of secular variation. By the steady accumulation of data and analysis of results our knowledge concerning the problem is constantly increasing. The isopors of Fisk have served to emphasize the regional character of the changes taking place in the Earth's magnetic elements and illustrate in a most striking manner the complexity of the problem. From time to time new theories are advanced in explanation of the phenomena taking place. The test of the tentative acceptance of any theory is whether or not it fits the observed facts, so far as known. As a result of some conclusions derived from recently acquired data and from analysis of older data, a few suggestions are offered with the hope of stimulating discussion of this very interesting and important question.

Bauer's analysis (Terr. Mag., v. 28, 1-28, 1923) indicated that of the total magnetic field of the Earth about 94 per cent is internal. It is well known that there exist in the crust of the Earth vast quantities of magnetic materials, but mathematical analysis indicates that these materials are insufficient to account for the main field. It may hardly be gainsaid, however, that they probably do account for a part of the main field. Let us assume that this part is a sufficient part of the whole so that changes in it *may* account for secular variation. Possibly what is considered as the true secular variation — the steady alteration of the magnetic moment of the Earth as a whole — is not something separate and distinct from the regional phenomena mentioned above but is simply the resultant of all regional changes over the entire Earth.

The interdependence of allied sciences is being recognized today to an extent undreamed of a few decades ago, and in none of the sciences is this more strikingly true than in the relations of geology, seismology, and terrestrial magnetism. The modern concept of the thermal history of the Earth, embracing as it does the hypothesis of thermal cycles as proposed by Joly (J. Joly, The surface history of the Earth, Oxford 1925, 2d ed. 1930), and the hypothesis of possible subcrustal convection-currents in the plastic layer now being investigated by Holmes (A. Holmes, Radioactivity and earth movements, Trans. Geol. Soc. Glasgow, v. 18, 559-606, 1928-29) and Bull (A. J. Bull, The convection-current hypothesis of mountain building, Geol. Mag., v. 68, 495-498, 1931), may have a most important bearing on the probable cause of magnetic secular-variation. Chapman (S. Chapman, Cosmical magnetic phenomena, Nature, v. 124, 19-26, 1929) suggests that "the maintenance and secular variation of the Earth's magnetic field are possible consequences of a deep-seated internal circulation of material," but considers the changes in the magnetic elements as being due to effects of the internal circulation on electric currents existing in the substratum — a view that may also be profitably discussed and one that *may* be more closely associated with the main phenomenon.

Either the theory of thermal cycles or the theory of convection-currents, which might very conceivably result in thermal cycles, offers a possible explanation of ferromagnetic materials in the Earth's crust passing from the magnetic to the non-magnetic state or vice-versa. From our present knowledge of geology and seismology the plastic layer in which convection-currents may exist begins at a depth of from 30 to 40 miles below the surface and extends downward to a depth of about 200 miles. Convection-currents exist on account of temperature-differences. Whether the source of heat that gives rise to temperature-differences is the natural internal heat of the Earth or whether it originates from the disintegration of the radioactive materials present, or from both, is immaterial. We leave that question to the geologists and accept the convection-currents they provide.

The more highly heated materials from below, rising and coming into contact with the non-plastic crust, produce fusion of a portion of the lower layers with a consequent steepening of the temperature-gradient between the upper and lower margins of the crust. It is reasonable to assume that the temperature of the upper margin of the plastic layer is considerably above the critical-temperature of magnetization of any ferromagnetic materials in the Earth's crust and therefore that the lower part of the crust is above the critical temperature. A steepening of the temperature-gradient crowds the isotherms toward the surface. If ferromagnetic materials exist in the vicinity of the critical-temperature isotherm, then as this isotherm is pushed outward whatever material it passes becomes non-magnetic. In regions of downward movements of the currents, crystallization with consequent thickening of the crust and movement of the isotherms downward or away from the surface results and some non-magnetic material may become magnetic.

Holmes (The thermal history of the Earth, J. Wash. Acad. Sci., v. 23, 169-195, 1933) states "that at any given place the thickness of the crustal layer and the thermal state of the substratum immediately below may vary from time to time."

The objection has been made that the observed changes in the Earth's magnetic field take place too rapidly to be accounted for by any geological changes taking place in the interior of the Earth such as possible temperature-changes might produce. The physical change from the magnetic to the non-magnetic state takes place over a very narrow temperature-band, perhaps but a few hundredths of a degree. Moreover, the specific heat of the materials involved is very low — that of magnetite being but 0.156 and various lavas ranging from 0.197 to 0.259 at temperatures approximating the probable critical temperature of these materials. The critical temperature of magnetite is about 567° C. It follows, therefore, that only a comparatively small quantity of heat would be involved in order to produce these changes, and it seems entirely possible that radioactivity alone might account for the heat necessary to produce the negative changes which are predominant at the present time.

Holmes says further concerning the hypothesis invoking subcrustal convection-currents that "It requires the local operation of thermal cycles within the crust." This is a condition which it seems would fit admirably into an explanation of the cause of centers of rapid change in the magnetic elements, the isopors of Fisk mentioned above.

Dep. Terr. Magn., C.I.W., August 10, 1933.

OCCURRENCE OF SUDDEN COMMENCEMENTS AT THE WATHEROO MAGNETIC OBSERVATORY

By A. G. McNISH

While much attention has been given to the study of individual sudden commencements and the simultaneity of their occurrence at widely separated observatories, little interest has been shown in the statistical aspects of these distinctive phenomena. A recent paper (Terr. Mag., v. 37, 273-279, 1932) by Rodés considers the diurnal, annual, and secular variation of the number of sudden commencements recorded at the Ebro Observatory from 1905 to 1931. A similar study, employing the data from the Watheroo Magnetic Observatory of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington from 1919 to 1930, is here presented.

While there is general agreement among investigators as to what constitutes a sudden commencement, this phenomenon was arbitrarily defined for the Watheroo Observatory as an abrupt movement of the traces, distinct in all elements — though possibly quite small in all except horizontal intensity — which is preceded by several comparatively quiet hours and followed by an increase in the activity of the traces, the predominating feature of which is an increase in the value of horizontal force. Sudden commencements are so distinctive at the Watheroo Observatory that no difficulty was experienced in identifying them. There were only a few movements during the 12-year interval, the classifications of which were doubtful; their inclusion or omission could not appreciably affect the averages obtained. A total of 151 sudden commencements was included in the study.

Secular variation — A high correlation was found to exist between the number of sudden commencements occurring in a given year and the magnetic activity for that year as given in a table of the modified interdiurnal-variability (u_1) measure prepared by Bartels (Terr. Mag., v. 37, 16, 1932). This is shown in Fig. 1 in which annual values of the number of sudden commencements and the magnetic activity are plotted separately. It may be remarked that the activity derived from Watheroo alone closely resembles, almost to identity, that derived from means for the world-wide distribution of observatories used by Bartels in preparing the table referred to above. Figure 1 also shows the number of sudden commencements recorded at the Ebro Observatory for the same years, taken from Father Rodés' paper. The data plotted for Ebro include only sudden commencements of the "A-type" as defined by Rodés, which accounts for the apparently smaller number recorded.

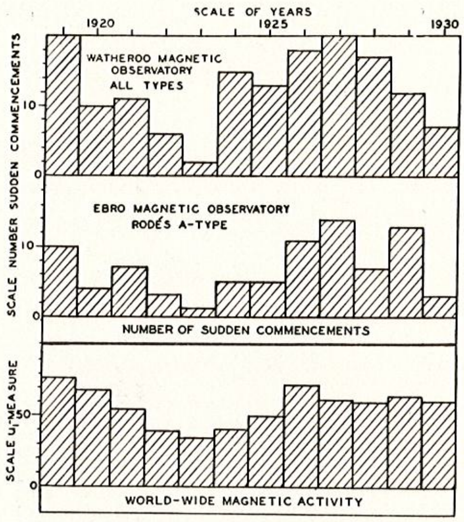


FIG. 1 — SECULAR VARIATION IN NUMBER OF SUDDEN COMMENCEMENTS AT WATHEROO AND AT EBRO AND OF WORLD-WIDE u_1-MEASURE OF MAGNETIC ACTIVITY

This evidence substantiates the natural conclusion that sudden commencements are strongly affected by extra-terrestrial causes, probably of solar origin. The obvious association of sudden commencements with magnetic disturbances, of which they are the initial part in general, leads to the expectation that the number of occurrences noted at different observatories will be at least approximately the same for any given time-interval. A further consideration of the evidence, however, indicates that this is not altogether true.

Seasonal variation — An attempt to classify sudden commencements at Watheroo according to the months in which they occurred proved unsatisfactory because of the irregularities introduced by the comparatively small number of the events. A seasonal grouping which gave an average of 50 events in each class-interval appears to exhibit reliably the distribution of sudden commencements throughout the year. The data were arranged in four groups as follows: (I) Southern summer solstice, that is, November, December, January, and February; (II) equinox, that is, March, April, September, and October; and (III) southern winter solstice, that is, May, June, July, and August. A marked and somewhat surprising distribution of the occurrences appears for this grouping. Figure 2 shows this distribution for Watheroo and for the "A-type" commencements at Ebro, as well as the seasonal distribution of magnetic activity.

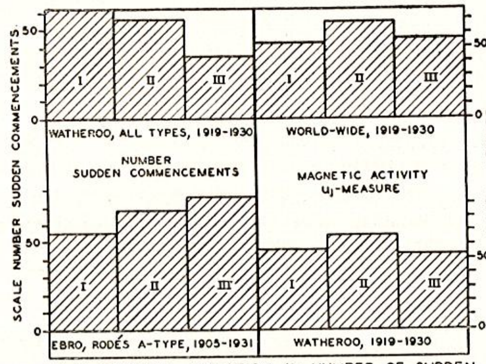


FIG. 2—SEASONAL VARIATION IN NUMBER OF SUDDEN COMMENCEMENTS AND IN u_1-MEASURE OF MAGNETIC ACTIVITY

I = JANUARY, FEBRUARY, NOVEMBER, AND DECEMBER; II = MARCH, APRIL, SEPTEMBER, AND OCTOBER; III = MAY, JUNE, JULY, AND AUGUST

From indications of the preceding paragraph a maximal number of sudden commencements would be expected during the equinox when magnetic activity is greatest, not only at Watheroo but throughout the world. That the occurrence of the maximum during the southern summer is not merely fortuitous is demonstrated since at Ebro the maximum occurs during the northern summer, a complete seasonal reversal for stations in the northern and southern hemispheres. Plotting the distribution by months for Ebro, Rodés found maxima occurring during March and August. A similar treatment of the Watheroo data, not illustrated here, found only one outstanding maximum which fell in October.

In discussing the cause of the two maxima which he found, Rodés stressed the fact that they occurred approximately at the time when the Earth was in the highest heliocentric latitudes. He apparently overlooked the fact that the mean equinoctial number was less than the mean for the northern summer. It seems to the writer that, although the correlation of sudden commencements with magnetic activity leads to the expectation of equinoctial maxima in their frequency, this correlation is overweighed by a seasonal effect which is reversed in the northern and southern hemispheres.

Diurnal variation — Further evidence of a local effect in the distribution of sudden commencements is supplied by investigating the diurnal variation. Figure 3 shows the number of occurrences grouped according to the time of day when they were observed. Anticipating a difference in the diurnal distribution of the occurrences at different seasons and endeavoring to test the reliability of any diurnal distribution which might be discovered, the diurnal variation was subdivided into seasonal groups as stated above. The data given by Rodés for the entire year are also shown, the hours being local standard time. It is evident that if the observations were plotted according to universal time striking dissimilarities would appear, again showing a strong local effect. Outstanding features of the Watheroo distributions are the forenoon minima and afternoon maxima. It seems there is a tendency for sudden commencements to occur immediately after noon, which has previously been noted by Moos (Magnetic observations made at the Government Observatory, Bombay, 1846-1905, Part 2, 455, 1910) although he has remarked that it may be purely fortuitous. The variation exhibited by the Ebro data is more regular but bears out the general aspect of the Watheroo distributions, namely, that more sudden commencements occur during the afternoon and evening than during the forenoon and early morning hours. Remarks on a possible change in the form of the diurnal variation with a change in season appears inappropriate on the basis of the data.

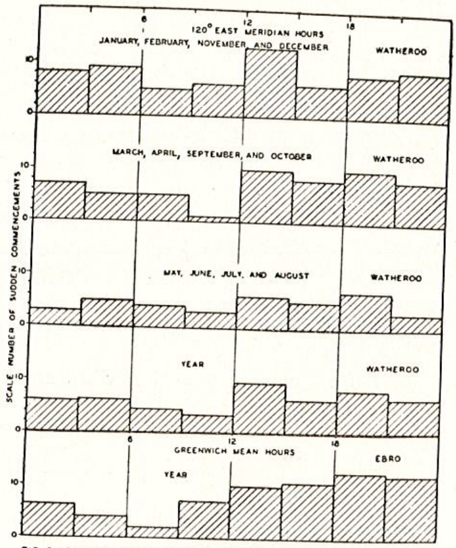


FIG. 3—DIURNAL VARIATION IN NUMBER OF SUDDEN COMMENCEMENTS AT WATHEROO (1919-1930 ALL TYPES) FOR SEASONS AND YEAR AND AT EBRO (1905-1931 RODÉS A-TYPE) FOR YEAR

Discussion — The writer favors the view that sudden commencements must be due to a complex of at least two causes, one terrestrial and the other extra-terrestrial which may be considered as existence and productive probabilities. The primary cause of sudden commencements undoubtedly is identical with the cause of magnetic storms such as corpuscular streams from the Sun. This explains the eleven-year period in their occurrence partly demonstrated in the present paper and more fully supported by the work of Rodés. To account for the seasonal and diurnal variations of the phenomena it is necessary to recognize a terrestrial influence dependent upon the location of the observatory. Rodés appears to believe that this second cause is associated with the position of the observatory relative to the Earth's axial and orbital motions. The author believes a sudden commencement is more likely to be observed when the upper atmosphere in the region of the observatory is more richly ionized, due presumably to currents induced there by the primary, extra-terrestrial cause. The large number of sudden commencements observed around noon suggests that a portion of the current causing them may flow in the E- and F_1-layers which radio measurements have shown to be most richly ionized at that time. Considerable doubts is still attached to the interpretation of measurements on the F_2-layer, which fact permits the theorist much latitude in seeking to explain the predominance of sudden commencements in the afternoon and evening. The obvious hypothesis it that the F_2-layer experiences its maximum ionization at that time.

Dep. Terr. Magn., C. I. W., July 29, 1933.

MEAN FORCE-VECTORS ASSOCIATED WITH SUDDEN COMMENCEMENTS AND MAGNETIC STORMS

By A. G. McNISH

From the extremely heterogeneous directions and magnitudes of the field-changes at times of sudden commencements and magnetic storms may be formed mean vectors which indicate that underlying these chaotic events are systematic phenomena. One hundred and fifty-one sudden commencements observed at the Watheroo Magnetic Observatory of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington during the interval 1919-30 have been measured and formed into mean vectors. When a sudden commencement involved more than a single movement in any component of the magnetic field the gross change involved was measured. The time required for the consummation of a gross change in no case exceeded three or four minutes. The mean storm-vector is the average of the differences of the five international quiet and disturbed days as they are indicated in the quarterly publication "Caractère magnétique de chaque jour".

Characteristics of the field-changes — The average vectors for the three seasons — southern summer (January, February, November, and December), equinox (March, April, September, and October), and southern winter (May, June, July, and August — are shown in Figure 1. Changes in the XY-plane, tangent to the Earth at Watheroo, are shown to the left, while changes in the XZ-plane, perpendicular to the XY-plane and including the rotational axis of the Earth, are shown on the right. In both planes, it may be observed the sudden-commencement vector, designated by C, is almost diametrically opposed to the mean

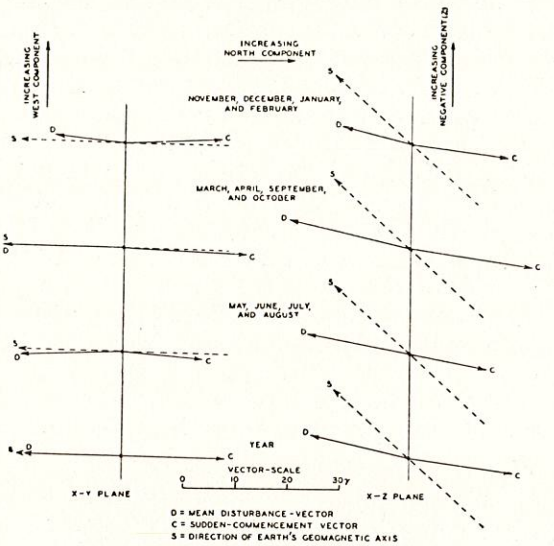


FIG. 1—MEAN DISTURBANCE-VECTORS AND SUDDEN-COMMENCEMENT VECTORS AT WATHEROO MAGNETIC OBSERVATORY, 1919–1930

storm-vector, disignated by D. The direction of the axis of uniform magnetization of the Earth is indicated in each diagram, the south-end of the axis being designated by S.

Discussion of the phenomena — As described in another paper (A. G. McNish, Nation. Res. Council, Trans. Amer. Geophys. Union, 14h annual meeting, 139-144, 1933), the ring-current conception of magnetic storms requires in every case that the mean disturbance-vector should be parallel to the Earth's geomagnetic axis. This is found to be the case in the XY-plane, but not in the XZ-plane. A divergence from the true axial direction in the XZ-plane is to be expected, partly due to currents flowing in the conducting layers of the atmosphere and partly due to induced currents within the Earth. Both would act to diminish the vertical component of the disturbance-vector and enhance, at least comparatively, the horizontal component.

The cause of the sudden commencement appears to be a reversal of the average cause of the entire disturbance, such as a ring-current flowing in the opposite direction, although it is conceivable that the cause might be something altogether different. Assuming a ring-current, inductive effects would likewise distort the sudden-commencement vector from parallelism with the Earth's geomagnetic axis. The striking observation is that the angle which the sudden-commencement vector makes with the geomagnetic axis is almost the same as that made by the disturbance-vector. If the ring-current is assumed and inductive effects called upon to explain this lack of parallelism, what explanation is to be offered for the fact that the inductive effect is approximately the same for a sudden commencement which requires but a few minutes for its completion and for an entire period of disturbance which lasts for 24 hours or more? Some slight solace may be derived from the fact that for each season and for the yearly mean, the ratio of the vertical component (which is diminished by induction) to the horizontal component is slightly greater for the disturbance-vector than for the sudden-commencement vector. This difference is not, however, satisfyingly great. Considering these facts it is unlikely that a ring-current in the form of a toroid will explain these phenomena fully and the conception of a current or other agent in outer space assuming a form more like a spherical shell may be necessary.

The data presented here do not constitute a complete proof of the conditions they suggest. No attempt has been made as yet to define the reliability of the means represented. In a further investigation it is planned to determine the probable limiting values of these vectors as a problem in three-dimensional probability.

Dep. Terr. Magn., C. I. W., July 29, 1933.

STEREOGRAMMATIC REPRESENTATION OF SOME SUDDEN COMMENCEMENTS

By William J. PETERS

A further application of Dr. Bartels' idea of stereogrammatic representation of geophysical phenomena where three dimensions are involved has been made in an investigation of the geographical distribution of initial features of magnetic storms having sudden commencements.

It is known that sudden commencements occur about the same time or within a minute or so the world over, and that the most conspicuous feature on magnetograms is the extraordinary change in horizontal intensity usually preceded by a comparatively small change in the opposite sense, sometimes called the preliminary kick. Simultaneous changes usually occur in the other magnetic elements. It is also shown by a comparison of magnetograms that these changes in the three elements vary in magnitude the world over. Consequently the resulting vector representing the superimposed magnetic field may vary from place to place both in direction and in magnitude.

It is difficult to visualize the distribution merely from an inspection of many magnetograms on which the traces of the three elements always appear on different scales for every observatory as well as from the lack of uniformity between observatories. The three stereograms submitted are intended to tentatively supply the picture for the commencements which occurred January 29, 1924 at 5h 26m, September 21, 1925 at 2h 15m, and March 5, 1926 at 10h 05m, G. M. T. The stereogram numbers 1, 2, and 3 apply in chronological order.

The model globe was assumed to have a radius of 111 mm and to be placed with its center 750 mm from the spectator, 211 mm below his horizon, and shifted 22.5 mm to his left. The picture-plane is 150 mm distant. The globe appears as intersections of the circles of latitude 0° and 30° with meridians 0°, 15°, 30°, ... 345°, and circles of 60° latitude with meridians 0°, 30°, ... 345°. Greenwich meridian is the nearest to the spectator; meridians of 90° west and 90° east are to the left and right, respectively. The long arrow through the center piercing the globe flies towards the Sun. N and S are the geographical poles. AB is a line drawn through the center parallel to the direction of a fictitious homogeneous magnetization of the Earth that would fit observational data best. P and P are the magnetic poles.

The observatories are shown as black perforated discs with the initial letter of the name adjoining as indicated in the following table which is arranged with reference to latitude.

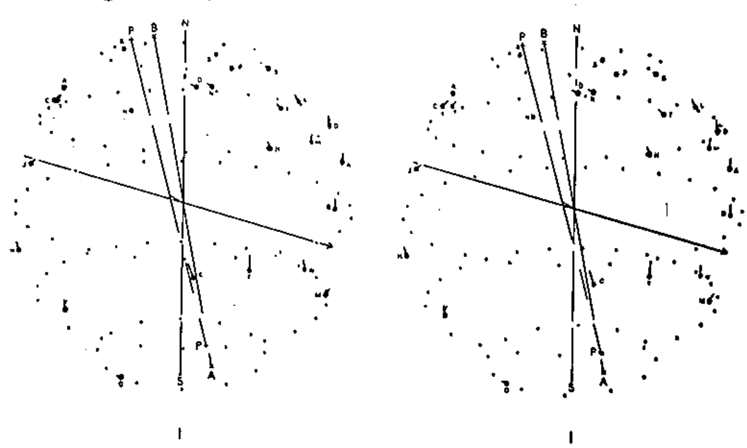
S, Sodankylä (Finland)
P, Pavlovsk (near Leningrad)
S, Sitka (Alaska)
S, Sverdlovsk (near Ekaterinburg)
N, Niemegk (near Potsdam)
D, De Bilt (near Utrecht)
A, Agincourt (near Toronto)
T, Tiflis
C, Cheltenham, (Maryland)
T, Tucson (Arizona)
L, Lukiapang (near Shanghai)
D, Dehra Dun (India)
H, Helwan (Egypt)
H, Honolulu

A, Alibag (near Bombay)
J. San Juan (Puerto Rico)
M, Manila (Philippine Islands)
B, Batavia
H, Huancayo (Peru)
A, Apia (Samoa)
M, Mauritius
V, Vassouras (near Rio de Janeiro)
W, Watheroo (Western Australia)
P, Pilar (Argentina)
T, Toolangi (near Melbourne)
C, Christchurch (New Zealand)
O, Orcadas (South Orkneys)

The whole list is not represented on all three stereograms because some element or elements are missing in the magnetograms.

The vectors originating at each observatory represent $R = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$ corresponding to the most conspicuous feature of the sudden commencement as already defined. Since the spectator can only estimate the directions of the vectors, it has been considered expedient in constructing these tentative stereograms to have him estimate their magnitudes as well. The scale for vectors is 5 gammas to 1 millimeter.

In stereogram 1*) representing the sudden commencement of

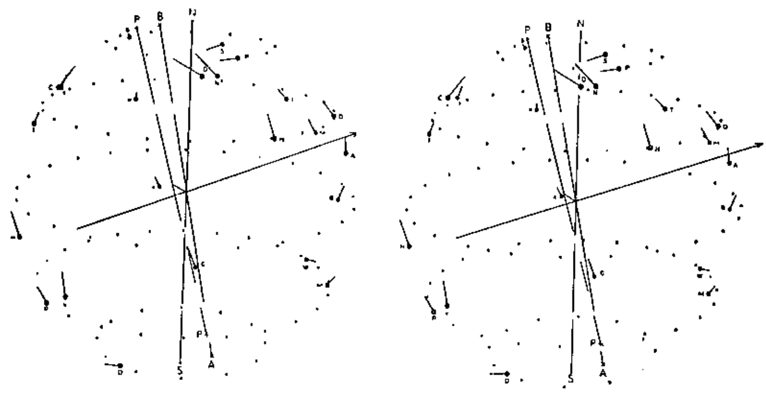


January 19, 1924 at 5h 26m, G. M. T., the Sun is seen to be in the zenith of the point in latitude 18° 08′ south and longitude 101° 45′ east. The longest vectors appear at Christchurch (C) and

*) Les stéréogrammes en dimension pour stéréoscope se trouvent à la fin du volume.

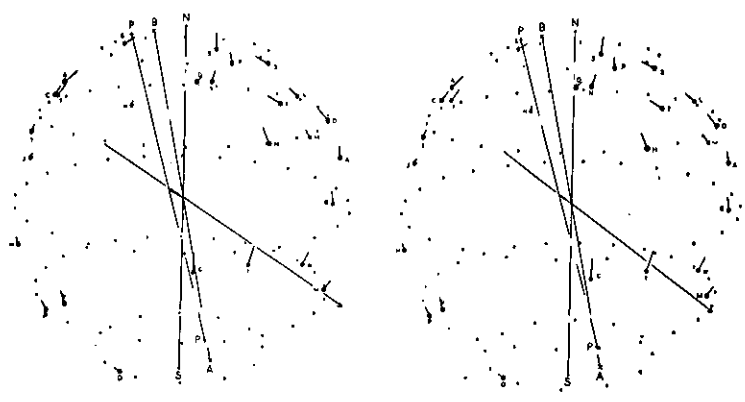
Toolangi (T). At Pavlovsk (P) and Sitka (S) they are so short that they do not extend beyond the black discs representing the observatories. In general the vectors lie in or close to the Earth's surface. Notable exceptions are Mauritius (M) where the vector is outward, San Juan (J) and Honolulu (H) where it is inward.

In stereogram 2*) representing the sudden commencement of September 21, 1925 at 2h 15m, G. M. T., the Sun is in the zenith



2 2

of latitude 0° 58′ north, longitude 144° 30′ east. The shortest vectors appear at Watheroo (W) and Mauritius (M) where they are directed outward to a greater extent than elsewhere. It might be noted that this storm was not considered as typically representative for Watheroo and that the Z-trace in particular shows a large but rapidly fluctuating change so that there is considerable uncertainty in scaling ΔZ.



3 3

In stereogram 3*) representing the sudden commencement of March 5, 1926 at 10h 05m, the Sun is seen in the zenith of latitude 6° 16′ south and longitude 31° 45′ east. The shortest vectors are mostly in the South American Continent. At Watheroo and Mauritius they are directed outward but not to the same extent as before.

The directions depend on the changes of three elements, and in many magnetograms the sensitivity of the Z-curve especially is much too low for precise determination of direction. These stereograms accentuate the sparsity of data in parts of the world, especially in Africa, already pointed out by Dr. Bartels' stereograms. Some European observatories are omitted for sake of clarity since their traces give very much the same results. If there is any significance in the distribution of such vectors, three examples are not sufficient to point it out. Three more storms are in the course of preparation.

Dep. Terr. Magn., C. I. W., August 11, 1933.

NOTE ON SUDDEN COMMENCEMENTS OCTOBER 14, 1932, AND APRIL 30 AND MAY 29, 1933

By W. J. PETERS and C. C. ENNIS

In compliance with the request of July 1, 1933, by the Committee on Sudden Commencements of the International Association of Terrestrial Magnetism and Electricity, the data in Table 1 are submitted concerning the times of sudden commencements as obtained from the quick-running magnetograms October 14, 1932, April 30, 1933, and May 29, 1933, at Watheroo,

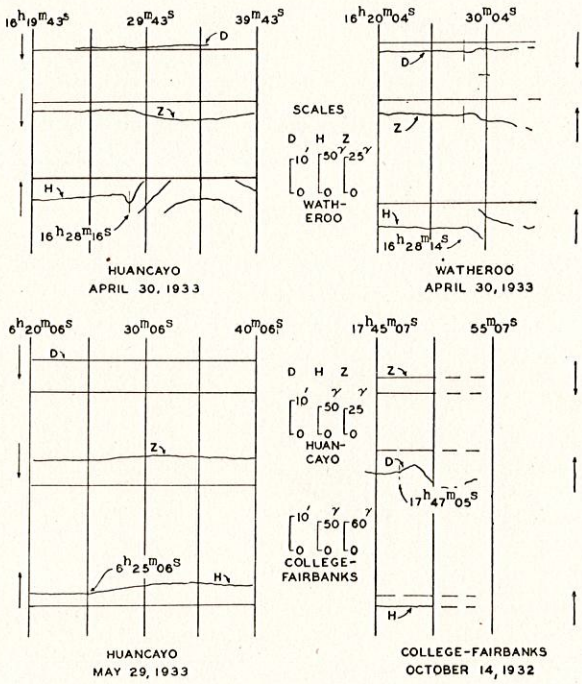
Table 1. — *Particulars of magnetic sudden-commencements*

Date	Greenwich mean times of beginning at				
	Watheroo 30°19′ S 115 52 E	Huancayo 12°03′ S 75 20 W	College-Fairbanks 64°51′ N 147 49 W	Kakioka 36°14′ N 140 11 E	Toyohara 46°57′ N 142 45 E
	h m s	h m s	h m s	h m s	h m s
October 14, 1932	.. .. ..	.. .. ..	17 47 05 (D)	17 47 03	17 47 10
April 30, 1933	16 28 14	16 28 16	16 28 30 (D)	16 28 14	16 28 22
May 29, 1933	6 25 22	6 25 06	6 25 45 (H)	6 25 22	6 25 31

Huancayo, and College-Fairbanks observatories. Also included for comparison are the data for Kakioka and Toyohara as reported by Dr. Okada, Director of the Central Meteorological Observatory of Tokyo, in his communication.

The quick-running magnetographs were not in operation at Watheroo and Huancayo October 14, 1932.

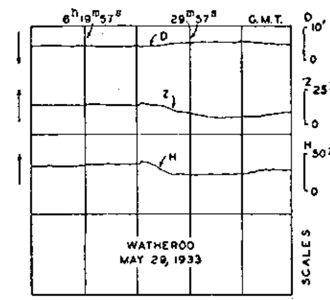
The accompanying tracings of the sudden commencements as recorded on the quick-running magnetograms were made from the five magnetograms available at present. The times



REPRODUCTION OF QUICK-RUNNING MAGNETOGRAMS
DIRECTION OF ARROW INDICATES INCREASING EAST DECLINATION, HORIZONTAL INTENSITY, AND POSITIVE VERTICAL INTENSITY
GREENWICH MEAN TIME

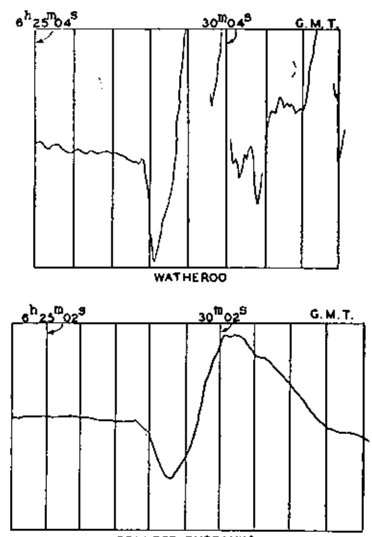
given for College-Fairbanks, April 30 and May 29, 1933, were obtained through telegraphic communication with the Observatory, the times as supplied by the United States Coast and Geodetic Survey for the different elements being 16h 28m 30s, 16h 27m 38s, and 16h 29m 17s for the declination, horizontal-intensity, and vertical-intensity records, respectively, of April 30, 1933, and 6h 26m 18s, 6h 25m 45s, and 6h 27m 02s for the declination, horizontal-intensity, and vertical-intensity records, respectively, of May 29, 1933.

The times for Huancayo and Watheroo were scaled from horizontal-intensity traces, but those for College-Fairbanks October 14, 1932, and April 30, 1933, were scaled from declination traces on account of the flatness of the horizontal-intensity traces. The discrepancies in the College-Fairbanks times above probably may be attributed to the same condition. It may be noted that the times at Watheroo (longitude 115° 52′ east) and Kakioka (longitude 140° 11′ east) are identical for April 30 and May 29, 1933.



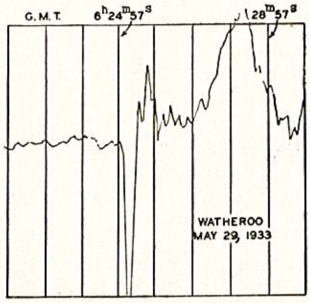
REPRODUCTION OF QUICK-RUNNING MAGNETOGRAMS
DIRECTION OF ARROW INDICATES INCREASING EAST DECLINATION, HORIZONTAL INTENSITY, AND POSITIVE VERTICAL INTENSITY

The difficulty of identifying critical points on these quick-running magnetograms suggests the advisability of increasing the sensitivity in all elements recorded. This preliminary examination also suggests the advisability of comparing the times of the very first change in the elements as well as the minimum point. There may be simultaneity here, even when there is a time of propagation for the minimum point as suggested by H. F. Johnston of this Department.

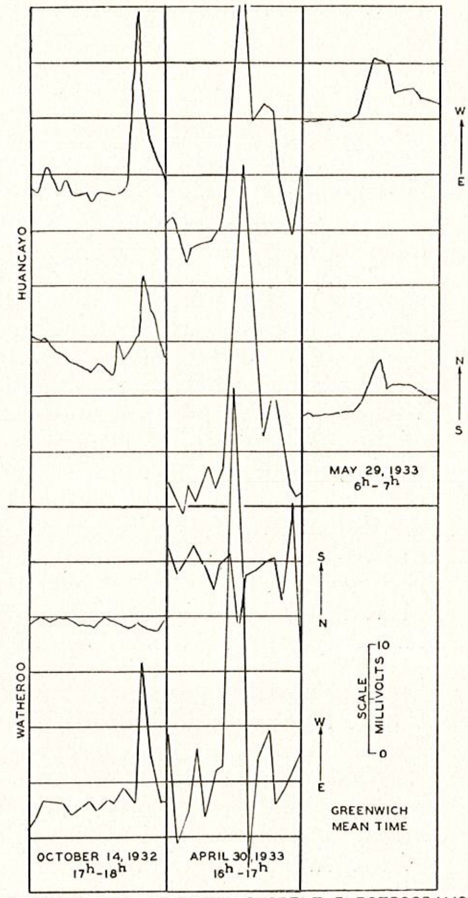


REPRODUCTION OF RECORD, MITCHELL VERTICAL-INTENSITY INDUCTOMETER, APRIL 30, 1933

In addition to the information requested by the circular letter of the Association's Committee, there are included herewith other traces which may be of interest in studying these commencements. These are: (*a*) Tracings of the records of the Mitchell vertical-intensity inductometer for Watheroo and College-Fairbanks, April 30, 1933, and for Watheroo, May 29, 1933, showing the sudden commencement very sharply defined —



REPRODUCTION OF RECORD, MITCHELL VERTICAL-INTENSITY INDUCTOMETER



REPRODUCTION OF EARTH-CURRENT ELECTROGRAMS

they seem to offer some opportunity for exact determination of times of the very first indication of sudden commencements; (*b*) tracings of records of eart-current potential showing the same sudden commencements of October 14, 1932, and April 30, 1933, at Huancayo and Watheroo and of May 29, 1933, at Huancayo — they may be found of interest in showing the close relation of the two phenomena though the time-scale does not offer so much precision.

In this connection, attention may be called to the brief note by J. A. Fleming and C. C. Ennis relating to enlargements of the regular-speed magnetograms for these storms at Watheroo and Huancayo magnetic observatories.

Dep. Terr. Magn., C. I. W., August 22, 1933.

DIURNAL VARIATION OF EARTH-CURRENT POTENTIALS ON MAGNETICALLY DISTURBED AND MAGNETICALLY CALM DAYS

By W. J. ROONEY

(The details of the records summarized in this communication, including tables showing the mean annual and mean monthly variations at the four stations, are to be published in an early issue of the Journal of Terrestrial Magnetism and Atmospheric Electricity).

Since the most striking indication that there is some relationship between the Earth's magnetic field and the natural electric currents which flow in its crust is given by the simultaneity of disturbances in the records of the two phenomena, a study of the effects of these disturbances on the normal diurnal variations may be expected to lead to a better understanding of the relationship. Comparisons of the diurnal variation records during disturbed and calm periods have been made frequently in the case of the magnetic records. Similar comparisons of the diurnal variation in earth-current potential-gradient are then in order. The main facts disclosed by comparing earth-current records in this manner, based chiefly on the results obtained at Watheroo but including some reference to those from Ebro, Huancayo, and Tucson, are briefly summarized herein.

In classifying days as "calm" or "disturbed" it has been found that electrical classification agrees so closely with that based on the magnetic records that it is immaterial which is applied. Hence the straight magnetic classification has been used so that any comparison which may be made with the magnetic records will be based on strictly simultaneous records of the two phenomena.

Only the diurnal-variation was considered in examining the earth-current records. As far as the absolute values of potential recorded are concerned, it should suffice to say that in no case has there been found any change in the mean values recorded during or after a disturbance which can be attributed to the disturbance. This strengthens the conclusion that earth-current flow is purely oscillatory in character with no so-called constant part corresponding to that of the Earth's magnetic field.

The comparison for Watheroo covers the five-year period 1924-28. Mean diurnal-variation curves for the five international disturbed and five international quiet days per month are shown in Figure 1. At Watheroo the flow of earth-currents is restricted to a direction only slightly west of south-north, so that the eastward component is extremely minute, as will be seen in the Figure, and the northward component is practically equivalent to the resultant. For this reason, only the records of the northward component are discussed. During the hours before noon the ordinates of the disturbed-day curve are higher than those of the calm-day curve, and during the afternoon they are

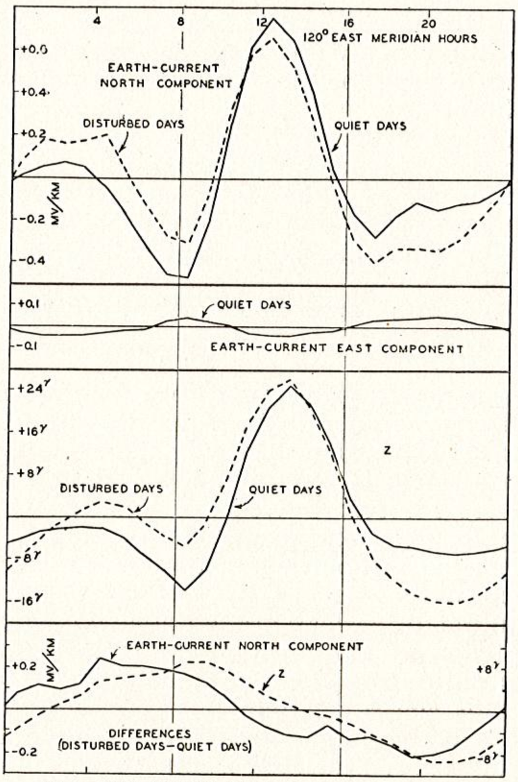


FIG. 1—MEAN DIURNAL VARIATION IN EARTH-CURRENT POTENTIAL-GRADIENT AND MAGNETIC VERTICAL INTENSITY (Z) AT WATHEROO MAGNETIC OBSERVATORY ON QUIET AND DISTURBED DAYS FOR FIVE-YEAR PERIOD, 1924-1928

lower. Positive ordinates indicate a flow of current northward, or towards the equator. The differences between the disturbed-day and calm-day curves have also been plotted at the bottom of the Figure. The difference-curve is essentially a single-period curve with maximum in the forenoon and minimum toward the end of the day.

Similar curves constructed for the individual months of the year show that exactly the same type of difference persists throughout the year. As is to be expected, the difference-curves are somewhat less smooth than the mean curve, but all have the same general characteristics. Hence there appears to be no marked change with season of the year in the relationship between disturbed-day and calm-day variation.

The difference between disturbed-day and calm-day diurnal variation of earth-currents as exemplified by these curves is very like that found in the magnetic records, as will be seen from the central pair of curves shown in the Figure. These give the mean diurnal variation in magnetic vertical intensity Z at Watheroo for the same five-year period. The differences between the disturbed-day and calm-day magnetic curves, plotted together with those for the earth-currents, show the similar way in which the two are affected by disturbances. Because the chief minimum of the earth-current diurnal-variation curve on calm days occurs nearly at the same time as the maximum of the difference-curve — that is, when the disturbances seem to promote a northward flow of current — the amplitude of the disturbed-day curve is slightly smaller than that of the calm-day curve. The amplitude of diurnal variation of the magnetic elements, on the other hand, is somewhat greater on disturbed days than on calm ones.

The earth-current records from Ebro for the same five-year period have been compiled in the same way and a comparison of the results indicates almost exactly the same type of difference between disturbed- and calm-day variation as that found in the Watheroo records. Since Ebro is in the northern hemisphere, negative ordinates mean flow of current towards the equator and positive ordinates indicate flow away from it. Hence the difference-curve is about the reverse of that shown for Watheroo, but the differences are the same not only in character but also in sign if viewed with reference to the equator. The Ebro differences during the individual months are more irregular and less consistent than those at Watheroo, but have the same tendency toward persistence throughout the year of the type of difference indicated by the mean curve.

Records sufficiently complete to permit a comparison of the variation on international quiet and disturbed days were not secured at Huancayo until 1930. For this reason the records examined from that Observatory do not cover the same nor as long a period. Mean curves for the two-year period 1930-31 indicate a difference between disturbed-day and calm-day variation which is like that at Watheroo and Ebro, in that the difference-curve is one of single period. Its amplitude, however, is somewhat smaller in proportion to that of the diurnal-variation, and there is a phase-shift of about 90° between it and the Watheroo curve. The reason for these dissimilarities is not apparent at present. That in amplitude may be merely due to the fact that the periods of observation were not the same. Here again there is no indication of any change with season in the effect of disturbances.

At Tucson, earth-current recording was begun in March 1931, and only a little more than one year's records are available at present. Those for the one-year period July 1931 to June 1932 give a disturbed-day diurnal-variation curve which differs from that on calm days by about the same amount as at Watheroo and Ebro, but the difference-curve for this short period is not smooth enough to bring out the details of the differences definitely. It does suggest that the disturbances affect the normal diurnal variation in much the same manner as at the other stations.

Finally, it appears from the records at all four stations that the effects of disturbances are confined almost exclusively to changes in the amplitude of variation, the restricted paths characteristic of earth-current flow remaining practically unchanged during disturbances, even those of great magnitude. This is evident not only in the mean values but also in the individual daily records.

Dep. Terr Magn., C. I. W., July 31, 1933.

ON THE CHARACTERIZATION OF DAYS IN THE PUBLICATION OF ATMOSPHERIC-ELECTRIC DATA

By O. W. TORRESON

The Department of Terrestrial Magnetism of the Carnegie Institution of Washington has been collecting atmospheric-electric data at its Watheroo Magnetic Observatory in Western Australia since 1922 and at the Huancayo Magnetic Observatory in Peru since 1923. The writer, as an observer at each of these stations for a considerable period, has participated in the maintenance and operation of the atmospheric-electric apparatus, and also in the tabulation and classification of the data obtained. The following remarks are the outgrowth of his work for some time past, on the basis of that earlier experience, in an intensive review of the atmospheric-electric data accumulated to date.

Unlike the magnetic work, in which the infrequent loss of record is caused largely by instrumental difficulties and abnormality of record is caused almost entirely by magnetic storms, the atmospheric-electric work is subjected to frequent loss and abnormality of record through thunder-storms and many other meteorological disturbances as well as through instrumental difficulties. It is a matter of experience at both Watheroo and Huancayo that loss or abnormality of record through instrumental difficulty is greatly exceeded by loss or abnormality due to meteorological disturbances. At Huancayo, thunder-storms cause the principal disturbances, whereas at Watheroo smoke is equally if not more prominent as a disturbing factor. Also, of course, there are disturbances caused by rain, fog, mist, and dust blown up by high winds. Snow is never found at either of the two stations.

Smoke at Watheroo is no minor difficulty. During January to April of each year, smoke is present on the average during 15 days of each month and is easily detected either by sense of smell, or by sight, or both. It arises from two sources, namely, the burning of brush over the great uninhabited region to the west of the observatory and the annual burning-over of land in the south and southwest by farmers as part of their refertilizing process. On nearly every afternoon during these four months the wind swings around to southwest between 15h and 20h, and when smoke comes with it the potential gradient always shows very high values and the conductivity-records, both positive and negative, show very low values. In Figure 1

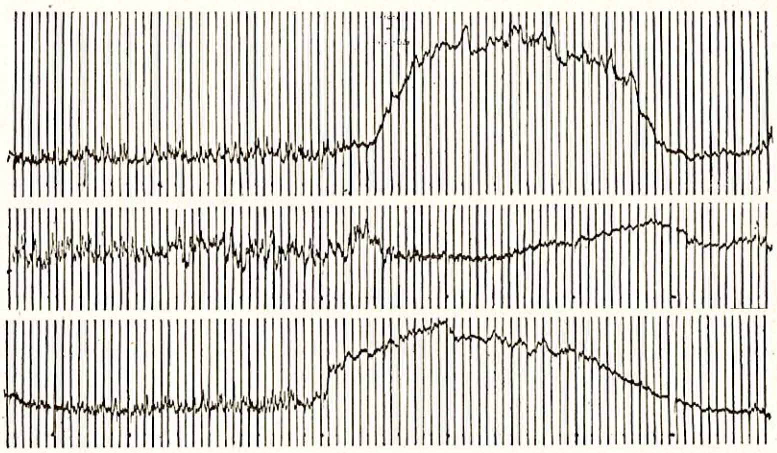


Fig. 1. — Three 24-hour records of potential gradient at Watheroo Magnetic Observatory, each beginning 8^h 120° east meridian time: January 27-28, 1929 — smoke-effect began 20^h, highest hourly mean value 398 v/m; March 11-12, 1929 — no known smoke-effect, highest hourly mean value 198 v/m; March 20-21, 1929 — sudden smoke-effect 18^h, highest mean hourly value 287 v/m

are reproduced two records of potential gradient disturbed by smoke and a third free from smoke-effects. It is obvious that these three records should not all be considered similar in character. Often the increase in gradient and decrease in conductivity is very abrupt, the former becoming in a period of several minutes several-fold as great and the latter only a fraction of the value prevailing just before the smoke arrived. The correlation of these effects may be said to be well established; the effects have been observed many times during actual occurrence, and the correlation has been confirmed by studies of meteorological and atmospheric-electric data and observations of condensation-nuclei. During the four smoky months there are also electrical storms causing negative potential on an average of seven days each month. There are, therefore, very few days remaining in any one of these months from which to select typical "least-disturbed" days. From May to August, although smoke is no longer a disturbing factor, electrical storms become numerous enough to cause negative potentials on an average of 13 days each month. The months of September to December are the least-disturbed months of the year.

At Huancayo smoke is a negligible factor, but electrical storms or stormclouds cause almost daily occurrence of negative potential. From May to August the negative potentials are least numerous but even in these months they occur on an average of 17 days each month. During the remaining eight months of

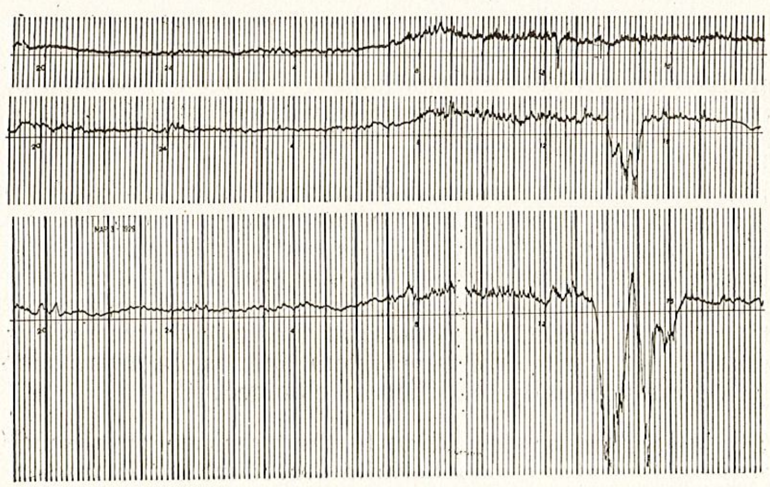


Fig. 2. — Three 24-hour records of potential gradient at Huancayo Magnetic Observatory, each beginning 19^h 75° west meridian time: January 17-18, 1929 — less than 10 minutes negative potential, otherwise a "least-disturbed" day; March 21-22, 1929 — one hour negative potential (mean hourly value —70 v/m, otherwise a "least disturbed" day; March 3-4, 1929 — about 2.5 hours negative potential, yet not beyond consideration as a "least-disturbed" day if interpolation is performed over the disturbed interval

the year negative potentials occur on an average of 25 days each month. However, on many occasions the periods of negative potential continue only a few minutes and on numerous other occasions are somewhat longer but still less than an hour in length. In such cases the return of the potential after the disturbance to that value which prevailed before is usually complete. Typical records from Huancayo are shown in Fig. 2.

The conditions which have been detailed here are undoubtedly not unique to the two observatories of the Department. Every station has local characteristics which affect the atmospheric-electric elements as much or perhaps more than do those encountered at Watheroo and Huancayo. The question is, then, how to present these data, when publishing, so that the reader of the paper may know, without too much searching, what the important conditions were under which the data were collected. One of the most informative devices is the characterization of days.

Various methods of characterizing days of atmospheric-electric data are at present in use by observatories throughout the world. By one method the days are judged to be "quiet" or "disturbed". By another the days are characterized according to the presence or absence of negative potential and upon the period of duration of the negative potential. Thus, a "0"-day is one free from negative potential, a "1"-day has less than three hours of negative potential for the whole day, and a "2"-day has more than three hours of negative potential.

The method of characterizing days as "quiet" or "disturbed" or by the more detailed system of "quiet", "moderately disturbed", and "greatly disturbed" is one which depends almost entirely upon the experience of the one who does the classifying. It may or may not demand any particular consideration of the meteorological conditions existing at the time the records were obtained. It is a quite arbitrary system, and, as observers change, may become gradually modified or changed.

The classification according to the presence or absence of negative potential is a very definite procedure but it has serious limitations. It accounts only for thunder-storm effects and leaves without classification abnormal effects associated with smoke, fog, mist, rain, dust, and other meteorological factors. By this procedure, no matter how great the positive potential may become, it alone is not considered abnormal. It is obvious that the Watheroo records would be inadequately characterized by such a method. For Huancayo also it has serious defects. Those days on which negative potential occurs for a few minutes or for any interval less than an hour, and on which the record after the disturbance appears as undisturbed as prior to it (as in the top and middle records of Fig. 2) are frequently suited for inclusion in what might be called "least-disturbed days," *provided the disturbed period is taken care of by interpolation based upon the preceding and following mean hourly values.* This seems a not unreasonable arrangement and the interpolation can be readily indicated by proper notations in an appropriate place on the tabulation. By such a method, many more days will be made available for inclusion in the monthly "means" than would be the case if the presence of negative potential were allowed to dictate the characterization of the day. Caution will, of course, need to be exercised in such a procedure, but it seems undesirable to rule out such an exercise of judgment on the part of the men who have had immediate supervision of the creation of the record and who are seeking to place the best possible interpretation upon the character of the result.

A system of numerical characterization of days which has been suggested by experience with the Watheroo and Huancayo atmospheric-electric records, and which is quite definite in its requirements, lays primary emphasis on the nature of the disturbing factor, rather than on the severity of the disturbance. The system is as follows:

"0"-days — days free from all known meteorological disturbances, including smoke and thunder-storms, or days affected for some short interval of time (one or two hours total for the day and preferably in a single interval) by any known meteorological disturbance but on which days, in the opinion of the observer, interpolation over the disturbed interval can fairly be made.

"1"-days — days known to be affected by smoke and all other meteorological disturbances except thunder-storms, for more than two hours or for any shorter interval over which interpolation cannot be permitted.

"2"-days — days known to be affected by thunder-storms, exclusive of smoke and other meteorological disturbances, for more than two hours, or for any shorter interval over which interpolation cannot be permitted.

"3"-days — days known to be affected by both thunder-storms and other meteorological disturbances (including smoke) for more than two hours, or for any shorter interval over which interpolation cannot be permitted.

In this classification, the character-numbers "0" to "3" tend to agree in an approximate way with the degree of severity of the disturbance. Meteorological disturbances other than thunder-storms produce, in general, less severe effects on the atmospheric-electric elements than do thunder-storms. The thunder-storm effects are given character "2", therefore, rather than "1". Similarly character "3" is given to days affected by both thunderstorms and other meteorological disturbances, on which days the total effect on the record might be expected to be greatest.

This method, unlike the preceding one, demands careful scrutiny of all available weather-notes and meteorological records in addition to inspection of the atmospheric-electric electrograms. This is, of course, the only correct way of arriving at a decision as to what constitutes a "least-disturbed" day as compared with a "moderately disturbed" or "greatly disturbed" day.

The discussion has centered around the potential-gradient records only because they are the most sensitive indicators of meteorological disturbances. At any observatory where both potential-gradient and some other element such as conductivity are being measured, it would seem desirable, after having assigned character-numbers to the potential-gradient records, to apply those numbers to the simultaneous records of the other element.

As part of the program of the meeting at Lisbon of the International Union of Geodesy and Geophysics "Numerical characterization of the electric field" is to be discussed. This note is contributed in the hope that a discussion of the problems confronting two of the atmospheric-electric observatories of the world net-work and a suggestion as to characterization based on experience with records from those observatories may assist toward the formulation of an international code of character-numbers which would be able to meet the requirements of atmospheric-electric observatories everywhere.

Dep. Terr. Magn., C. I. W., July 16, 1933.

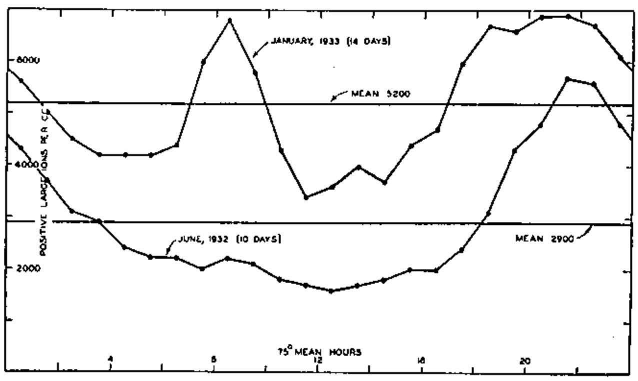
SEASONAL VARIATION IN THE NUMBER OF LARGE IONS AT WASHINGTON, D. C.

By G. R. WAIT and O. W. TORRESON

Langevin, in 1905, first called attention to the fact that there are ions present in the atmosphere which have mobilities very much smaller than that of the ionized air-molecule. Since that time various investigators have added to our knowledge of the nature and character of the so-called Langevin or large-ion, and it is now generally accepted that large ions are condensation-nuclei which have acquired electric charge. Up to the present, however, very little has been done to determine whether or not there are characteristic variations in the large-ion content of the atmosphere through the day or whether there are significant differences in the diurnal curve from one season to another.

In March, 1932, continuous recording of the large-ion content of the atmosphere was begun on the laboratory grounds of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in the northwest residential and park section of the city of Washington. Fifteen months of record have thus far been obtained, with from 10 to 20 complete days in each month. In actual practice, the number of electronic charges present per cc in the atmosphere has been recorded, and for the present paper it has been assumed that each large ion carries only one electronic charge.

From inspection of the data it was found that in the summer months the diurnal-variation curves are very similar and that the winter months have also a characteristic diurnal variation which differs from the summer curve. It is of interest to present in the accompanying Figure the diurnal curves



DIURNAL VARIATION, POSITIVE LARGE IONS IN SUMMER AND WINTER, WASHINGTON, D.C.

derived for the two months, June, 1932, and January, 1933, the June curve being typical of the summer months and the January curve of the winter months.

The morning maximum on the January curve is recognized immediately as the distinctive feature which differentiates it from the summer curve, although the fact that the ions are much more numerous at all times of day in winter is also an obvious feature. The morning maximum, perhaps, can be attributed to the effect of smoke from the morning replenishment of the fires which at that season of the year heat the homes in the vicinity of the laboratory.

The evening maximum cannot, however, be attributed to the same cause since the effect appears in summer as well as in winter. No satisfactory explanation can be offered for the evening maximum at this time, and it would be of great interest to obtain measurements at observatories differently located to determine whether or not a similar maximum is found at other places throughout the year.

Dep. Terr. Magn., C. I. W., July 31, 1933.

REPORT ON ION-COUNTERS, METHODS OF USE, AND RESULTS

By G. R. WAIT

Voir la IIIe Partie: Rapports sur des sujets spéciaux.

B. MAGNÉTISME TERRESTRE

MAGNETIC STANDARDS AND COMPARISONS

By J. A. FLEMING

(Voir cette note dans la communication générale du Department of Terrestrial Magnetism, ci-dessus. Après la communication faite en séance par M. Fleming, M. la Cour a présenté les observations et la communication suivantes:)

REMARQUES DE M. LA COUR A PROPOS DE LA COMMUNICATION DE M. FLEMING

M. LA COUR dit qu'il considère comme préférable de faire des comparaisons entre les instruments électromagnétiques des divers pays à l'aide d'un instrument auxiliaire quelconque permettant de comparer entre eux de tels instruments dans leur propre installation. Dans cet ordre d'idées, Mr. la Cour présente une courte description (voir ci-après) des deux instruments nouveaux pour les déterminations de H et de Z dont il a mentionné la construction dans son rapport sur les travaux magnétiques du Danemark.

DESCRIPTION DES DEUX MAGNÉTOMÈTRES BM ET QHM*)

Par D. la COUR

Résumé de la Rédaction.

1. *La Balance Magnétométrique BM.*

Un aimant monade du même type que celui employé dans la Balance de Godhavn**) repose dans une chambre cylindrique sur deux morceaux d'agates à surfaces planes. Quand la chambre, avec l'aimant, est tournée autour d'un axe vertical, l'aimant ne garde son inclinaison vers le plan horizontal que dans le cas où l'axe magnétique se trouve exactement dans ce plan. Si cela n'est pas le cas, l'inclinaison de l'aimant peut être considérablement changée en faisant tourner la chambre un demi tour à partir d'une position où l'aimant se trouve dans le méridien magnétique.

Pour faire une détermination de la force verticale, il faut lever ou baisser un aimant qui peut être déplacé dans un tuyau gradué qui, à son tour, est vissé dans une position verticale au-dessous de la BM jusqu'à ce que l'axe magnétique de l'aimant soit horizontal, et par conséquent l'inclinaison de l'aimant indépendante de son azimut. L'inclinaison du miroir de l'aimant est observée à l'aide d'une lunette par intermédiaire d'un prisme à réflexion totale, et la lecture de la position de l'aimant dans le tuyau gradué indique, à l'aide d'une table empirique, le champ positif ou négatif qui est additionné au champ à mesurer pour arriver au champ «zéro» de l'aimant. Les lectures de BM doivent éventuellement être réduites des différences de la gravitation et en premier lieu pour la variation de celle-ci avec la latitude.

En cas d'une grande différence entre le champ à mesurer et le champ «zéro» de l'aimant, on peut augmenter ou diminuer le champ d'une quantité constante et connue en appliquant un aimant auxiliaire.

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*) Voir pages 24-25.
**) Communications magnétiques, etc., No. 8, publiées par l'Institut Météorologique de Danemark, Copenhague.

2. *Le Quartz H-Magnétomètre.*

Le QHM consiste en une chambre de cuivre qui peut être montée sur presque tout théodolite magnétique. La chambre contient un aimant bien vieilli dont le moment magnétique est de quelques unités C. G. S. L'aimant est suspendu à un fil de quartz à deux têtes qui sont fixées dans deux porte-têtes en bronze. On observe les déviations φ' et φ'' provoquées en tordant le fil de quartz exactement $+n \cdot 360°$ et $-n \cdot 360°$ où n est un nombre entier (ordinairement $n = 1$). L'angle exact de la torsion du fil est obtenu sans toucher à la tête de torsion, mais en tournant tout le théodolite.

SUR UNE NOUVELLE DÉTERMINATION DES CONSTANTES DE GAUSS

Voir la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting..... (New determination of the Gaussian constants, by M. A. TUVE and A. G. McNISH).

PROPOSITION REGARDING THE PUBLISHING OF THE INTERNATIONAL CATALOGUE OF MAGNETIC DETERMINATIONS

By BORIS WEINBERG

The distribution of magnetic elements over the globe and their variations in time are the only two direct objects of the observational work with respect to terrestrial magnetism. For practical purposes the first object is the only essential one together with the distribution for the nearest epoch, the second object presenting an interest only inasmuch its results give the possibility of extrapolating the data concerning the present distribution. But from a theoretical standpoint both objects are of equal importance and both necessitate a cooperation of scientists on a world-wide scale. Still the practical tendencies have almost always led the international organisations, — created for the coordination of magnetic work, — to establish only a coordination for the future, leaving the results attained in the past in the same chaotic state in which these results have been before the commencement of the activity of these international organisations.

The result of this neglecting of the past is that after the famous "Untersuchungen über den Magnetismus der Erde" by Hansteen and "Contributions to Terrestrial Magnetism" by Sabine there has not been any attempt to summarize the whole of the available data concerning the development of magnetic observations from the earliest times up to the present date.

The necessity and utility of such an exhaustive summary is undoubted and cannot be overestimated,*) especially if we consider the difficulties which have been met with by Hansteen and Sabine in collecting the data for their catalogues. It may be mentioned that for the territory of the USSR and of the adjacent countries Hansteen and Sabine gave only respectively 53 and 55 % of the data which were published in different journals, books, maps etc. up to the time when they were compiling their catalogues and that I succeeded to find some 38 and 12 % of respective unpublished data, and I am sure that still more comprehensive searches in old maps, in land measurations, in ship journals, measurements of orientation of all churches etc. can still augment this material.

All these considerations compel me to make a proposition of publishing with the help of a mutual cooperation of the scientific organisations of the different countries an "International Catalogue of Magnetic Determinations" which could permit any investigator in terrestrial magnetism to avoid the tedious necessity to look over all the available sources some of which are practically inaccessible.

In order to show the practical possibility of such an international enterprise as well as its extent, I take the audacity to trace its possible general outlines.

1. The scientific organisations which would consent to take part in the compiling and publishing the "International Catalogue of Magnetic Determinations" divide the whole surface of the globe in several regions for each of which a definite organisation should be responsible.

2. The representatives of these organisations elect an Editorial Committee which will summarise all the materials collected

*) *Cfr* the "Anmerkung" of A. Nippoldt to his article "Unsere heutige Kenntnis über die Verteilung des Erdmagnetismus" (Zeitschr. f. Geophysik, *5*, 358, 1930) concerning the Catalogue of magnetic determinations over the territory of the USSR and the adjacent countries from 1556-1926, compiled by me and the desirability of analogous catalogues for many other countries.

by separate organisations and publish the results of such a summarisation.

3. First of all must be published a "List of sources" which is intended to be used by each organisation and must contain the determinations of 1875-1924, of 1825-1874, of 1775-1824 and so on for each region with special notation of those of the sources where determinations outside of the region are to be found.

4. The next publication of the Editorial Committee must be "The supplement I to the List of Sources" which has to contain all the supplementary sources indicated by the other organisations after their acquaintance with the main List, and also all the sources containing the determinations from 1925 up to the date of the publication of this supplement and intended for determining the annual changes to be used, e. g. for 1920-1930.

5. Each organisation prepares for the region for which it is responsible preliminary tables (or maps) of the values at equidistant points of annual changes of magnetic elements relating to 1925, 1900, 1850 and so on, and of the values of the elements and sends those to the Editorial Committee which makes the necessary adjustments relating to the boundary parts of adjacent regions and communicates the results of such adjustments to corresponding organisations.

6. After having received these adjusted data each organisation prepares for the press the whole of the determinations in the region for which it is responsible made during 1875-1924 and reduced to 1900, made during 1825-1874 and reduced to 1850, and so on, and sends these data to the Editorial Committee which published them in a systematic order for the whole surface of the globe.

7. On the base of these reduced data and adjusted values on the distribution each organisation computes the weighted mean values of the elements at equidistant points and sends such tables to the Editorial Committee.

8. The Editorial Committee recomputes the values relating to such equidistant points, the area of action of which overlaps two or more adjacent regions and after having received the consent from the organisations responsible for these regions publishes the tables of the values at equidistant points for the whole globe as well as maps based on these data.

9. The results of microsurveys are not to be published *in extenso* but the notion of the "microsurvey" has to be precised

by the mutual consent of the representatives of the organisation taking part in the International Catalogue.

10. After 1938 in the same manner have to be edited the "List of Sources", "Catalogue", "Tables of values at equidistant points" and "Maps" relating to the determinations made during 1913-1937 and reduced to 1925.

O MAGNETISMO TERRESTRE: ESTADO ACTUAL DA SUA TEORIA

Par M. A. FERRAZ DE CARVALHO

Note de la Rédaction: Cet article a paru dans la Revue "A Terra" 1932.

SECULAR CHANGE IN THE MAGNETIC ELEMENTS IN THE UNITED STATES (180 YEARS OF DECLINATION AND 80 YEARS OF HORIZONTAL INTENSITY)

By N. H. HECK*)

The purpose of this paper has been to put in graphical form the tables developed by D. L. Hazard, which appear in the publications of the United States Coast and Geodetic Survey, "Magnetic Declination in the United States for 1930" and "United States Magnetic Tables and Charts for 1925," and to attempt thereby to secure light on several problems in terrestrial magnetism. While the United States comprises a comparatively small portion of the Earth's surface, few other areas of similar extent can be found which may be discussed in this manner and for periods of similar length.

The problems which will be considered include: (1) Why has it not been possible to use after 1900 the interpolation-formulas of Charles A. Schott (see "Secular variation of the Earth's magnetic force in the United States and some adjacent foreign countries, 1895") which were quite satisfactory prior to that date? (2) What kind of systematic movement has made it possible for the line of zero-change in declination to lie in or near Florida while for 25 years other portions of the line have shifted greatly during the same period? (3) Do foci (see

*) Chief, Division of Terrestrial Magnetism and Seismology, United States Coast and Geodetic Survey.

"Unsymmetrical distribution of magnetic secular-variation" by Harlan W. Fisk, Terr. Mag., v. 37, 235-240, 1932, and "Isopors and isoporic movements," C.-R. Assemblée de Stockholm, Août 1930, Union Geod. Geophys. Internat., Sec. Mag. Electr. Terr., Bull. No. 8, 280-292, 1931) remain in the same general region or move through great distances in the course of time?

This last problem has considerable practical importance in relation to the selection of stations for observation of secular variation. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington has held the view that stations should be more closely spaced in the general regions of the more important foci. While no major focus and only a few minor foci have been located within the United States during the period, it will be shown that something can be deduced regarding the movements of foci in regions adjacent to the United States. While we have no evidence as to whether major and minor foci (high and low rates of change respectively) have the same degree of mobility, it is not unreasonable to suppose that they have.

It is obviously quite impossible to deal with year-by-year changes. Hazard computed his tabular values for every ten years for the period prior to 1900 and, while after that year he gives values for five-year intervals, the ten-year interval has been adopted throughout. The rates of change used are the average change for the ten years considered as applying to the middle of the period.

It should be understood that the values prior to 1900 have by no means the same accuracy as those subsequent to that date when there were sufficient observatories to control the observations over considerable areas. In the very early observations there may have been errors as great as one-half degree. However, it should be understood that Hazard has adjusted a considerable amount of data scattered both in time and space and in making the best possible adjustment has approximated the true values.

Two methods have been adopted in the study of secular change in declination. One was to divide the United States into certain regions and to find the regional curve of mean secular change for the longest possible period. The other method, adopted for horizontal intensity, was to draw isopors for ten-year intervals.

In applying the first method, the United States was arbitrarily divided into nine regions (I to IX) as shown on Map 2. Hazard gives tables of secular change of declination for the intersection of even-numbered meridians and parallels. The values given in Table 1, represented graphically in Figure 1, are the means of the values for all intersections included within each region. The values for intersections falling on the border between two regions are necessarily repeated for each region. The curve is assumed to apply to the middle of the region. A source of error in the earlier periods is the fact that the earliest values are for different times, since observations usually followed permanent settlement and, accordingly, the available intersections are not spaced symmetrically over the section.

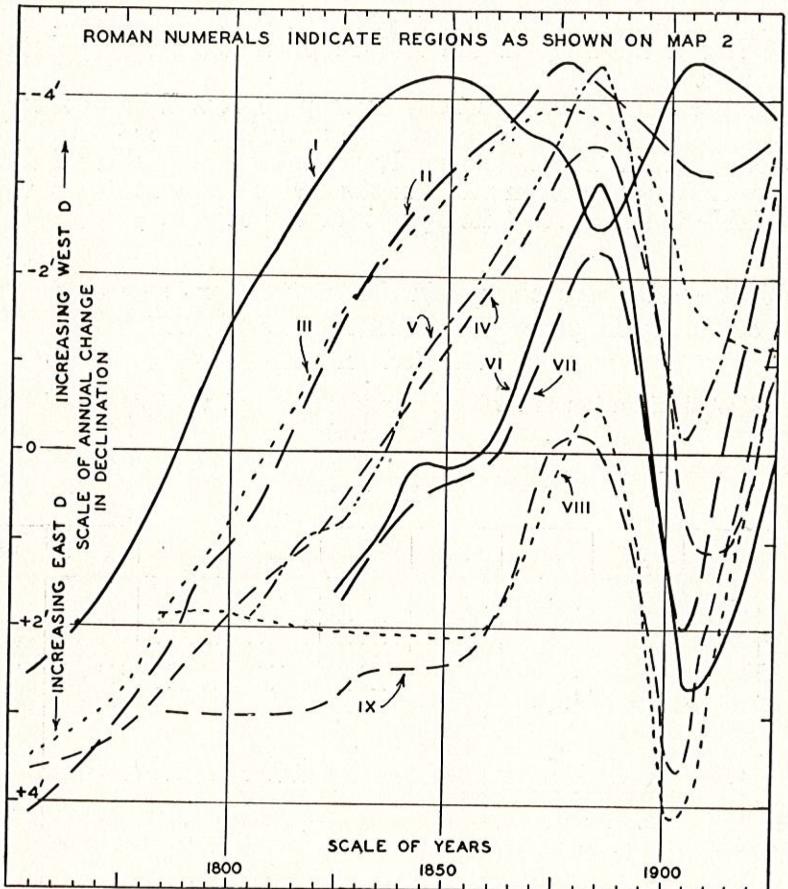


FIG. 1—ANNUAL CHANGE IN DECLINATION IN UNITED STATES FOR TEN-YEAR PERIODS, 1755-1925

Figures in parenthesis to the right of the values in Table 1 indicate the number of intersections available in each case. It should be noted that in spite of the lack of symmetry the curves are not seriously affected, that is, there are no sudden changes with great increase of the number of intersections used.

The curves have several striking features. The first is that regions lying in a north-south direction from each other have very similar curves from the earliest periods up to 1880. The next outstanding feature is the reversal in the period 1880-89, with the same north-south relation continuing except for regions I-III. Another reversal in the period 1900-10 is of different character with complete breaking down of the north-south relation. Magnetic-observatory results seem to indicate that a minor reversal may be going on at the present time.

Undoubtedly the distinctly different type of reversal after 1900 has a bearing on the failure of Schott's interpolation-formulas.

Before considering the ten-year isopors, it will be of interest to consider what has happened to a single isopor — the line of zero-change. This is especially desirable because at all times since 1765 it has been in a region where observations were available to fix at least its approximate position.

Table 1 — *Average change in declination for ten-year periods centering in years named in regions of United States as indicated on Map 2*

(East declination is reckoned as positive and west declination as negative)

Year	Region								
	I	II	III	IV	V	VI	VII	VIII	IX
	′	′	′	′	′	′	′	′	′
1755	+2.5(20)	+4.2(13)	+3.6(28)	+3.7(7)	......	......	......	......	......
1765	+2.2	+3.9	+3.3	+3.7	......	......	......	......	.....
1775	+1.5	+3.2	+2.9	+3.4	......	......	......	......	......
1785	+0.4	+2.3	+2.2	+2.8	......	......	......	+1.9(13)	+3.0(15)
1795	—0.9(21)	+1.4	+1.4	+2.2	......	......	......	+1.9	+3.0
1805	—1.6	+0.8(27)	+0.5(30)	+1.9(24)	+2.0(9)	......	......	+1.9	+3.0
1815	—2.6	—0.2	—0.3	+1.1	+1.2(12)	......	......	+1.9	+3.0
1825	—3.4	—1.3	—1.2	+0.8(38)	+0.9(33)	+1.8(7)	+1.9(3)	+2.1(16)	+3.0
1835	—3.9	—2.2	—1.9	—0.1	0.0(38)	+1.2(20)	+1.1(12)	+2.2	+2.5(20)
1845	—4.2	—2.8	—2.6	—0.8	—1.0	+0.4	+0.1	+2.2(34)	+2.6(30)
1855	—4.1	—3.3	—3.2	—1.5	—1.7	+0.5(36)	+0.4(42)	+2.4	+2.5(40)
1865	—3.6	—3.7	—3.6	—2.1	—2.4	—0.1	—0.4	+1.8	+1.9
1875	—3.5	—4.5	—3.8	—3.1	—3.7	—1.5	—2.0	+0.3	+0.1
1885	—2.2	—4.6	—3.7	—3.6	—4.4	—2.4	—3.1	—0.5	—0.2
1895	—3.0	—3.6	—3.2	—2.2	—2.9	—0.5	—0.9	+1.1	+1.2
1905	—4.5	—3.2	—1.6	+1.0	+0.1	+3.0	+2.4	+4.4	+4.1
1915	—4.3	—3.1	—1.1	+1.3	—1.2	+2.1	+0.2	+1.8	+0.9
1925	—3.7	—3.7	—1.1	—0.2	—3.6	—0.1	—2.8	—0.8	—2.0

It will be seen from Map 3 that from its first appearance in Maine about 1765 the line of zero-change moved steadily westward, retaining an approximately north-south direction until about 1880 when it turned back, but keeping the same general direction. Shortly after 1900 a change occurred and while its southern part continued to move eastward the northern part slowed down, stopped, and then reserved. In 1915 it began to pivot around Florida and by 1920 it had reached a nearly east-west direction, which it still maintains.

Before taking up the maps of isopors, 1A to 1Q for declination and 4A to 4H for horizontal intensity, the definition of plus (+) and minus (—) foci should be stated. A focus is the place where the rate of change reaches a maximum, and under the system followed the plus sign indicates that east declination is increasing and west declination decreasing, while the minus sign indicates the opposite.

Considering the entire series of maps it seems that the isopors can best be explained on the assumption that they are related to a pair of foci, one plus and one minus, whose maximum rates seldom, if ever, exceed 6 minutes in declination per year, though this of course cannot be proved. The following approximate movements of the pair of foci have been inferred. In 1750 a plus focus was probably in the general region of Newfoundland and a minus focus in the region of the Great Lakes. The latter appears to have continued to move in a generally westerly direction, probably well out into the Pacific Ocean west of the United States by 1900. The plus focus reached the United States about 1860 and by 1885 it was in the Great Lakes Region. It then moved northeastward but about 1900 it probably moved northwestward, while the minus focus was probably moving rapidly southeastward. About 1925 they had reached the positions given by Fisk — the plus focus in central Canada and the minus focus south of the Isthmus of Tehuantepec, Mexico. It is of interest to note, as having a bearing on the correctness of previous inferences, that examination of the isopors for 1920-30 indicates foci in the general region where they were found by Fisk.

It is therefore reasonable to assume that these minor foci in declination have in the 180 years moved through at least the width of the Continent and that the plus and minus foci have not moved entirely independently.

An opportunity for a similar study is afforded in Europe. Fisk showed a major focus in declination south of Scandinavia and undoubtedly information is available for the study of its movement during the past 150 or 200 years.

Since Hazard has given horizontal-intensity isopors only for every five degrees of longitude, regional curves cannot be prepared. Few accurate measurements of horizontal-intensity were made before 1845. Probably some of the early values are not very accurate, since the instrumental problems in measuring horizontal intensity are more difficult than in the case of declination. In the maps horizontal intensity (H) is used directly instead of $\Delta H/H$ as used by Fisk, since this does not seriously affect the position of the foci, the only thing in which we are here interested.

It may be inferred from the maps that in 1845 there was a plus focus at about latitude 30° north off the coast of the United States and that it moved either in a straight line or perhaps by a path curving to the east of a straight line to the position given by Fisk off the coast of Laborador for about 1925. The minus focus was probably in Mexico in 1845 and moved eastward to its 1925 position as given by Fisk in the Greater Antilles. These may be considered as major foci, though the maximum rate of change has apparently varied through a wide range during the period.

The information is too incomplete to bring out exactly what happened in horizontal intensity about 1885 and 1905 when the rate of change of declination reversed. However, comparison of Maps 4D and 4E and of Maps 4F and 4G shows considerable change in the form of the isopors in each case.

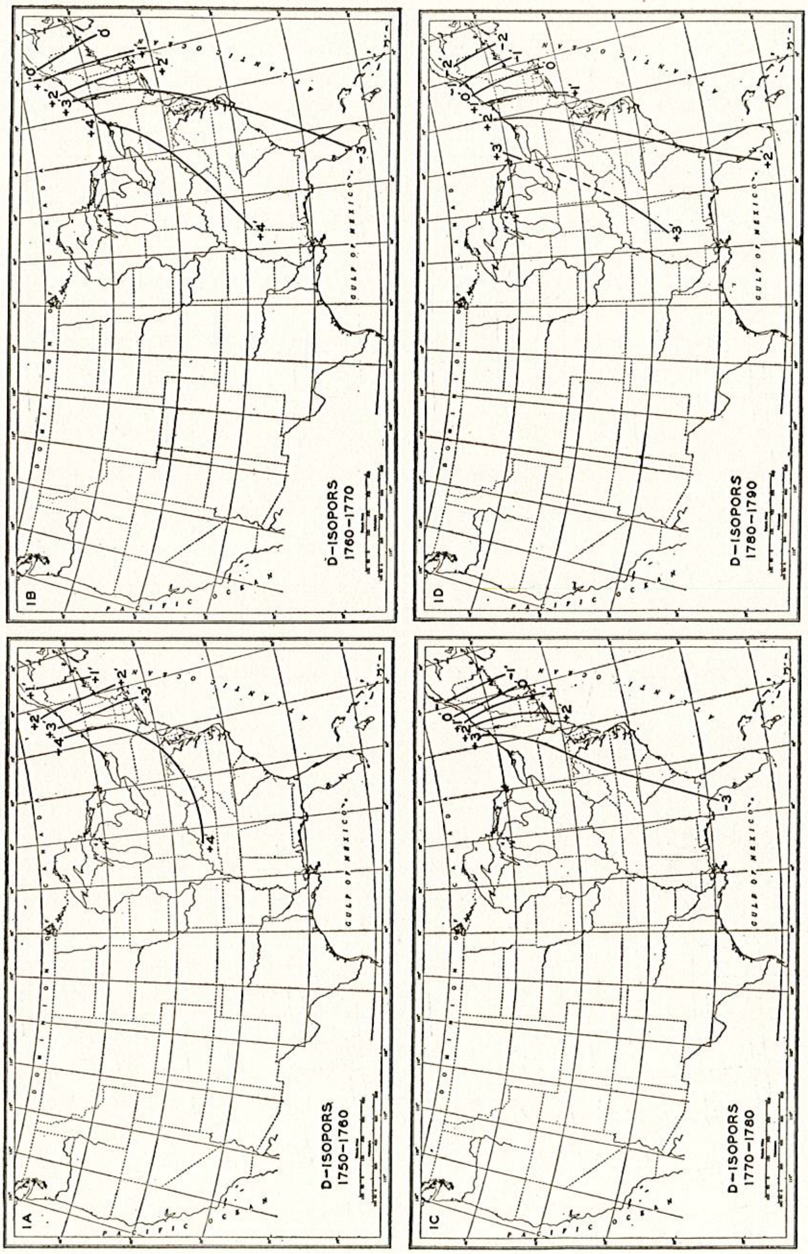
The investigation has brought out clearly the difficulties in dealing with problems in terrestrial magnetism which involve long periods. On the other hand, it has shown that it must not be assumed that no useful information can be derived from study of the early, less accurate data, provided that it is interpreted with care and judgment.

The importance of convenient arrangement of data is emphasized. If similar convenient arrangement of information were possible for the rest of the Earth, secular-change investigations would be greatly expedited.

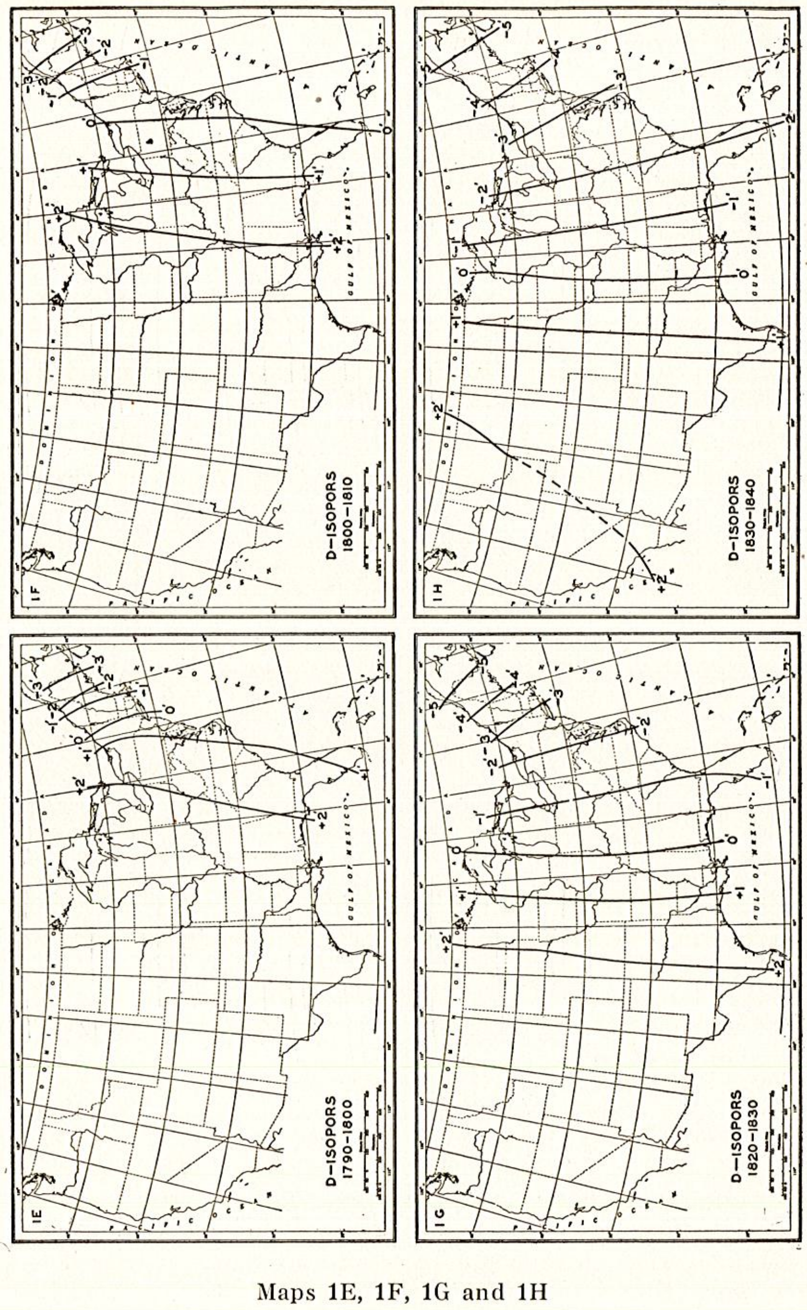
The maintenance of a greater number of secular-change stations in the general region of a major focus, while still an unsettled question, is probably justified, but it must be understood that the relation of the position of such stations to the focus is subject to wide changes.

In the absence of observations of solar and other phenomena during the periods 1880-90 and 1900-10 we have no basis for deductions as to the physical explanation of the reversals during these periods and especially for their different character. It seems probable that in the future, observations during such periods of reversal will be specially profitable.

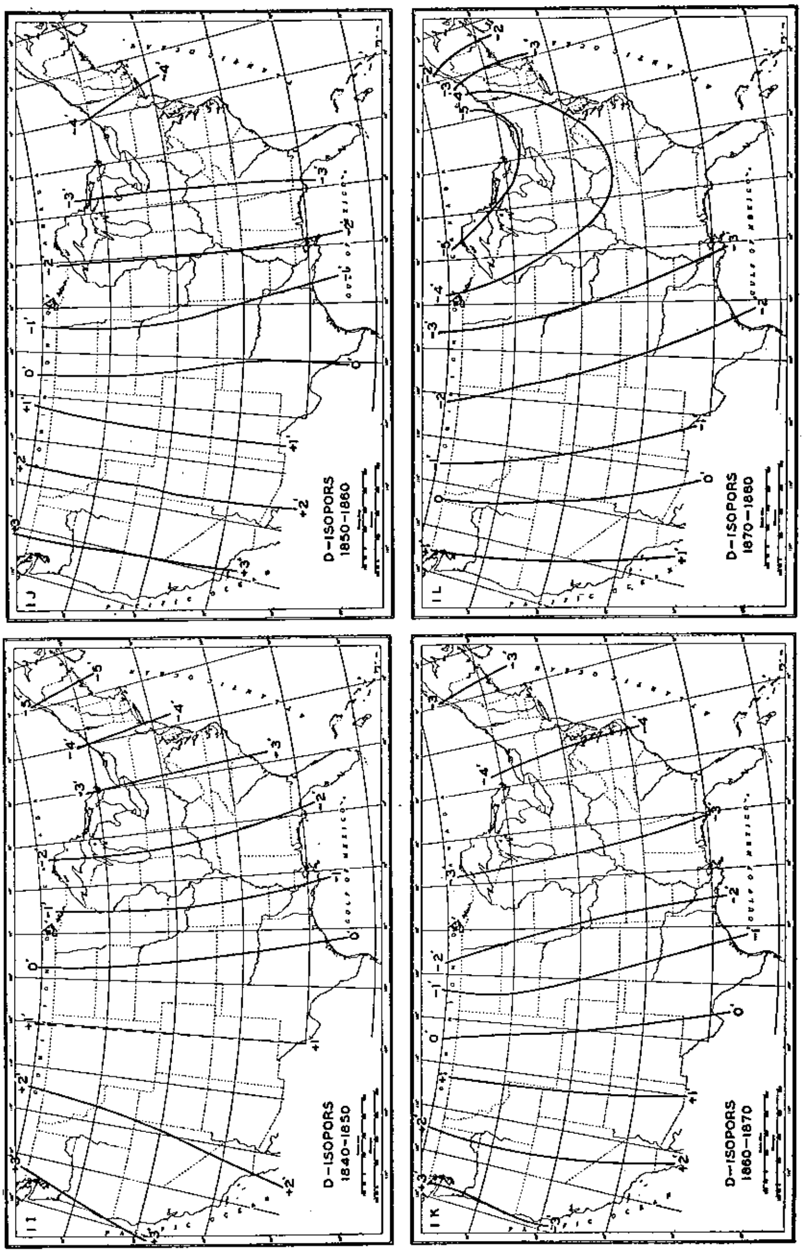
U. S. Coast and Geodetic Survey, Washington, D.C., July 31, 1933.



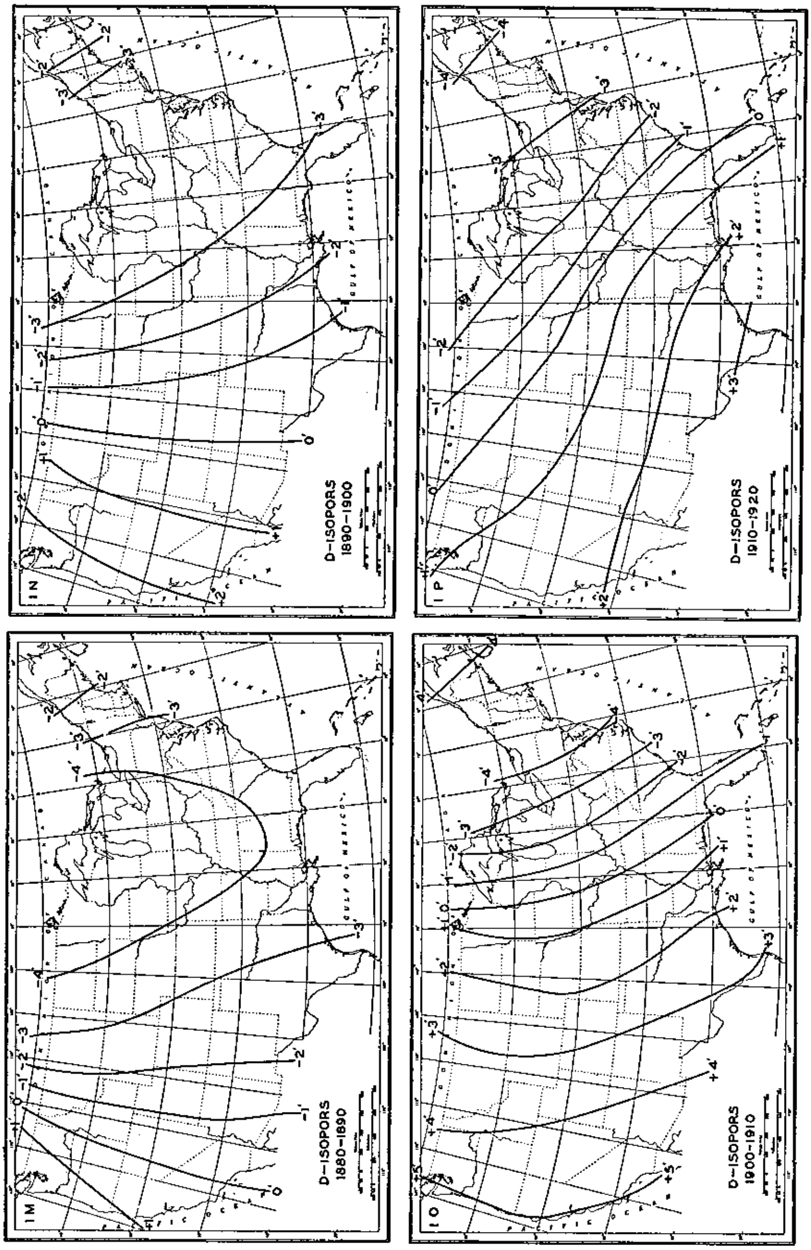
Maps 1A, 1B, 1C and 1D



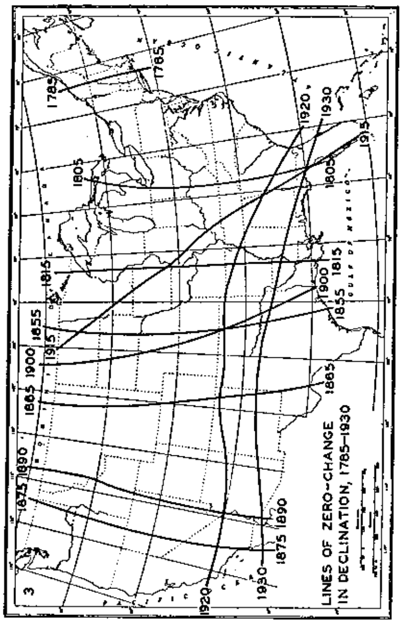
Maps 1E, 1F, 1G and 1H

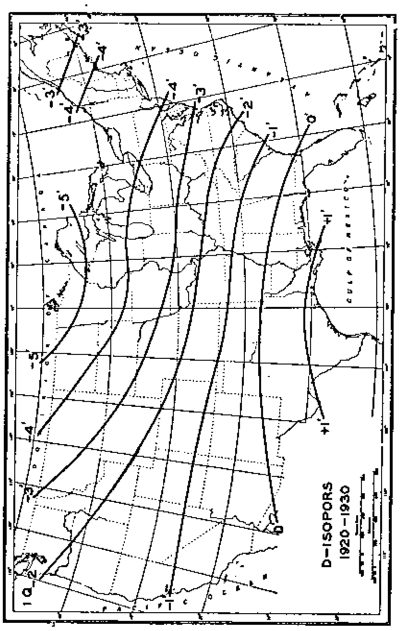


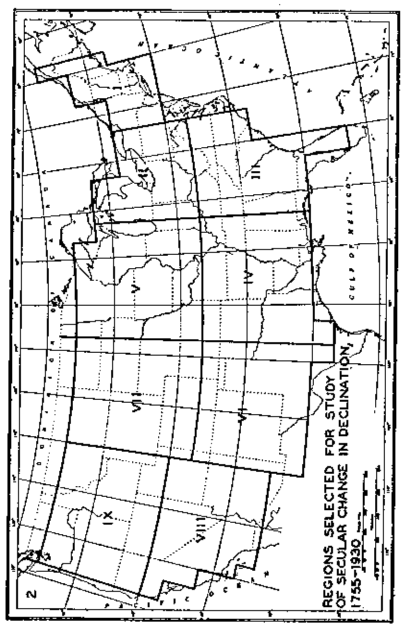
Maps 1I, 1J, 1K and 1L



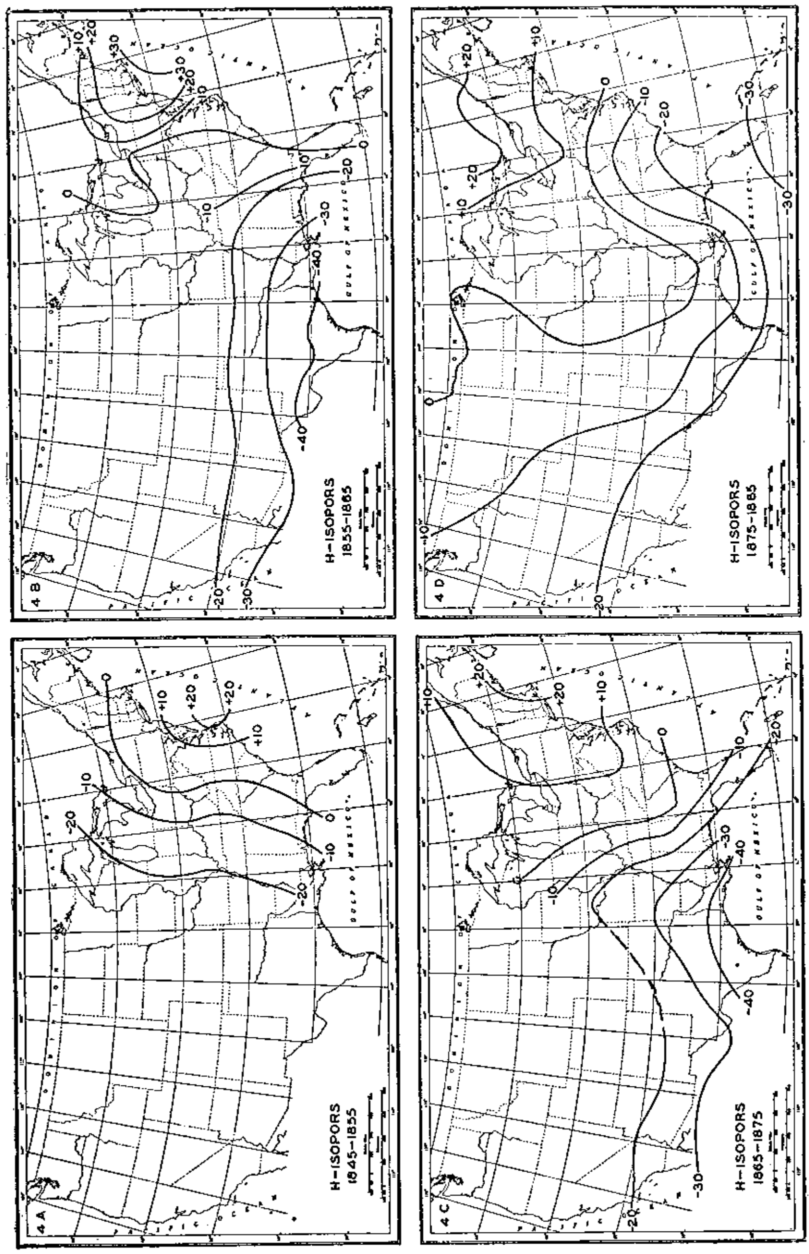
Maps 1M, 1N, 1O and 1P



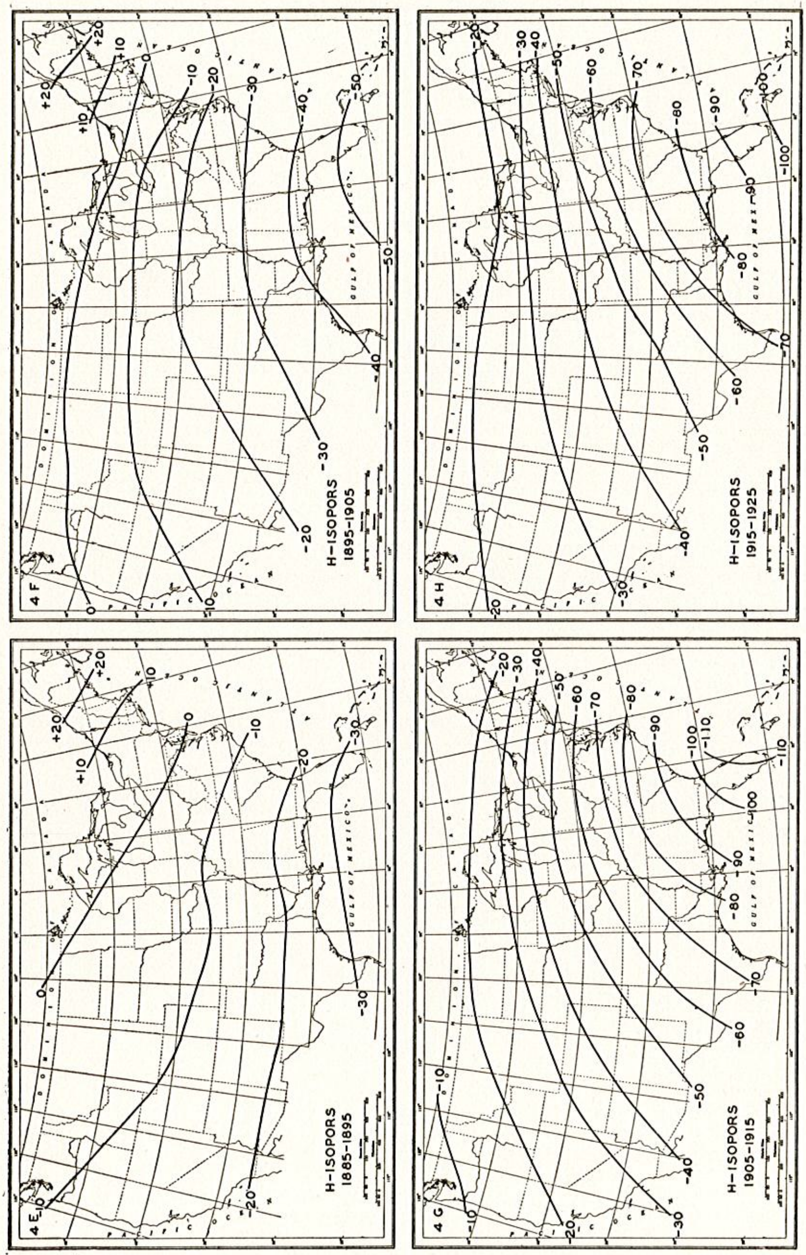




Maps 1Q, 2 and 3



Maps 4A, 4B, 4C and 4D



Maps 4E, 4F, 4G and 4H

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie:

Preliminary note on the latest secular-change values in the Caribbean area and South America, by J. W. GREEN.

Subcrustal convection-currents and magnetic secular variation, by J. W. GREEN.

SUDDEN COMMENCEMENT OF MAGNETIC STORMS

Observed in Japanese Observatories during the second polar year 1932-1933

By T. OKADA

Director of the Central Meteorological Observatory Tôkyô

1. For the purpose of observing sudden commencements of magnetic storms, specially constructed quick-running magnetographs of the same pattern with high sensitivities were installed at the Observatories of Kakioka and Toyohara (Karahuto). The magnetographs are of Eschenhagen type, but greatly improved by Mr. Imamiti of the Kakioka Observatory. The recording drum is 24 cm in diameter and it is run at such a rate that 12-15 mm corresponds to 1 minute, or 0.2 to 0.25 mm to one second. The uniformity is kept fairly constant by means of a governor, the time being controlled by wireless signals specially sent from the Observatory in Tôkyô. The sensitivities are 1.5 gamma at Kakioka, and 1.5 to 1.0 gamma per mm at Toyohara.

The magnets of the magnetograph in use at the observatories at Kakioka and Toyohara have the form of an elongated ellipse with major and minor axis 15 and 5 mm respectively and being 0.4 mm thick, while the free period of oscillation is 6.5 and 5.0 seconds at Kakioka and Toyohara respectively.

	λ	φ	Λ	Φ
Kakioka	140° 11′ E	36° 14′ N	206°.0	26°.0
Toyohara	142° 45′ E	46° 57′ N	206°.5	36°.4

2. Since last October, there were registered three sudden changes which show the same characteristics, both in regard to the aspect of the changes and the difference in time of occurrence in the two observatories. In all the sudden changes herein mentioned, there is a small change in opposite direction to that of the main change. This looks like a point in ordinary magnetographs; it appears, however, as a smooth curve in a quick

running record. The minimum point of this curve ascertained by magnifying this portion is taken as the time of sudden commencement, or abrupt change. The following are the results so far obtained: —

The time of the sudden commencement

Date (Greenwich time)		Kakioka (S. Imamiti)	Toyohara (H. Hatakeyama)
1932, Oct. 14	17h 47m	03s	10s
1933, Apr. 30	16 28	14	22
1933, May 29	6 25	22	31

Amount of sudden change

Date	October 14, 1932			April 30, 1933			May 29, 1933		
Element	H	V	D	H	V	D	H	V	D
Kakioka	11γ	5γ	0.′19	36γ	21γ	1.′3	17γ	10γ	—
Toyohara	10	2	0.50	35	—	1.4	19	—	0.′4

In the table the values for H and V show the amount of increase of the elements at the sudden commencement. The value for D shows the decrease in the westward declination at the sudden commencement.

3. It appears from the above table that there is a retardation in occurrence of S. C. at the north station of about 8 seconds as compared with that at the south station, which, as Mr. Imamiti points out, will give a speed of propagation along the Meridian of about 140 km per second, if there is a propagation at all.

4. The intensities of magnetic storms on the days above mentioned are given in the Appendix below.

APPENDIX

THE INTENSITY OF THE MAGNETIC STORMS

1. *Kakioka*

1932 Oct. 14.

	Maximum Time			Maximum Value	Minimum Time			Minimum Value	Range
	d.	h.	m.		d.	h.	m.		
H	15	6	39.9	29791γ	15	12	04.4	29581γ	210γ
V	15	14	20.2	34817	15	9	25.5	34763	54
D	16	3	09.4	5°49.′0	15	9	39.0	5°41.′8	7′2

1933 April 30.

	Maximum Time			Maximum Value	Minimum Time			Minimum Value	Range
H	Apr. 30	16	34.1	29778γ	May 2	01	06.3	29644γ	134γ
V	May 1	12	48.0	34818	May 1	15	02.4	34745	73
D	May 1	3	55.8	5°49.′5	May 1	18	50.1	5°38.′3	11′2

1933 May 29.

	Maximum				Minimum				Range
	Time			Value	Time			Value	
	d.	h.	m.		d.	h.	m.		
H	29	6	31.9	29778γ	30	9	21.4	20703γ	75γ
V	30	16	56.3	34824	30	1	0.0	34776	48
D	......			.....	......			.....	...

II. *Toyohara*

1932 Oct. 14.

H	15	6	43	25060γ	15	12	06	24929γ	131γ
V	15	13	29	44562	15	3	00	44546	16
D	16	3	13	9°0.′2	15	9	38	8°49.′2	11′0

1933 April 30.

H	30	16	35	25102γ	May 2	1	00	24901γ	201γ
V May	1	14	14	44601	May 2	1	00	44569	32
D May	2	3	0	9°02.′8	May 1	18	50	8°44.′5	18′3

1933 May 29.

H	30	16	54	25074γ	30	8	58	25002γ	72γ
V	30	18	11	44606	30	1	47	44518	88
D	30	5	0	9°02.′5	30	17	25	8°49.′4	13′1

SUR LES ORAGES MAGNÉTIQUES A DÉBUT BRUSQUE

Par D. la COUR

Au cours de l'Année Polaire, les enregistreurs à marche rapide (180 mm par heure) ont fourni de très longues courbes, (à peu près 1700 m pour chaque élément), et les courbes originaires des stations arctiques montrent des perturbations presque continues dont le mesurage et la description exigeraient un travail énorme. Etant donné que ce sont les perturbations non-locales qui sont d'un intérêt immédiat, l'Observatoire de Copenhague s'est mis d'accord avec M. Ljungdahl à Stockholm et M. Sucksdorff à Sodankylä sur la circulation de listes préliminaires avec détails intéressants des courbes faites par enregistreurs à marche rapide aux observatoires de Rude Skov, Lovö et Sodankylä, et ceci de la manière suivante: De Copenhague, où les perturbations sont les plus rares, on a envoyé à Stockholm tous les dix jours une liste avec des informations sur les événements de Rude Skov. A Stockholm on a indiqué sur cette même liste les informations correspondantes de l'Observatoire de Lovö tout en y ajoutant quelques remarques sur les oscillations ou les débuts brusques qui, dès le début à Copenhague, n'ont pas été considérés comme remarquables. La liste a ensuite été envoyée à l'Observatoire de Sodankylä pour y être complétée, et enfin elle a été retournée à Copenhague pour y être révisée encore une fois.

Ces listes sont évidemment d'une grande valeur pour l'étude en Scandinavie des perturbations magnétiques non-locales et cet essai de faire circuler des listes semblables pourrait peut-être servir plus tard de modèle pour des échanges d'informations d'une étendue beaucoup plus grande.

Comme exemple de l'emploi de ces listes, mentionnons que, pour 10 débuts brusques, M. Egedal a calculé une différence de temps de 0.1±0.1 minute.

YEARLY AND DAILY PERIOD ON THE FREQUENCY OF SUDDEN COMMENCEMENTS OF MAGNETIC STORMS

By the F. L. RODÉS

The object of these lines is to give a short communication on the sudden jumps of the magnets throughout the year and throughout the day.

We have revised some ten thousand records, all available at the Ebro Observatory, from 1905 to 1931. During these 27 years we have found 218 sudden commencements of sufficient definition to be classified as such, their amplitude ranging from a few gammas to more than hundred in some exceptional cases.

Most of these jumps are the initial phases of a magnetic storm; others take place during the storm itself, and some, relatively few, are connected with very moderate perturbations and even with periods of calm.

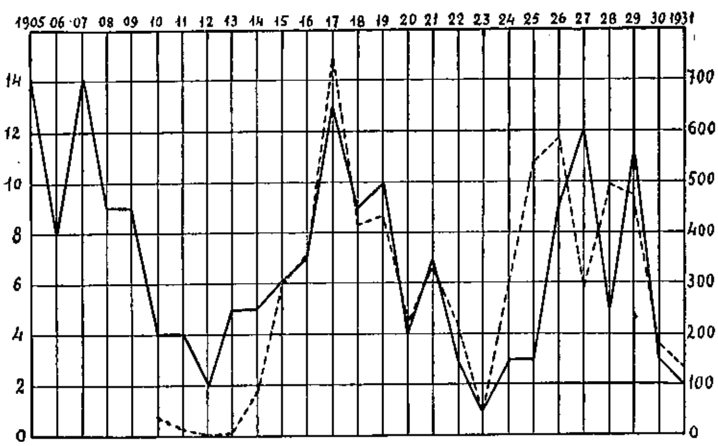


Fig. 1. Full line, frequency of sudden sommencements at *Ebro:* broken line, area of sunspots on the north hemisphere.

The two curves of fig. 1 show, quite conspicuously, the influence of the sun on the frequency of sudden commencements. These are given by the continuous line, the broken one corresponding to the area of sunspots *on the north hemisphere.* The parallelism is striking and much better than the one we would get if we considered sunspots on the south hemisphere. Our observatory being in the north, this result points, I believe, to a differential effect on the earth in accordance with the different degree of activity in the two solar hemispheres. Another remarkable feature is the lag of one year in the general features of the magnetic curve around the last maximum — a fact which, although registered in some other records of magnetic activity, one would scarcely hope to find reflected in the frequency of sudden commencements.

The same correlation between solar activity and sudden commencements can be seen in the curve (fig. 2) which gives

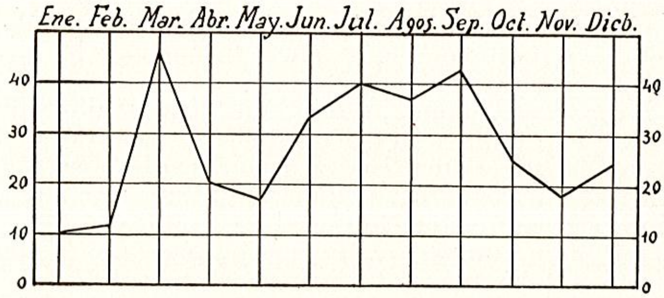


Fig. 2. Annual frequency of sudden commencements at *Ebro.*

their distribution through the year and shows two maxima and two minima, corresponding roughly to the maximum and minimum heliographic latitude of the earth.

By ploting sudden changes in the intensity of the magnetic field against local time we get the curves of fig. 3, which present a very definite diurnal wave, with a sharp maximum at 21h., and a minimum at 8h. The full line represents all sudden commencements unweighted, and the broken one only those which may be classified as being of 1st category, that is to say, those which are very sharp and connected with a great perturbation. Although the daily period appears more definite in the first curve its presence can also be seen in the latter showing that there is a preferential hour for the beginning of magnetic storms.

This fact presents, we believe, a very interesting problem. Is the daily maximum a function of local time or is it rather connected with universal time? How can a phenomenon which is registered simultaneously all over the world be a function of local time? And, if it is a function of universal time, what is the feature on our planet responsible for the higher frequency of sudden commencements at a certain position of the earth in its daily rotation with respect to the Sun?

To solve this question, the curves obtained from the records of other observatories, far separated in longitude, would be very welcome.

If there is a displacement of phase according to local time, (manifestly, the maximum occurs towards evening) it would

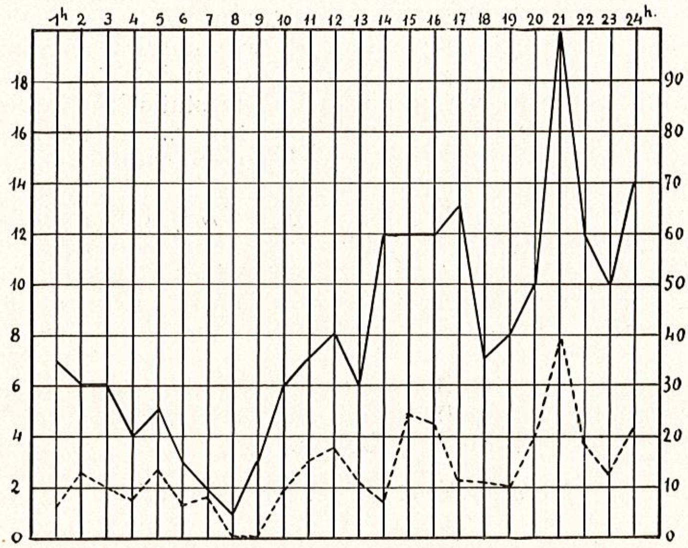


Fig. 3. Diurnal frequency of sudden commencements at *Ebro;* full line, all cases unweighted; broken line, 1st. category cases with their weight.

mean that either we are dealing with a cause having a merely regional influence, or, if this cause is of a general character effecting the whole earth, there is a position of the local meridian for which the effect is maximum. We do not believe that the first hypothesis can be wholly eliminated. The exact coincidence of the Mont Pelée eruptions with the magnetic storms of May the 8th. 1902, speak in its favour. If the cause were always of a cosmic character, such as a cloud of electric particles striking the earth, and, notwithstanding, the statistics showed that the maximum frequency of sudden perturbations were shifted with local time, we should necessarily accept for the local meridian some *positions of protection* and some *positions of danger* on its way around the earth. From the records at "del Ebro" we would infer that the local meridian is more exposed to receive the impact of the electric particles in the evening when it is on the back with respect to the orbital motion of the earth than in the morning, when it is going ahead. If curves from the other observatories would confirm our results, we should be ready to confess that the theory of Chapman receives from the facts a better support than the one proposed by the author.

To us the most interesting question is to decide whether magnetic storms, registered simultaneously all over the earth, have sudden commencements clustering around a preferential hour of absolute time or, what amounts to the same, a preferential position of our planet in its rotation with respect to the Sun. Our curve (fig. 3) based, as we mentioned above, on sudden commencements of 1st category, points to this result. If it would come to be supported by the statistics of other observatories as a real fact, the only feature we can think of as capable of modifying the effect of an external cause, is the geographical position of the magnetic axis. Taking account of the longitude of its north pole, some 95° W*), our records show a maximum frequency of sudden commencements three hours after the meridian containing the same has passed in front of the Sun, and a minimum ten hours before the passage takes place, or when the same meridian is almost on the opposite side.

We hope that the Committee on sudden commencements will include on the programme the gathering of material to solve this very interesting problem.

Tortosa, Observatorio del Ebro, September 1933.

REMARQUE DE M. J. BARTELS SUR LA COMMUNICATION DU P. RODÉS RELATIVE A LA DISTRIBUTION DES ORAGES MAGNÉTIQUES A DÉBUT BRUSQUE

N. A. F. MOOS (in Colaba Magnetic Data, 1846 to 1905, § 439; Bombay 1910) has found, from 33 years of observations at Bombay, 1872 to 1904, that the sudden commencements of 113 magnetic storms are fairly evenly distributed over all the hours of the day, without preference of any particular day-time.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie:

Photographically enlarged magnetograms for study of sudden commencements, by J. A. FLEMING and C. C. ENNIS;

Occurrence of sudden commencements at the Watheroo Magnetic Observatory by A. G. McNISH;

*) *Note de la Rédaction.* Longitude du pôle nord de la surface.

Mean force-vectors associated with sudden commencements and magnetic storms by A. G. McNISH;

Stereogrammatic representation of some sudden commencements by W. J. PETERS;

Note on sudden commencements October 14, 1932, and April 30 and May 29, 1933 by W. J. PETERS and C. C. ENNIS;

Comments on the agenda for the Lisbon meeting.......

(Annual and diurnal distribution of sudden commencements; by J. A. FLEMING and A. G. McNISH).

DISCUSSION ON METHODS OF NUMERICAL MAGNETIC CHARACTERISATION OF DAYS

Introduction by A. CRICHTON MITCHELL

The object of the discussion which I have been asked to introduce is to consider the validity and usefulness of the numerical character quantity given by the formula

$$F = \frac{HR_H + VR_V}{10000} = \frac{NR_N + WR_W + VR_V}{10000}$$

which was adopted at Stockholm three years ago. With the cooperation of De Bilt Observatory we now have records of the daily values of this quantity from a number of observatories for three years from 1st January 1930.

The purpose of this formula was two fold. First, it was intended as an additional means of selecting five quiet days and five disturbed days in each month. Second, it was hoped that the publication of the values of F would provide data for the correlation of terrestrial magnetic phenomena with other geophysical or cosmical phenomena.

It may be convenient to refer to one result which has been obtained by an examination of a part of the data already published. Duvall (*Terr. Magn.* XXXVI. 311; XXXVII. 261) and Egedal (in a communication to be made at this meeting), have shown that the quantity F has a pronounced seasonal or semi-annual variation, with maxima at the equinoxes. That this should be so was quite expected, for it could be shown from the records of absolute daily range at Eskdalemuir, where the question has been closely studied for the last fifteen years. The results of Duvall and Egedal do not call in question the usefulness of the formula for its first purpose; viz, the selection of five quiet and five disturbed days in a given month. Further, it was shown in the report submitted at the Prague meeting in 1927, that there was close agreement between the days indicated by the formula and those selected by De Bilt under the international arrangement. Hence, so far as the first purpose of the formula is concerned, the resolution reached at Stockholm in 1930 should, in my opinion, still stand.

With regard to the second purpose, perhaps more important — the correlation of magnetic with cosmical phenomena — the interpretation of these numerical magnetic character data is more difficult.

To begin with, there is the fundamental difficulty that the daily range in an element or component is taken from instantaneous values which are not simultaneous. I have recently attempted a closer examination of the question as applied to the records of a single observatory — Eskdalemuir — for a period of 12 years, 1914-1925. If the absolute hourly range of the force components during a given hour be denoted by r_N, r_W, r_V the activity for that hour may be assumed to be

$$\frac{Nr_N + Wr_W + Vr_V}{1000}$$

and the mean value of this quantity for the day is denoted by A. The results have been published in *Trans. Roy. Soc. Edinburgh,* LVII, 617-632, and, in so far as they bear upon the scheme now in operation, provide the following results: —

(a) The mean annual values of A and F have a correlation coefficient of 0.99 with a negligible error.

(b) The ratio F/A of the mean annual values of F and A varies between 0.69 and 0.79. The breadth of the band of maximum frequency is due to the quantity F/A having a seasonal variation.

(c) The mean monthly values of A show a semi-annual variation similar to that of F, with maxima at the equinoxes.

The frequency distribution, throughout the 24 hours, of maxima and minima of the three force components at Eskdalemuir was dealt with in the *Annual Report of the Eskdalemuir Observatory* for 1916.

So far then, the examination of the hourly ranges at this particular observatory yields results confirming those based upon the daily range now being tabulated at De Bilt. They also, of course, confirm the observations made by Duvall and Egedal.

But the paper I have referred to gives other results which, though not entirely new, tend to give more precise form to ideas on the subject of magnetic disturbance in the earth's field. Among these, there is evidence of the difference between disturbance due to regular diurnal variation and that due to sporadic or irregular disturbance such as occurs in magnetic storms. The phases of these two forms of disturbance differ by 12 hours; the former having its maximum at or near noon, the latter at or near midnight. Thus, although the onset of a magnetic storm has no relation to local time, its particular form at a given place is affected by local time. It is for this reason that yesterday, in connection with another matter, I suggested the publication of times of occurrence of daily maxima and minima.

There is also evidence that the regular diurnal variation is affected by disturbance. I do not refer here to the well-known fact that the amplitude of the diurnal inequality is increased on disturbed days. This effect begins to show when A reaches a value of 500, that is when the daily range of N, W, and V exceed 84γ, 87γ, and 44γ respectively.

Now what we are aiming at all the time is the nature of the connection between solar and terrestrial magnetic disturbance, and it would therefore seem that, for the terrestrial magnetic part of any correlation, we must separate activity due to the diurnal variation, by subtracting it from the total of the day. This has been suggested several times and in several forms during the last ten years. But as far as I am aware, this has now been proposed on the basis of any reasoned process. It must be remembered that beyond the fact that the amplitude of the diurnal inequality increases with disturbance, we know practically nothing as to the details of this increase, and consequently we cannot legitimately proceed with this subtraction of quiet day activity from disturbed day activity. There are, besides, other objections which could be urged against it, among these being the fact that we should be applying a different rule to such widely separated observatories as Sodankylä and Huancayo.

I may mention however that this examination of the diurnal inequality on days of different magnetic activity has been begun for Eskdalemuir for the 12 years 1924 to 1925, and has already made substantial progress.

We may further hope that the observations made during the Polar Year will place at our disposal a large quantity of data of high importance for this study.

I would finally suggest that the Association should appoint a Reporter to continue the watch on this important subject and to make a communication regarding it to our next meeting.

REMARQUES DE M. BARTELS SUR LA COMMUNICATION DE M. CRICHTON MITCHELL

It will be interesting to obtain the separation of the two parts of magnetic activity, due to the regular diurnal variation and to actual disturbance, as announced by Dr. Crichton Mitchell. There is a great difficulty in the fact, that even on quiet days the regular diurnal magnetic variation differs very much from day to day, even at equatorial stations.

COMMUNICATION CONCERNING THE MAGNETIC NUMERICAL CHARACTER-NUMBERS

By J. EGEDAL

In an article "Magnetic activity — Some results of the measure adopted at Stockholm" in the Journal "Terrestrial Magnetism and Atmospheric Electricity", vol. 36, p. 311, 1931 Dr. Duvall has communicated some results obtained by a comparison of the international character-numbers and the numerical character-numbers. In the article it is stated that the numerical character-numbers do not give an explicit expression for the magnetic activity, and on account of this an amendment to the derivation of the numerical character-number has been proposed.

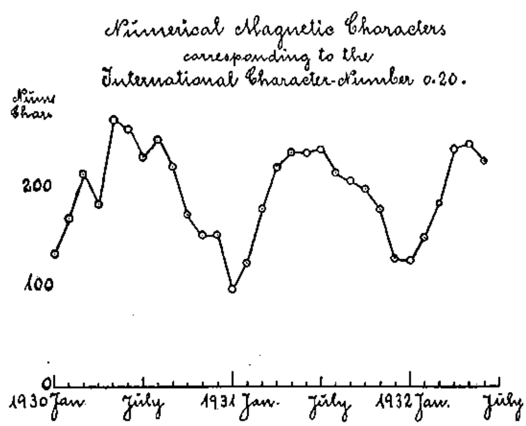
In order to throw more light on this question some results obtained by an examination of the numerical character-numbers derived from the registrations of the magnetic observatory Copenhagen (Rude Skov) will be given below.

Table: *Means of international and numerical character-numbers*

	1930			1931			1932		
	Int. ch.-n.	Num. ch.-n.	Reduced num. ch.-n.	Int. ch.-n.	Num. ch.-n.	Reduced num. ch.-n.	Int. ch.-n.	Num. ch.-n.	Reduced num. ch.-n.
Jan.	0.23	144	133	0.12	82	96	0.16	119	125
Feb.	0.26	190	169	0.20	123	123	0.16	143	149
March	0.02	151	214	0.23	182	177	0.23	187	182
April	0.25	200	182	0.18	217	220	0.15	229	237
May	0.30	301	266	0.18	231	234	0.16	235	241
June	0.20	258	258	0.22	236	233	0.20	225	225
July	0.24	244	230	0.17	231	236			
Aug.	0.33	292	246	0.31	232	213			
Sep.	0.27	244	219	0.22	208	205			
Oct.	0.22	178	171	0.35	222	196			
Nov.	0.21	155	151	0.27	188	176			
Dec.	0.12	123	151	0.15	119	128			

In the above table the data for a comparison of the numerical character-numbers and the international character-numbers derived for the period January 1930 — June 1932 are given. The second column of the table contains the mean for each month of the year 1930 of all international character-numbers below 0.5, the third column contains the means of the numerical character-numbers for each month and for the same days as used in the precceding column, and the fourth column contains numerical character-numbers reduced to the international character-numbers 0.20 by means of a reduction-factor calculated for each year. The following columns of the table contain similar data from the years 1931 and 1932. The reduction-factor has been derived and used on the assumption that for the interval from 0 to 0.5 of the international character-numbers proportionality exists between corresponding variations of international character-numbers, Δ i, and numerical character-number, Δ n, in other words that the quantity $\frac{\Delta n}{\Delta i}$ may be considered as constant. This latter quantity has been derived from the original data, and is just what is used as reduction-factor. Details of the reduction being of no great importance for the matter in question shall not be mentioned here.

From the table it will be seen that the mean numerical character-numbers for the summer are higher than those for the winter, and this is also to some extent the case for the means of the international character-numbers. The reduced values of the numerical character-numbers still show the same tendency although the numbers have been reduced to the value 0.20 of the international character-numbers (cf. the figure). As there is reason to think that the international character-number 0.20 corresponds to a certain nearly constant activity, we conclude that the numerical character-numbers are systematically different for the same magnetic activity. In our case the summer-values are nearly twice as great as the winter-values.



In conclusion it should be remarked that the seasonal difference between numerical character-numbers corresponding to small international character-numbers found by Duvall for observatories lying in low geographical latitude also appears in the present data from an observatory lying in relatively high latitude and in a still more pronounced manner.

SÉPARATION DES DIFFÉRENTES FORMES D'ACTIVITÉ MAGNÉTIQUE

Par L. EBLÉ

Ce qu'on désigne sous le nom d'activité magnétique comprend en réalité 3 phénomènes qui se manifestent sur chacun des éléments, mais que nous étudierons seulement sur la composante H: A, le déplacement de la moyenne diurne par rapport à sa valeur normale; B, la déformation de la marche diurne par rapport à la marche normale; C, l'agitation, variations plus ou moins rapides et irrégulières. Il est visible que ces deux dernières formes ne sont pas inséparables, car certaines journées sans agitation présentent des variations tout à fait anormales.

Les différentes méthodes proposées pour évaluer l'activité tiennent compte de préférence de l'une de ces 3 formes, ou de l'ensemble de deux d'entre elles, ou même des trois comme la fréquence des écarts de Mascart. Mais aucune ne les distingue nettement. Nous avons essayé de faire la séparation par une méthode qui ne peut pas être proposée pour établir régulièrement les caractères magnétiques de chaque jour, mais qui peut permettre d'étudier sur des exemples particuliers, pendant un mois par exemple, ce que donnent les procédés habituellement employés. Il est bien certain, d'autre part, que toute convention, en pareille matière, comporte une part d'arbitraire, la définition de l'agitation étant peu précise; nous espérons l'avoir réduite au minimum.

La méthode proposée consiste à faire chaque jour la somme des écarts horaires, pris en valeur absolue, par rapport à une certaine marche diurne qu'on considère comme normale. Mais, au lieu de partir, comme Bidlingmaier, des valeurs effectives de la composante horizontale, on part de celles-ci débarrassées de l'agitation irrégulière. Pour éliminer cette dernière d'une façon moins arbitraire que le tracé d'une courbe moyenne, on représente la marche de chaque journée par un développement en série de Fourier à quatre termes, d'après lequel on calcule les valeurs horaires régularisées. La suite de celles-ci manifeste par rapport à la marche diurne moyenne mensuelle des écarts qui correspondent à la déformation B; la somme de leurs valeurs absolues sera l'indice de déformation.

L'indice d'agitation correspondant à ce phénomène C, s'obtiendra par la somme des différences horaires entre les valeurs effectives de H et les valeurs régularisées qui résultent du développement harmonique.

L'indice de déplacement A résulte immédiatement de la différence entre la moyenne diurne et la moyenne mensuelle. On multipliera cette dernière par 24 pour conserver à l'indice l'ordre de grandeur d'une somme de 24 valeurs horaires.

La décomposition, faite sur un exemple, a permis de rapprocher les valeurs des indices B et C de celles qu'on obtient par d'autres méthodes. Nous avons choisi le mois d'octobre 1931, qui présentait une grande variété, et les valeurs de H enregistrées au Val-Joyeux, observatoire de l'Institut de Physique du Globe. Le tableau ci-après donne jour par jour les valeurs

Tableau des indices d'activité

Octobre 1933	1°	2°	3°	4°	5°	6°
1	1.2	141	8.4	112	178	10
2	1.6	198	11.3	173	284	21
3	0.9	92	9.1	169	108	14
4	1.2	198	10.6	229	150	18
5	1.5	226	16.3	358	321	15
6	0.8	135	6.0	264	211	15
7	0.5	92	4.3	124	73	7
8	0.4	71	5.2	104	41	8
9	0.3	80	4.8	109	60	7
10	0.4	84	6.5	140	81	0
11	0.3	106	7.4	139	73	7
12	1.5	324	16.7	363	258	0
13	1.7	147	10.2	137	287	8
14	0.7	98	4.3	136	101	9
15	0.9	112	6.2	87	128	8
16	0.4	94	5.1	100	61	0
17	1.1	128	7.8	188	101	0
18	1.2	175	7.7	130	147	0
19	1.1	139	7.9	141	125	8
20	0.8	94	7.0	123	88	8
21	0.9	96	5.0	172	121	10
22	1.0	173	8.3	141	175	9
23	0.9	147	8.8	228	128	25
24	0.6	77	6.1	137	86	18
25	0.3	67	5.4	101	58	12
26	0.8	94	7.3	170	61	11
27	1.1	192	9.0	182	99	11
28	1.3	179	14.0	312	157	11
29	2.0	418	39.1	713	327	9
30	1.8	269	18.5	310	337	12
31	1.5	96	7.8	134	139	18

des indices obtenus par les méthodes suivantes: 1° caractères internationaux (De Bilt), 2° valeurs de $HR_H/10000$, 3° valeurs de $\sum |A_d^x|$ suivant la définition de Bidlingmaier, 4° indices de déformation (B), 5° indices d'agitation (C), 6° indices d'activité solaire (Zurich).

Pour voir si les différents indices quotidiens ont la même signification, le procédé le plus simple est de chercher si leurs successions au cours du mois présentent la même allure. C'est ce que permet la méthode de corrélation qui exprime par un nombre la concordance des suites; la corrélation rigoureuse s'exprime par l'unité, au-dessous de 0,5 la corrélation est à peu près inexistante. Nous avons donc calculé les coefficients de corrélation entre les indices qui paraissaient les plus intéressants à comparer.

Caractères internationaux. — Ils sont fixés par l'aspect des courbes; or, ce qui frappe l'œil, c'est surtout l'agitation. Leur corrélation avec les indices C est très forte et s'exprime par 0,98.

Valeurs de $HR_H/10000$ — Nous rappelons que la quantité $\frac{HR_H + ZR_Z}{10000}$ est prise aujourd'hui pour mesure de l'activité; mais on sait qu'elle ne la représente qu'approximativement; elle présente l'avantage d'être vite calculée, les amplitudes diurnes R_H et R_Z se lisant facilement sur les courbes enregistrées. Nous avons comparé seulement $HR_H/10000$ avec nos indices de déformation et d'agitation, ceux-ci étant déduits de la composante horizontale. Les coefficients de corrélation sont:

entre $HR_H/10000$ et la déformation B: 0,87
entre $HR_H/10000$ et l'agitation C : 0,81.

Les nombres $HR_H/10000$ expriment plutôt la déformation que l'agitation: lorsque l'amplitude diurne s'écarte de la valeur moyenne du mois, c'est plus souvent par suite d'une déformation générale de la courbe que par suite de pointes interrompant la régularité de celle-ci.

Il est intéressant de remarquer que, si l'on compare $HR_H/10000$ avec la somme B + C des indices contenus dans les colonnes 4° et 5°, la corrélation s'améliore, le coefficient s'élévant à 0,92. De telle sorte que $HR_H/10000$ représente en gros l'ensemble des deux formes d'activité produisant la déformation et l'agitation.

Valeurs de $\sum|A_d^x|$ — Rappelons la définition de Bidlingmaier. La moyenne diurne H_d s'écarte de la moyenne mensuelle H_m d'une quantité $H_d - H_m = A_h^d$. Chaque valeur horaire H_x s'écarte de la valeur horaire mensuelle correspondante d'une quantité $H_x - H_h = A_h^x$; cet écart comprend deux parties: la différence A_d^h, et l'écart horaire par rapport à la moyenne déplacée A_d^x, qui se calcule donc par la différence

$$A_d^x = A_h^x - A_d^h$$

La somme des 24 valeurs absolues de $\sum|A_d^x|$ est l'indice de l'activité de la journée.

On a comparé cet indice aux 2 indices B et C et à leur somme. Les coefficients sont:

entre $\sum |A_d^x|$ et la déformation B : 0,94

entre $\sum |A_d^x|$ et l'agitation C : 0,75

entre $\sum |A_d^x|$ et la somme B + C : 0,92

On est un peu surpris de voir que la corrélation est surtout étroite entre $\sum |A_d^x|$ et la déformation. Le nombre de Bidlingmaier est une valeur approchée de l'énergie; celle-ci est donc surtout absorbée par la déformation. En d'autres termes, les écarts dus à la déformation sont beaucoup plus grands et plus fréquents que ceux qui résultent de l'agitation. Cette prédominance est tellement marquée que la corrélation de $\sum |A_d^x|$ est plus forte même avec la forme d'activité B qu'avec la somme de B + C.

Toutes ces corrélations, qu'elles concernent les indices B ou C, sont élevées. On pourrait croire que cela tient à ce que les deux modes d'activité correspondants sont inséparables. Il y a donc lieu de chercher s'il existe entre eux une corrélation aussi forte. Le coefficient est seulement de 0,65; il indique encore une corrélation probable, mais pas une coexistence absolue. Il y a donc lieu de croire que le procédé employé sépare la déformation et l'agitation d'une façon assez complète. Nous concluons donc:

les caractères internationaux de De Bilt indiquent surtout le degré d'agitation;

les valeurs de $HR_H/10000$ donnent l'ensemble de l'agitation et de la déformation,

les valeurs de $\sum |A_d^x|$ de Bidlingmaier indiquent surtout la déformation de la marche diurne.

Quant aux rapprochements que l'on peut faire avec l'activité solaire, ils conduisent à des coefficients de corrélation extrêmement faibles: 0,10 pour B, 0,09 pour C; si l'on néglige les trois derniers jours du mois, où se présente une perturbation importante, les coefficients deviennent respectivement 0,22 et 0,24. On sait, en effet, que l'activité magnétique présente un retard par rapport à l'activité solaire et que, de plus, celui-ci est variable. La simple méthode de corrélation ne peut rien indiquer ici.

CONTRIBUTION A LA CARACTÉRISATION DE L'AGITATION MAGNÉTIQUE

Par Mme Y. LABROUSTE

Note de la Rédaction: Cet article a paru dans les Comptes Rendus de l'Académie des Sciences, Paris, t.197, 1933, p.653-655.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la V^e partie: Numerical magnetic character - numbers by C. R. DUVALL; Comments of the agenda for the Lisbon meeting .... (Magnetic activity and characterization, by C. R. DUVALL, S. E. FORBUSH and A. G. McNISH).

CONTRIBUTION A L'ÉTUDE DES VARIATIONS PÉRIODIQUES DU MAGNÉTISME TERRESTRE

(Composante diurne et semi-diurne de la déclinaison)

Par M. et Mme H. LABROUSTE

Parmi les composantes périodiques de la variation diurne de la déclinaison, les plus importantes sont généralement la composante diurne et la composante semi-diurne.

Nous avons isolé ces deux composantes, jour après jour, en utilisant les valeurs horaires de la station du Val-Joyeux relatives à l'année 1913, époque de minimum d'activité solaire, par un procédé de calcul déjà utilisé dans d'autres études analogues.

A titre d'exemple, nous reproduisons, pour le mois de Janvier 1913, deux courbes, I et II fig 1, donnant l'aspect des deux composantes diurne et semi-diurne. On constate sur chacun des deux graphiques des variations d'amplitude et de phase: c'est ainsi que la composante diurne présente quatre maxima principaux d'amplitude A, B, C, D, dont le plus important est le troisième.

La composante semi-diurne se distingue immédiatement de la première par des fluctuations d'amplitude moins accentuées et présentant des maxima et des minima qui ne coïncident pas en général avec les précédents; par exemple, au dernier maximum de la composante diurne correspond un minimum de la composante semi-diurne.

Pour étudier plus commodément ces variations, nous avons tracé, en fonction du temps, les courbes d'amplitude et de phase. Les variations de phase sont généralement faibles sur la composante semi-diurne (inférieures à une heure), tandis qu'on observe des avances notables correspondant aux augmentations brusques de l'amplitude dans la composante diurne: on note, par exemple, une avance de 2 heures ⅓ au début d'Avril; mais cette relation entre l'amplitude et la phase ne paraît pas absolue.

En ce qui concerne les courbes d'amplitude, on remarque, pour les divers mois, l'indépendence déjà constatée en Janvier,

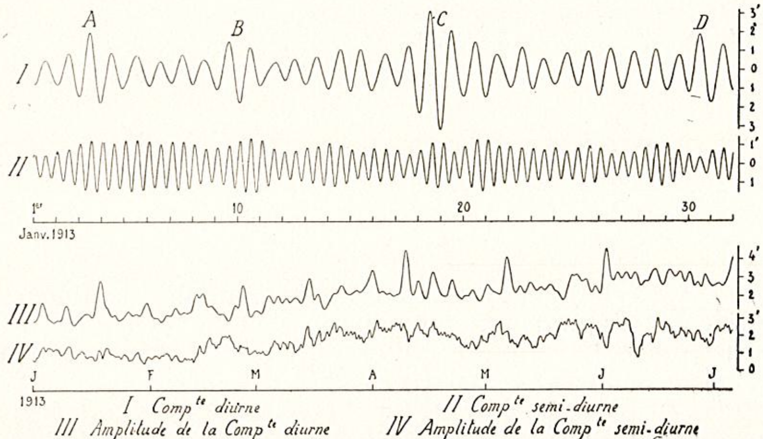


Figure 1

comme on peut le voir sur les courbes III et IV de la figure 1. Dans la composante diurne, les variations se traduisent principalement par des pointes qui correspondent à des maxima d'amplitude, tandis que les variations de la composante semi-diurne comprennent des oscillations, les unes assez rapides, les autres lentes, dont les causes sont encore à déterminer.

La courbe relative à la composante diurne montre un parallélisme étroit avec l'agitation magnétique. Cette relation a déjà été trouvée par d'autres moyens: en particulier, Charles Chree, en calculant les coefficients de Fourier sur des moyennes de dix ans, a montré que l'amplitude de la composante diurne relative aux jours ordinaires ou aux jours perturbés est notablement plus grande que celle qui correspond aux jours calmes et qu'à cette augmentation d'amplitude correspond une avance de phase.

Pour étudier, jour par jour, la correspondance entre les deux phénomènes, nous avons représenté l'une au-dessous de l'autre, dans la figure 2: 1° l'amplitude de la composante diurne et 2° l'agitation magnétique,*) de Décembre 1912 à Décembre

*) Obtenue par le procédé indiqué dans: *Contribution à la caractérisation de l'agitation magnétique,* par Mme Y. Labrouste (Voir p. 292).

1913. On est frappé du parallélisme qui existe entre ces deux courbes et qui est presque parfait de Décembre à Mai (on a numéroté les sommets qui se correspondent).

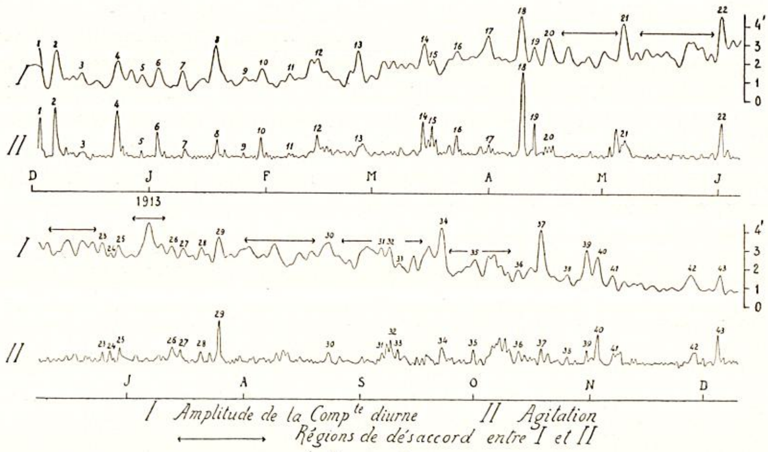


Figure 2

Il a été vérifié que l'augmentation de l'amplitude diurne corrélative d'une agitation notable existe bien indépendamment des crochets importants qui introduisent des valeurs très anormales dans les données; nous avons choisi, à cette fin, certaines époques présentant des oscillations ou des crochets marqués et calculé à nouveau la composante diurne après avoir remplacé chacune des valeurs anormales des données horaires par la moyenne des valeurs qui l'encadrent. L'amplitude de la composante diurne se retrouve sensiblement la même qu'avec les données non corrigées.

Si, au lieu de comparer les mois d'hiver ou de printemps, on considère les mois d'été, le parallélisme signalé est moins étroit; certes, on trouve encore une correspondance entre les grandes manifestations d'agitation et les maxima d'amplitude, mais il y a d'importantes variations d'amplitude de la composante diurne sans correspondant dans l'agitation. L'amplitude dépend donc de plusieurs causes distinctes.

Parmi les exceptions à la relation indiquée, la plus manifeste est celle du 6 Juillet qui consiste en une grande augmentation de l'amplitude sans agitation magnétique. On peut se demander si cette anomalie s'étend à une région notable ou à la totalité du globe.

On a examiné, d'une part, l'amplitude de la composante diurne durant le mois de Juillet d'après les données de onze stations. Parmi celles-ci, les quatre stations européennes (De Bilt, Val-Joyeux, Ebro, Pola) sont les seules qui manifestent nettement l'anomalie; De Bilt et le Val-Joyeux présentent la plus grande variation d'amplitude. Les autres observatoires distribués dans diverses parties du globe (Sitka, Cheltenham, Tucson, Honolulu, Irkoutsk, Zi-Ka-Wei) ne fournissent que des résultats douteux.

D'autre part, le caractère magnétique moyen publié par la Commission internationale de Magnétisme terrestre n'est que 0,3 pour ce jour; 31 stations sur 42, parmi lesquelles De Bilt et le Val-Joyeux, ont donné l'indice zéro.

En rapprochant ces résultats, on voit que la variation du 6 Juillet est localisée dans une région limitée et qu'elle existe indépendamment de l'agitation.

Par contre, on constate le 25 Juillet une perturbation à laquelle correspond une augmentation brusque d'amplitude dans toutes les stations ci-dessus. Ainsi, les deux maxima d'amplitude du 6 et du 25 Juillet ont des causes distinctes et se manifestent sur le globe suivant des lois différentes.

D'autres études seraient nécessaires pour généraliser les résultats obtenus.

ÉTUDE DE LA COMPOSANTE DIURNE DU GRADIENT DE POTENTIEL ÉLECTRIQUE

Par R. GUIZONNIER

(présentée par M. Maurain à la suite de la communication de M. et Mme Labrouste, comme utilisant la même méthode de recherche).

M. Guizonnier a isolé la composante diurne du gradient de potentiel électrique au Val-Joyeux de 1925 à 1930. En laissant de côté les mauvais jours (jours de pluie ou de neige), il a pu néanmoins conserver d'assez longues séries de jours successifs pour constater des fluctuations généralement irrégulières de l'amplitude et de la phase de cette composante.

Il a montré également que la phase et l'amplitude présentent une variation annuelle régulière: pour la phase, l'heure du maximum d'amplitude — qui est 17 heures en Janvier — avance progressivement jusque vers 12 heures en Juillet et revient de nouveau à 17 heures l'hiver suivant. Quant à l'amplitude, elle est maxima en hiver et minima en été: l'écart moyen entre les valeurs maxima et les valeurs minima a été trouvé de 15,7 volts par mètre.

A côté de ces résultats, M. Guizonnier a étudié une intéressante relation entre l'amplitude du gradient de potentiel électrique et la pression atmosphérique diurne moyenne, manifestée par le parallélisme que suivent certaines variations de ces éléments au cours du temps. Si l'on effectue sur les données des deux éléments des combinaisons destinées à supprimer les irrégularités ou à favoriser certaines périodes déjà apparentes, les graphiques relatifs au gradient et à la pression présentent entre eux une similitude frappante dans tous les cas étudiés, qui se rapportent au Val-Joyeux et à Batavia.

INFLUENCIAS LUNARES SOBRE O MAGNETISMO TERRESTRE

Par M. A. DIAS PRATAS

Note de la Rédaction: Cet article a paru dans la Revue de la Faculté des Sciences de l'Université de Coimbra, 1932, Vol. II, No. 3, p. 185-197.

LA GÉOLOGIE PROFONDE DE LA FRANCE D'APRÈS LE NOUVEAU RÉSEAU MAGNÉTIQUE ET LES MESURES DE LA PESANTEUR

Par Jean JUNG

L'étude géologique des parties de l'écorce terrestre, trop profondes pour pouvoir être atteintes par le sondage ou le marteau, peut être abordée par l'interprétation des anomalies du magnétisme et de la gravimétrie, ainsi que par celle des mouvements séismiques. Le principe de la méthode consiste, en somme, à appliquer, aux socles continentaux, les méthodes éprouvées à une échelle moindre, par la prospection géophysique. Dans un mémoire récemment paru*), nous avons tâché de tirer, principalement du Nouveau réseau magnétique, une première contribution à la connaissance de la géologie profonde de la France. Ne pouvant résumer ici la matière de ce mémoire, nous en exposerons quelques conclusions.

Structure profonde des Alpes. Les Alpes, dont nous avons pu suivre les zones structurales profondes depuis le Saint Gothard jusqu'à la Corse, peuvent être étudiées avec une richesse de

*) *J. Jung.* La géologie profonde de la France d'après le nouveau réseau magnétique et les mesures de la pesanteur. *Annales de l'Institut de Physique du Globe de l'Université de Paris,* Tome XI, 1933.

documents particulière en Suisse, grâce à la coexistence d'un réseau gravimétrique (Niethammer) et d'un réseau magnétique (Brückmann).

La carte des anomalies de Bouguer montre un déficit de masse régulièrement réparti suivant l'axe orographique des hautes chaines et correspondant à la zone molassique subalpine et aux zones helvétiques et penniques. L'axe minimum suit les confins des Massifs cristallins et de la zone pennique, avec environ -150 milligals. La largeur de la zone déficitaire va donc du Jura au Piémont. Au sud de cette zone, suivant les racines internes insubriennes, c'est-à-dire à hauteur des Lacs italiens, surgit, au contraire une vive et brusque anomalie positive, qui s'atténue vers les plaines lombardes.

Le magnétisme montre des unités structurales correspondantes: le minimum helvétique et pennique et le maximum de la zone insubrienne. Mais l'allure des anomalies est, à plusieurs points de vue, différente.

Le calcul des masses perturbatrices, suivant l'hypothèse d'après laquelle les anomalies seraient dues à la proximité plus ou moins grande du tréfonds basique, a permis de dessiner une coupe des Alpes dans la totalité de leur profondeur. Cette coupe montre l'existence d'un soubassement gneisso-granitique épais de 50 à 100 km sous les zones helvétiques et penniques et la montée très brusque du magma basique suivant la zone insubrienne. Cette interprétation se trouve coïncider non seulement avec les observations de la géologie de surface, mais aussi avec les conclusions que O. Mengel avait tiré de la séismologie, dès 1929.

L'avant-pays alpin. Des variations très lentes, dites crustales, de la gravimétrie et du magnétisme sont mises en évidence par les anomalies de l'isostasie ainsi que par les anomalies magnétiques totales, obtenues en comparant le champ réel à celui que présenterait la région si la terre était une sphère homogène aimantée. Les anomalies à l'isostasie et les anomalies magnétiques totales montrent, sur la majeure partie de la France (la Bretagne fait, en effet, exception) une remarquable coïncidence. La France se trouve divisée en deux parties par une ligne qui va de la Hollande à la Catalogne. La partie située à l'est est d'anomalie positive et le maximum est situé vers la région Vosges-Forêt-Noire avec 50 milligals pour la pesanteur et 1000 gammas pour le magnétisme. Conformément à la doctrine d'Airy sur l'isostasie, c'est dans cette zone que se trouvent, non seulement tous les fossés d'effondrements et champs de fractures, mais aussi tous les massifs et pointements de roches volcaniques tertiaires et quaternaires.

Quant à la ligne de séparation diagonale entre la zone positive et la zone négative, elle correspond à des phénomènes géologiques superficiels, qu'il est curieux de pouvoir mettre en évidence. Ici encore la correspondance est complète avec les zones sismiques de O. Mengel.

Conclusions. L'examen des données géophysiques relatives aux différentes régions de la France, et aux pays voisins, permet de se former une idée des traits, et plus encore des problèmes, de la géologie profonde.

Les anomalies crustales montrent que la croûte gneisso-granitique va en s'épaississant de la Méditerranée à la Manche. La partie mince dessine un angle ayant son sommet en Hollande et dont les côtés se dirigent respectivement vers la Catalogne et vers la Silésie. La partie la plus mince est le domaine Tyrrhénien.

Dans cet angle est venu s'inscrire l'arc alpin, constitué, de la Suisse à la Méditerranée, par un double repli de la croûte acide: l'un, anticlinal, du côté sud, forme les racines insubriennes, tandis que l'autre, synclinal, constitue le géosynclinal pennique.

En avant s'amortissent des plis de fond de moindre envergure, dans lesquels les anomalies régionales montrent l'injection de masses magmatiques basiques, donnant naissance parfois, comme en Auvergne, à du volcanique de surface. Cette zone est en déséquilibre isostasique: d'où la localisation des champs de fractures.

Cependant, la région N. W. de la France, à croûte gneisso-granitique plus épaisse n'a subi que des mouvements d'ensemble, d'affaissement et de surélévation.

REMARQUES DE M. MATHIAS A L'OCCASION DE LA COMMUNICATION DE M. JUNG

Quand *Moureaux* découvrit, dans le tertiaire non-magnétique du Bassin de Paris, l'anomalie qui affecte une douzaine de départements, on ne s'expliquait pas ce résultat. Le forage du puits artésien de Grenoble (525 m. de profondeur) n'ayant mis en évidence que des roches peu ou pas magnétiques*), le champ magnétique superficiel paraissait dû à des roches magnétiques extrêmement profondes, exerçant sur les pôles des aimants des forces verticales, indépendantes des singularités de la surface terrestre.

On ne comprenait pas que certains départements, entièrement réguliers pour la composante horizontale et l'inclinaison, le vecteur magnétique y étant normal, eussent exclusivement des anomalies de la déclinaison ou inversement.

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*) On ignorait alors l'existence possible, à des profondeurs de l'ordre du kilomètre, de masses énormes de magnétite, comme celles qui produisent, dans le gouvernement de Koursk, les anomalies formidables découvertes par *Smirnoff,* puis étudiées par *Moureaux* et que le professeur *Lasareff* a approfondi avec tant de soin.

Pour les physiciens de 1880-1900, la Terre, corps à noyau de ferro-nickel, tournait dans un champ magnétique nul. La température énorme du Soleil annulait le magnétisme de ses composants malgré sa masse prodigieuse et à la faveur de sa grande distance de nous. *Hale* n'avait pas encore découvert les champs magnétiques puissants de la surface solaire, et on n'était pas fait à l'idée que la Lune pût, à 60 rayons terrestres de distance, produire un champ magnétique sensible, grâce auquel la rotation de la Terre donnait par induction des courants, producteurs partiels (certains disent totaux) du champ magnétique de sa surface.

Des mesures de la déclinaison et de la composante horizontale dans les Gorges du Tarn, région calcaire non magnétique, faites là où l'axe des Gorges est sensiblement parallèle au méridien magnétique, dans une section droite des Gorges, sur les lèvres (à *Saint-Rome de Dolan* et à *la Maxane)* et dans le fond, 500 m. plus bas *(aux Vignes),* m'ont donné une déclinaison et une composante horizontale plus grandes dans le fond que sur les lèvres. Visiblement, dans ce cas, en terrain non magnétique, le relief influait sur le champ magnétique de la surface.

A l'époque (1901), j'expliquais ce résultat en admettant qu' «une partie du magnétisme terrestre de la surface était due à des courants telluriques *(ainsi nommés faute d'un meilleur vocable)* réguliers, circulant dans le sol de l'Est à l'Ouest, au voisinage immédiat de sa surface et ayant, suivant la verticale, une épaisseur qui ne doit pas être très considérable»*).

Une solution de continuité perpendiculaire à la direction de ces courants (Gorges du Tarn, dans la région de *Saint-Rome-de-Dolan)* ou, en terrain continu, la conductibilité électrique différente de deux terrains contigus suivant une *faille,* doivent produire une *réfraction* des courants telluriques, donc une anomalie de la déclinaison, indépendamment d'autres effets sur la grandeur du vecteur magnétique et de ses composantes.

J'étais ainsi conduit à une explication simple des anomalies du Bassin de Paris, de l'influence du relief et aussi de la nature des couches superficielles du sol agissant par leur conductibilité électrique. De là, à accorder de l'importance à des statistiques des anomalies des différents éléments magnétiques suivant la nature du terrain superficiel, il n'y avait qu'un pas. Une telle méthode, conjuguée avec les méthodes de prospection magnétique profonde et appliquée aux différents terrains superficiels représentés par des stations nombreuses, reste toujours susceptible de donner des résultats partiels intéressants.

J'avais conclu ainsi: «De tout ce qui précède, il semble bien découler que les études de magnétisme terrestre sont une

*) E. MATHIAS, L'alpinisme et les études de magnétisme terrestre, *Annuaire du Club alpin français,* 28e. volume, 1901, p. 9 du tirage à part.

application directe, ou devront, dans un avenir plus ou moins éloigné, être considérées comme une application directe de la physique à la géologie»*)

En résumé, dès 1901, l'idée qu'une partie du champ magnétique superficiel de la Terre est due à des courants circulant au voisinage de sa surface et à l'intérieur, permettait à un physicien français de montrer que l'anomalie du Bassin de Paris n'était pas inintelligible et conduisait non seulement à l'influence du relief et des failles, mais aussi à montrer l'existence de relations profondes entre le magnétisme terrestre et la géologie, ce que *Moureaux* pressentait en notant, dans toutes ses mesures, la nature du terrain superficiel des stations magnétiques.

C. ACTIVITÉ SOLAIRE

COOPERATIVE OBSERVATIONS WITH THE SPECTROHELIOSCOPE

By George E. HALE

Several hypotheses to account for terrestrial magnetic storms have been advanced, but hitherto it has been impossible to make a final selection among them. There can be no doubt, however, that the most intense magnetic storms usually occur when an exceptionally large and active sunspot is not far from the center of the sun's disc and that the eleven-year period in the fluctuation of terrestrial magnetism coincides closely with the corresponding period in the frequency of sun spots. The fact remains that very large spots sometimes cross the sun's disc without producing magnetic storms and we are thus driven to the use of all available means of measuring the sun's activity in the hope of detecting the true source of the relationship.

Solar observers are aware that the size of a sun spot is not invariably a fair measure of its activity. In fact, there is not only a wide diversity between the activities of different spots but also a striking variation in the behavior of a given spot during the several stages of its existence. Such variations are shown, not only by the rate of change in form or structure of the spot but especially by the eruptive phenomena of the solar

*) E. MATHIAS, loc. cit, p. 12-13.

atmosphere above or near it. These phenomena were seen and partially analyzed soon after the earliest application of the spectroscope to the observation of the sun's disc. The subsequent development of the spectroheliograph provided a means of recording the forms of the eruptive regions, as I found in 1892. The brilliant eruption photographed on July 15 of that year in the light of calcium vapor was followed about 24 hours later by a violent terrestrial magnetic storm and a very bright aurora. Various other cases of the same general character, recorded in France, India, England, and the United States on monochromatic images produced by calcium or hydrogen light, are described and illustrated in a recent paper.*)

If there were a sufficient number of spectroheliographs distributed around the world, and if these could be used often enough to give us a continuous record of the solar atmosphere, most of these eruptions would be registered. In practice, however, the comparatively small number of spectroheliograms taken daily makes the record far from complete, and supplementary observations are essential.

In a series of papers published in the *Astrophysical Journal* the advantages offered by the spectrohelioscope for work of this kind have been enumerated.**) The small solar telescope and spectrohelioscope there described, though comparatively simple and inexpensive, permit a complete survey of the sun's disc to be made with hydrogen (Hα) light in a few minutes. Moreover, they enable the observer to detect instantly occasional eruptions which are moving too rapidly in the line of sight to be recorded by the spectroheliograph, unless its adjustments are especially altered for the purpose. As the existence and radial velocities of such eruptions are not known in advance, the second slit of the spectroheliograph may not fall on the line as displaced by the great velocity of the eruptive gas. A simple device in the spectrohelioscope obviates this difficulty, and permits all such eruptions to be quickly observed and their rapidly varying forms and motions to be analyzed.

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*) Hale, *Astrophysical Journal*, vol. 73, pp 379-412, 1931.

**) Hale, "The Spectrohelioscope and its Work", *Astrophysical Journal*, Part I. "History, Instruments, Adjustments, and Methods of Observation", vol. 70, pp 265-311, 1929; Part II. "The Motions of the Hydrogen Flocculi near Sun-spots," vol. 71, pp 73-101, 1930; Part III. "Solar Eruptions and their Apparent Terrestrial Effects," vol. 73, pp 379-412, 1931; Part IV. "Methods of Recording Observations," vol. 74, pp 214-222, 1931.

Spectroheliosopes are now available for use at the following observatories:

Observatory	Place	Latitude	Longitude
		° ′	h m
Royal	Greenwich, England	+51 29	0 00
Solar Physics	Cambridge, England	+52 13	0 00
Paris (Meudon)	Meudon, France	+48 48	— 0 09
Federal	Zürich, Switzerland	+47 23	— 0 34
Astrophysical	Florence, Italy	+43 45	— 0 45
American College	Beirut, Syria	+33 54	— 2 22
Solal Physics	Kodaikanal, South India	+10 14	— 5 10
Department of Terrestrial Magnetism of the Carnegie Institution of Washington	Watheroo, Australia	—30 18	— 7 44
National Institute of Astronomy	Nanking, China	+32 07	— 7 55
Commonwealth Solar Observatory	Canberra, Australia	—35 20	— 9 56
Apia	Apia, Samoa	—13 48	+11 27
Mount Wilson, Carnegie Institution of Washington	Mount Wilson, Calif.	+34 13	+ 7 52
Mount Wilson, Carnegie Institution of Washington	Pasadena, Calif.	+34 08	+ 7 52
Pomona College	Claremont, Calif.	+34 06	+ 7 51
University of South Dakota	Vermilion, S.D.	+42 42	+ 6 28
Yerkes	Williams Bay, Wis.	+42 34	+ 5 54
Adler Planetarium	Chicago, Ill.	+41 50	+ 5 51
Ohio State University	Columbus, Ohio	+40 00	+ 5 32
Department of Terrestrial Magnetism of the Carnegie Institution of Washington	Huancayo, Peru	—12 03	+ 5 01
G. W. Cook	Wynnewood, Montgomery Co., Pa.	+40 00	+ 5 01
Vassar College	Poughkeepsie, N.Y.	+41 41	+ 4 56
Bell Telephone Laboratories	Deal, N.J.	+40 14	+ 4 56
Massachusetts Institute of Technology (Physical Laboratory)	Cambridge, Mass.	+42 23	+ 4 44

Several of these instruments are not yet in regular use, but it is hoped that most of them may soon be employed regularly. Spectroheliosopes have also been built or ordered for use at the following additional stations: Griffith Planetarium, Los Angeles; Franklin Institute, Philadelphia; and the Observatory, Athens.

Pasadena, July 20, 1933.

METHODS OF RECORDING AND MEASURING SOLAR ACTIVITY

By J. BARTELS

1. The following measures, observations and records of solar activity are those mainly used for comparison with geophysical phenomenae:

a) *Solar constant,* that is, the amount of solar radiation transmitted at the Earth's average distance, expressed in cal/cm²min, and now measured by the Observatories of the Smithsonian Institution.
b) *Relative sunspot number,* as defined by the Zürich Sternwarte for the whole Sun disc and the central circle zone. Since 1926, the daily relative sunspot-numbers are supplemented by remarks about new-formation of spots, passage across the central meridian, or entrance on the visible disc. They are published in the "*Astronomische Mitteilungen*", in "*Terrestrial Magnetism*" and some other journals.
c) *Areas of Sunspots and Faculae,* as published in the *Greenwich Photoheliographic Results.*
d) *Character Figures of Solar Phenomena,* for Ca-Flocculi, bright and dark Hα--Flocculi, for the whole sun disc and the central circle zone, published in a quarterly *Bulletin, for the International Astronomical Union,* by the Eidgen. Sternwarte in Zürich. Results are available for all years since 1917.
e) *Ratio of ultra-violet to green radiation,* as measured on Mount Wilson, and published in the same *Bulletin.*
f) Observations with the *spectroheliograph* and *spectrohelioscope,*[1]) taken in increasing number at various stations, and partially published in the *Bulletin;* the organization of the work with the spectrohelioscope is being organised.[2])
g) *Heliographic Charts,* published since 1926 in the "*Astronomische Mitteilungen*", Zürich for the photosphere, and giving the situation, extent, and intensity of spots and faculae for each rotation; the observatory of Meudon does the same for the chromosphere in his "Cartes synoptiques de la chromosphère solaire et catalogue des filaments de la couche supérieure." Daily pictures of the solar limb with the protuberances are published in "Immagini Spettroscophie Del Bordo Solare, osservate a Catania, Madrid, Zô-Sè, e Zurigo, publicate per cura del R. Osservatorio Astrofisico di Arcetri".
h) Daily areas of the *limb prominences,* since 1926 in the "*Astron. Mitteilungen*", and, in monthly means, since 1910.

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[1]) For a clear account of the work with the spectrohelioscope see W. *Brunner, Neujahrsblatt d. Naturforsch. Ges., Zürich* 1933.
[2]) See *communication* by G. E. *Hale,* and § 3 of *this paper.*

Among all geophysical phenomenae, the variations of terrestrial magnetism show by far the closest relationships to solar phenomenae.[3),4)] The correlations of monthly and annual means of terrestrial magnetic activity to measures of solar activity are about equally close for the measures listed under b), c), d) in the list above. As far as monthly means go, all solar measures fail to show correlation with terrestrial magnetism in the years 1928 to 1931, though the 27-day sequences (due to the Sun's rotation) are very prominent in magnetic disturbances just then. It could be shown[4)] that terrestrial magnetic disturbance is caused by rather long-lived active *"M-regions"* on the solar surface, which, in the 11-year cycle, run fairly parallel in intensity and frequency to the sunspots, but are not identifiable with sunspots, faculae or flocculae. The latter, the solar measures of activity, are so highly correlated with each other, that remarkable differences in their correlation with terrestrial magnetic activity are not to be expected and, indeed, not found.

2. *W. Brunner*[5)] has found, that, for the years 1923 to 1929, the dark hydrogen flocculi and, especially, the limb prominences, give markedly higher correlations with terrestrial magnetic activity than other measures of solar activity, including sunspots. This interesting result, which seems to contradict the remark made above, has, however, not been confirmed for a longer series of years: *Brunner* has, since then, published a valuable table of monthly means of areas of limb prominences for the years 1910 to 1932.[6)] From these, I have calculated averages (P) for quarters (three-monthly intervals) and their correlations with the u_1-measure of magnetic activity[4)] and with sunspot-numbers R. The correlation-coefficients for the 76 quarters 1912 to 1930 are: between

P and u_1, + 0.70; R and u_1, + 0.73; P and R, + 0.83.

Brunner's table for P also indicates the number of limb observations, which varies between rather wide limits; it was therefore possible to test whether quarters with many observations yielded better correlations than quarters with few observations. The resulting correlation-coefficients are:
for 43 quarters with 33 observations of limb-prominences or more (45 observations on the average)

P and u_1, + 0.76; R and u_1, + 0.74; P and R, + 0.86;

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3) See, for instance, the author's report "Geophysikalischer Nachweis von Veränderungen der Sonnenstrahlung," *Ergebn. d. exakt. Naturwissenschaften 9*, 38-78, *Berlin* 1930.
4) *J. Bartels*, Terr. Magn. 37, 1-52, 1932; also "Ueberblick über die Physik der hohen Atmosphäre" *Elektr. Nachrichten-Technik 10*, Sonderheft. *Berlin*, 1933.
5) Character Figures of Solar Phenomenae 1923 to 1928. *Zürich* 1932.
6) Astronom. Mitt. *130*, 217, *Zürich* 1933.

for 33 quarters with 32 observations or less (24 observations on the average)

P and u_1, + 0.62; R and u_1, + 0.72; P and R, + 0.80.

The reduction of the correlation with fewer solar observations is obvious. — On the whole, the longer series 1912 to 1930 does not support the possibility of a decided superiority of P, the limb prominences, over the relative sunspot number R, with regard to correlation with terrestrial magnetic activity. The same holds for the 36 monthly means of the years 1928 to 1930; we find for

P and u_1, + 0.03; R and u_1, + 0.01; P and R, + 0.57;

again the use of P does not materially improve the poor correlation with u_1, [4]) while the solar measures P and R remain correlated.

3. Geophysicists are aware of the fact that they have not exhausted to any extent, for the study of solar and terrestrial relationships, the large observational material about solar phenomenae provided by astrophysical observations. In view of the statistical nature of all correlations between solar and terrestrial phenomena, single cases of coincidences between solar outbreaks and magnetic storms may be interesting, but not decisive. The available long series of photoheliographic observations have already been successfully studied by *W. M. H. Greaves* and *H. W. Newton, Ch. Maurain, J. M. Stagg* and others. It always appears that each solar phenomenon entails a terrestrial effect not with certainty, but only with some degree of probability. If, then, the spectrohelioscopic observations, made possible at a number of stations by *G. E. Hale's* ingenious instrument, are hoped to improve our imperfect insight in the mechanism of transmission from the Sun to the Earth, it would help greatly if they would be published in a form suitable for convenient comparison with terrestrial magnetic data and for statistical treatment.

It is a great pleasure to say that such a publication is now assured by the International Astronomical Union. Prof. W. *Brunner* (Zürich), as president of Commission No. 10 (on sunspots and solar activity), and Prof. *L. d'Azambuja* (Meudon), as president of Commission No. 11 (Chromospheric phenomena) of the I. A. U. have been kind enough to supply information on the plans. In a circular addressed to the stations equipped with spectrohelioscopes, Prof. *d'Azambuja* says:

"Le travail avec le spectrohélioscope est inclus dans les attributions d'une Commission nouvelle, la Commission No. 11 (Phénomènes chromosphériques). Après entente entre M. G. E. *Hale,* M. W. *Brunner* et le Président de cette dernière Commission, il a été décidé que ce serait celui-ci qui se chargerait de la centralisation des observations pendant que M. *Brunner* les publierait dans le *"Bulletin for character figures of solar phenomena"*.

Le but du nouveau centre est de chercher à réaliser une observation du Soleil aussi continue que possible. Aussi, je vous serais obligé de bien vouloir m'indiquer combien de fois, ou pendant combien de temps, chaque jour de ciel clair, vous pourrez consacrer à l'observation avec le spectrohélioscope, et à quelles heures?

Un programme précis, s'inspirant des réponses reçues, sera établi ultérieurement. Jusque là, nous pourrions peut-être convenir qu'au cas où vous observeriez une éruption solaire, les caractères de celle-ci me seraient transmis avec, notamment, les indications suivantes:

1 Temps civil de Greenwich
2 Position héliographique approximative (coordonnées de Carrington)
3 Etendue (très petite, petite, moyenne, etc.)
4 Intensité
5 Effet Doppler-Fizeau (éventuellement)

Je me chargerais ensuite de grouper les observations recueillies dans un tableau qui serait inséré trimestriellement dans le *"Bulletin for character figures"*.

Il serait évidemment très désirable que la nouvelle organisation pût atteindre sa pleine efficacité au moment prochain où l'activité solaire va reprendre. Aussi, je serais très heureux de recevoir, dès à présent, vos remarques et suggestions relatives à son fonctionnement pour que je puisse, en temps utile, y apporter les précisions et les perfectionnements nécessaires."

The thanks of the geophysicists who are highly interested in a comparison of their continuous records with the results of a continuous watch of solar phenomena, are expressed to the International Astronomical Union in a resolution, unanimously adopted as No. 8 at Lisbon.

REMARQUES DU P. RODÉS A L'OCCASION DE LA COMMUNICATION DE M. BARTELS

Father Rodés expresses his opinion upon the usefulness of the intercomparison of curves obtained at different observatories in order to distinguish between local perturbations which might not be due to the Sun, and universal perturbations which have an extraplanetary cause.

He added that the curve of solar activity based on the relative number of calcium flocculi visible as sun spots, such as the one obtained at "del Ebro", gives the best parallelism with the curve of magnetic activity in its different manifestations. He believes that flocculi which manifest themselves in the form of sun-spots affect deeper layers of the sun's atmosphere and are therefore more suitable for an index of its activity.

MESURE ET MÉTHODES D'OBSERVATION DE L'ACTIVITÉ SOLAIRE

Par G. SARMENTO DA COSTA LOBO

Au sujet de l'exposition sur la «Mesure et méthodes d'observation de l'activité solaire» je résumerai ici quelques résultats obtenus à l'Observatoire Astronomique de Coimbra.

Le travail poursuivi par les différents observatoires dans l'organisation des statistiques des phénomènes solaires, considérés comme manifestations de l'activité solaire est d'une grande importance. Dans son ensemble, plusieurs phénomènes présentent une variation sensiblement parallèle.

La périodicité de certains phénomènes magnétiques une fois vérifiée, les taches du Soleil, premier de ces phénomènes observés, révélèrent peu après ce parallélisme.

Pourtant, les taches de même que, pendant ces derniers quarante ans, les phénomènes que les méthodes spectroscopiques permirent d'étudier régulièrement dans l'atmosphère intérieure du Soleil, ne peuvent pas fournir des renseignements assez précis sur cette relation, ni son explication, sans une interprétation préalable des aspects variés que nous présentent les phénomènes enregistrés jusqu'à présent dans les statistiques solaires.

Ces méthodes, comme on le sait, ont permis un enregistrement quotidien incomparablement plus complet qu'auparavant, car, jusqu'en 1868, les enregistrements étaient limités aux phénomènes photosphériques.

L'examen des spectrohéliogrammes obtenus à l'Observatoire Astronomique de Coimbra, et avec lequels j'ai réalisé les photographies des couches chromosphériques de l'atmosphère intérieure du Soleil, m'a démontré souvent que la classification des phénomènes chromosphériques est insuffisante.

Cela nous permis dès lors de fixer les différences qui existent dans chaque catégorie des figures caractéristiques du Soleil.

Ainsi, l'intensité lumineuse des plages faculaires et des mouvements révélés par sa configuration et par le spectro-enregistreur des vitesses radiales indiquent différentes activités.

Un autre cas important, que j'ai observé depuis le dernier maximum de 1929, consiste en ce que l'un des hémisphères, malgré qu'il ne présentât à certaines époques, aucune plage faculaire des dimensions minimes habituellement enregistrées, a cependant une zone où le réseau chromosphérique est plus au moins déformé par des vestiges de plages faculaires. Ces perturbations arrivent à s'étendre à toute une zone royale.

Les protubérances, par rapport à l'activité solaire, doivent être considérées en ensemble avec les filaments. Ces derniers éléments, comme je l'ai demontré dans une récente communication, du fait des conditions dans lesquelles on les observe et aussi de leurs différentes natures, représentent en général, en projection, seulement une partie de la protubérance correspondante. Parfois la protubérance n'est pas observée pendant son passage à l'hémispère, ceci démontre certains cas intermédiaires où la protubérance qui paraît surgir brusquement au bord du Soleil n'est justement que la protubérance que devait former le filament au moment d'atteindre le bord du Soleil en vertu de sa rotation.

Les phénomènes de caractère éruptif qui, en général, s'écoulent dans un court espace de temps, n'ont pas toujours permis de trouver des relations dans les cas isolés. Pour apprécier l'action des différents phénomènes solaires sur la terre, sa localisation sur la zone de plus grande influence ne suffit pas, mais il est aussi indispensable de considérer l'orientation de ces mouvements qui présentent des directions variées.

Le spectrohélioscope a permis d'augmenter le nombre de ces observations. Une bonne distribution de ces instruments dans le monde entier apporterait un grand avantage à ces études.

Je profite de cette occasion pour vous informer que dans un mois, ou à peu près, l'installation d'un spectrohélioscope à l'Observatoire Astronomique de Coimbra sera terminée.

SUR L'INTERVALLE DE TEMPS ENTRE LES PHÉNOMÈNES SOLAIRES ET LES PERTURBATIONS MAGNÉTIQUES TERRESTRES

Par Ch. MAURAIN

M. Maurain rappelle qu'il a publié en 1926 un mémoire sur ce sujet, étudié par une méthode statistique *(Comptes Rendus de l'Acad. des Sciences,* Paris, t. 182, 1926, p. 1550; *Annales de l'Institut de Physique du Globe,* t. 5, 1917, p. 86.). Le résultat était qu'il y avait un retard moyen de deux jours et demi des perturbations magnétiques sur les phénomènes solaires.

Il a reprit récemment cette étude, mais par une méthode individuelle, c'est-à-dire en recherchant l'intervalle de temps entre un phénomène solaire et une perturbation magnétique paraissant lui correspondre. La plus grande partie de l'étude est consacrée aux phénomènes solaires constitués par le passage d'une tache importante ou d'un groupe de taches au méridien central du Soleil. Tous les cas des années 1930, 1931, 1932 ont été examinés, au nombre de 34. Sur ces 34 cas, 24 permettent l'évaluation d'un intervalle de temps entre le passage et une perturbation magnétique consécutive; ces intervalles de temps varient entre 23,5 et 116,5 heures, et leur moyenne s'accorde avec celle obtenue dans l'étude statistique rappelée ci-dessus.

De plus ont été étudiées à ce point de vue un certain nombre de phénomènes solaires éruptifs, qui conduisent à des intervalles de temps du même ordre.

Enfin ont été rapportés des cas très rares pour lesquels la littérature scientifique indique d'ordinaire qu'il y a eu quasi-simultanéité entre un phénomène solaire et une perturbation magnétique; le cas célèbre de Carrington a été examiné dans un mémoire récent de G. Hale, et semble correspondre plutôt à un intervalle de temps de 17,5 heures; le cas de Trouvelot, d'après le texte original, n'a pas de réalité; le seul cas de Young (1872) correspondrait à une coïncidence impressionnante. Ce serait le seul cas de simultanéité, du moins apparente, alors que dans un nombre très grand de cas apparaît un intervalle de temps de l'ordre indiqué plus haut.

En somme, il semble qu'on doive considérer que dans un très grand nombre de cas, sinon dans tous, il y a un intervalle de temps, variable, entre les phénomènes solaires et les perturbations magnétiques correspondantes. — Les théories relatives à cette relation doivent permettre d'interprêter ce fait.

Les résultats de ce travail ont été résumés dans les *Comptes Rendus de l'Acad. des Sciences, Paris,* t. 196, 1933, p. 1182, et un mémoire paraîtra dans le tome XII des *Annales de l'Institut de Physique du Globe.*

D. HAUTE ATMOSPHÈRE. RAYONS COSMIQUES

THE SOLAR-DIURNAL AND LUNAR-DIURNAL VARIATION OF THE HIGH ATMOSPHERE

By J. EGEDAL

Résumé de l'auteur.

In order to examine the solar-diurnal variation in height of the upper atmosphere (115 km of height) 3566 observations of the height of aurora made by Störmer and Vegard and Krogness have been treated. During the hours from 2 to 9 hours after sunset the mean height of aurora decreased 20 km. A lunar-diurnal variation could not be stated with any accuracy. The author expresses the hope that the application of radio methods will enlighten the treated problem.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la V^e partie: Multi - frequency measurement of virtual heights of the ionized regions of the ionosphere, by L. V. BERKNER;

Memorandum on the use of fixed - frequency virtual - height records in correlations with other geophysical phenomena, by L. V. BERKNER;

Comments on the agenda for the Lisbon meeting .... (Ionization and diurnal variation of the conducting regions of the high atmosphere and their relations to terrestrial magnetism and electricity, by M. A. TUVE and H. F. JOHNSTON).

DESIGN OF A RECORDING COSMIC-RAY METER

By Arthur H. COMPTON and Ralph D. BENNETT

The recent discovery of a component of the cosmic rays whose intensity depends upon the position in the Earth's magnetic field and which seems to consist of electrically-charged particles, gives new importance to the search for correlations between possible variations of the cosmic rays and changes in the Earth's magnetic field and the atmospheric potential-gradient. The objective of the systematic recording of the cosmic rays is to find first whether true variations in the intensity of the cosmic rays occur, and if so, whether they are ascribable to terrestrial effects or to some lack of uniformity in the distribution of the cosmic rays in space. Many observers have reported small but systematic variations of the cosmic rays which were not ascribable to barometric changes. It is difficult however to distinguish such systematic variations from the statistical fluctuations which are inherent in cosmic-ray ionization. The present instrument is designed to reduce to a minimum any effects due to changes in the local gamma-rays or to statistical fluctuations, and to be highly sensitive to changes in the ionization due to the cosmic rays. Critical comments will be helpful in determining the final form of the instrument and will be highly appreciated.

We have considered two features to be essential in the design of an instrument for this purpose, namely, (1) relatively large size in order that the effect of statistical fluctuations may be minimized, and (2) a balancing-current, so that the measured quantity will be the departure of the actual ionization from a mean value. Both of these features are present in the Hoffmann and Steinke forms of cosmic-ray meters. A determined effort to include these features in an instrument patterned after the electroscope of Kolhörster, Millikan, and Regener led to less satisfactory results.

The main features of our design, as indicated in the accompanying figures, are as follows:

(1) A spherical steel bomb, with a volume of about 21 liters, filled with pure argon at 50 atmospheres. This arrangement gives a much larger ionization-current than that in existing chambers, consequently reducing the importance of any spurious currents that may be present. The high pressure makes necessary a spherical design instead of the bell-jar shape of chamber used by Steinke.

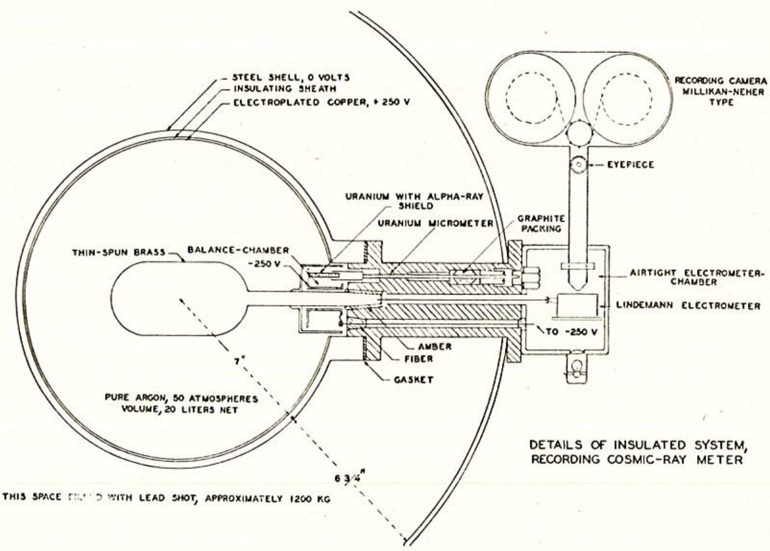
(2) The balancing-current is supplied by the ionization in a small auxiliary chamber (within the sphere) by the beta-rays from an adjustable surface of metallic uranium. The electric field will be strong enough to give approximate saturation. This gives an adjustable compensating-current, which is affected by changes in the pressure and temperature in nearly the same way as is the ionization-current to be measured. Experience with the meter used on our cosmic-ray survey has shown the value of a radioactive standard, which the uranium will supply. Because of the small dimensions of the balance-chamber, the statistical fluctuations introduced by the beta-ray ionization should be small compared with the statistical fluctuations of the cosmic-ray ionization.

(3) Current is measured with a Lindemann electrometer of standard construction, housed in an air-tight, dried chamber. This gives sufficient sensitiveness so that the *variations* from the

normal current will be sufficient to cause an occasional full-scale deflection of $\pm$ 12 mm on the recording-film. The electrometer is accessible for adjustment or repair, and replacement requires no recalibration of the instrument.

(4) The record is made on a continuously moving standard moving-picture film, in a camera of the Millikan-Neher type. There is also an eyepiece for visual observation without interfering with the record. For normal operation, the electrometer-needle will be insulated for 30-minute intervals, during which the film will move 6 mm. At 4-hour intervals a known potential (perhaps one volt) will be applied to the needle to calibrate the sensitivity of the electrometer. At 24-hour intervals the lamp will be turned off for a short period to mark the days.

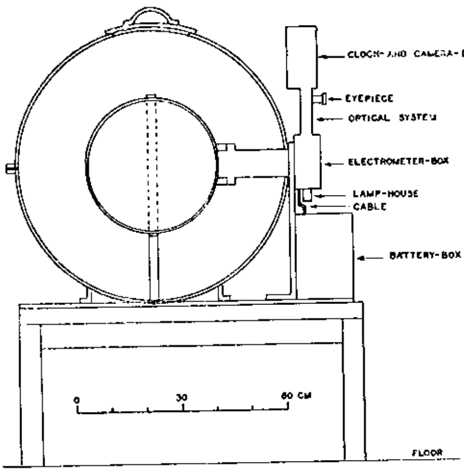
(5) The lead shield will consist of a 17-cm layer of lead shot, equivalent to an 11.4-cm layer of solid lead. The total weight of the shot, 1160 kg, will be 27 per cent greater than that of an equivalent solid shell. It is, however, preferred because of the ease of handling and transportation. It is this weight which limits the practicable size of the instrument.



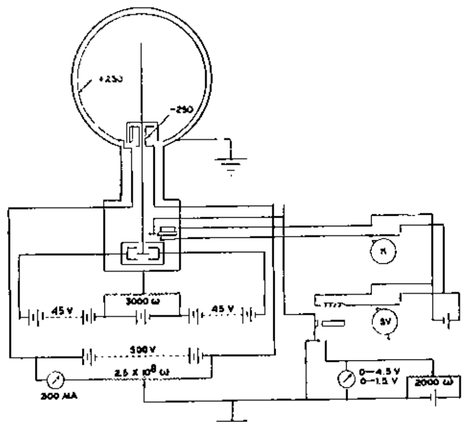
DETAILS OF INSULATED SYSTEM, RECORDING COSMIC-RAY METER

(6) For supplying potential to the inner insulated surface of the sphere and to the balancing-chamber, our design calls for a 500-volt dry-battery, connected across a 2.5-megohm potentiometer, as indicated in the drawing of electrical connections. This type of connection, as Swann has pointed out, may be adjusted to eliminate induced charges due to variations in the battery-voltage. These batteries and potentiometer, and also the batteries supplying the plate-potential of the electrometer, will be enclosed in an air-tight, dried, and carefully insulated battery-box.

An alternative source of potential under consideration is a battery of standard cadmium-cells, to be used without a potentiometer, in accord with the practice of Steinke. We shall appreciate expressions of opinion on this point.



GENERAL ASSEMBLY
RECORDING COSMIC-RAY METER



ELECTRICAL CONNECTIONS
RECORDING COSMIC-RAY METER

(7) For operation of the lamp and the relays, any convenient source of low-voltage power may be used, preferably storage-batteries or small transformers.

(8) The estimated weight of the complete assemblage, excluding lead shot and batteries, is about 80 kg.

It is hoped that the accompanying drawings will make clear the essential details as we have at present designed them.

Chicago, August 24, 1933.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting .... (Equipment for study and for recording of cosmic rays at fixed stations and possible relations to terrestrial magnetism and electricity, by A. G. McNISH).

TABLES CRÉPUSCULAIRES

Voir la note de Mr. LUGEON (Pologne) dans la IIe partie.

WORK OF THE BELL SYSTEM RELATING TO GEOPHYSICS

The Bell System*) has for a number of years been making an active study of those natural phenomena that affect electrical communication. This study began about twenty years ago with an investigation of the effects of earth potential disturbances on grounded telegraph lines. When radio communication became important, this type of work was extended to a study of atmospherics and to a correlation between radio transmission and the more common solar and terrestrial phenomena. Also at a fairly early date a more direct study of the nature of the ionosphere was instituted utilizing forms of the general methods now in use.

In addition to the results obtained from the more general work mentioned above, there has also been accumulated a large amount of useful information quite incidental to the main problem of developing and operating communication facilities. Practically all of the work mentioned above is being continued. Its nature is outlined more completely in the paragraphs which follow. The appended bibliography includes the material of a more incidental nature.

Correlation Work

Soon after the first transatlantic telephone tests were conducted in 1923, it was noted that rather abnormal radio transmission prevailed at the time of and immediately following a magnetic disturbance. For the long waves, then in use, the relatively weak daylight signals were improved while the normally strong nighttime signals were somewhat depressed. Later when short waves came into more general use it was found that magnetic storms produced serious deleterious effects on this type of transmission, sometimes lasting for hours or even days.

During the time in which the study of radio transmission has been in progress, many important characteristics have been brought out. They include normal diurnal and annual variations of radio transmission as well as definite indications of 27 day and 11 year cycles. Several papers relative to this work have been published (6, 9, 13, 14, 19)**)

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*) The Bell System consists of the American Telephone and Telegraph Company and 24 associated and operating companies, each doing business in a different part of the United States. The research of the Bell System is conducted mainly by a subsidiary company known as the Bell Telephone Laboratories.

**) Refers to attached bibliography.

Studies of the Ionosphere

In 1925 Nichols and Schelleng (4) investigated theoretically the comparatively poor transmission of radio waves in the neighborhood of 200 meters and showed that a selective absorption effect in this region could be expected to result from the existence of free electrons in the atmosphere when the magnetic field of the earth is taken into account. They developed the mathematical theory of critical effects in rotation, bending of the wave, and absorption at the resonant frequency; and they derived formulas for these effects.

Following this, measurements of the height of the ionized region were made by R. A. Heising (8) in 1925-1926 by means of reflected waves, the principal method used being somewhat similar to that of Breit and Tuve, in which the time lag between impulses arriving over a direct and the reflected path afforded an indication of the virtual height. The results were in general accord with those now being obtained by other observers.

Work along this line was continued in 1929 by J. P. Schafer and W. M. Goodall. Their results were published in 1931 (22). These experiments differed from others in that not only were frequencies chosen for which no data had previously been published, but simultaneous transmission and reception on two frequencies were employed. The results in general verified those of other investigators as to the variation in the virtual heights of the ionized region with frequency and time of day. These studies were resumed in 1931 (May to December) and further results published by the same authors in 1932 (27).

More recent work by the same investigators (37, 44) has shown that the ionosphere frequently tends to have from 3 to 5 regions of maximum ionization instead of the two ordinarily recognized. Three of these are usually well-defined layers, in that definite maxima are actually developed. They have been designated as E (lower), F (upper), and M (intermediate). The other layers are present as subdivisions of the F region and have a step-like structure, not ordinarily exhibiting an actual maximum. Great variability in the maximum ionic density of the uppermost layer was noted, in marked contrast to the steadiness of the lowest layer, a phenomenon which may have an important astrophysical or meteorological significance. In explanation, the authors favor the view that there is an erratic source of ionization, solar or cosmic, which is superposed on the regular diurnal variation of the ionization due to the light from the sun, and that this variable agency does not penetrate to the lower part of the E region.

Further experiments during the current year by the same observers (45) have thrown more light on the variations in ionization of the several regions. The accompanying chart (Fig. 1) illustrates the variation of virtual height measured during a typical spring day. In this drawing the virtual height for March 27, 1933, is given as a function both of the time of day and of frequency. Beginning at the bottom of the figure at noon the dashed lines represent in order the separations between the

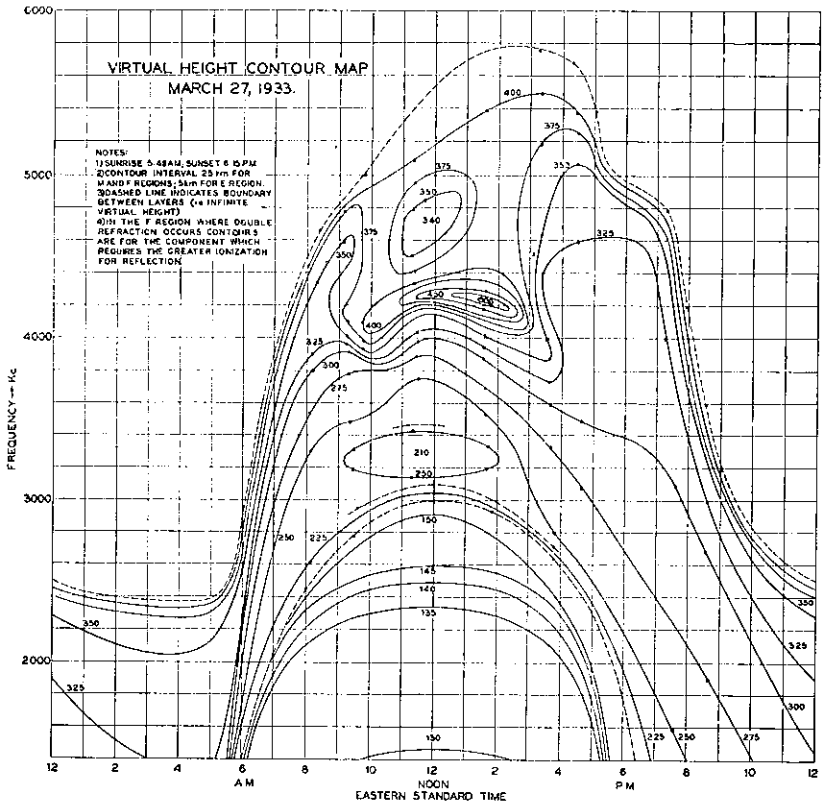


Fig. 1.

various parts of the E, M and F regions which were found on that day. On this day there was no actual discontinuity between the lower and upper F region but the separation is indicated by the peak in the virtual height contours at about 4200 kilocycles.

The belief that the ionization in the lower part of the F region and in the lower part of the E region, which is substantially the same from day to day and has the same diurnal variation, is due to ultra-violet light from the sun is strongly supported by tests made by these authors during the solar eclipse of August 31, 1932 (29).

In two papers by A. M. Skellett in 1931 and 1932 (20, 32), reasons were given for believing that meteors may cause sufficient ionization in the upper atmosphere to affect radio-wave propagation. In order to investigate this possibility measurements were made by Schafer and Goodall (33) of the virtual heights of the Kennelly-Heaviside layer during the Leonid meteor shower of November, 1931. While the results were not regarded as conclusive, due to the occurrence of a moderate magnetic disturbance during this same period, there seemed reason to believe that the presence of meteors in unusual numbers causes increased ionization of an intermittent nature in the region of the lower (E) layer. Such measurements were repeated during the Leonid shower of 1932 (30) and the results confirmed this belief.

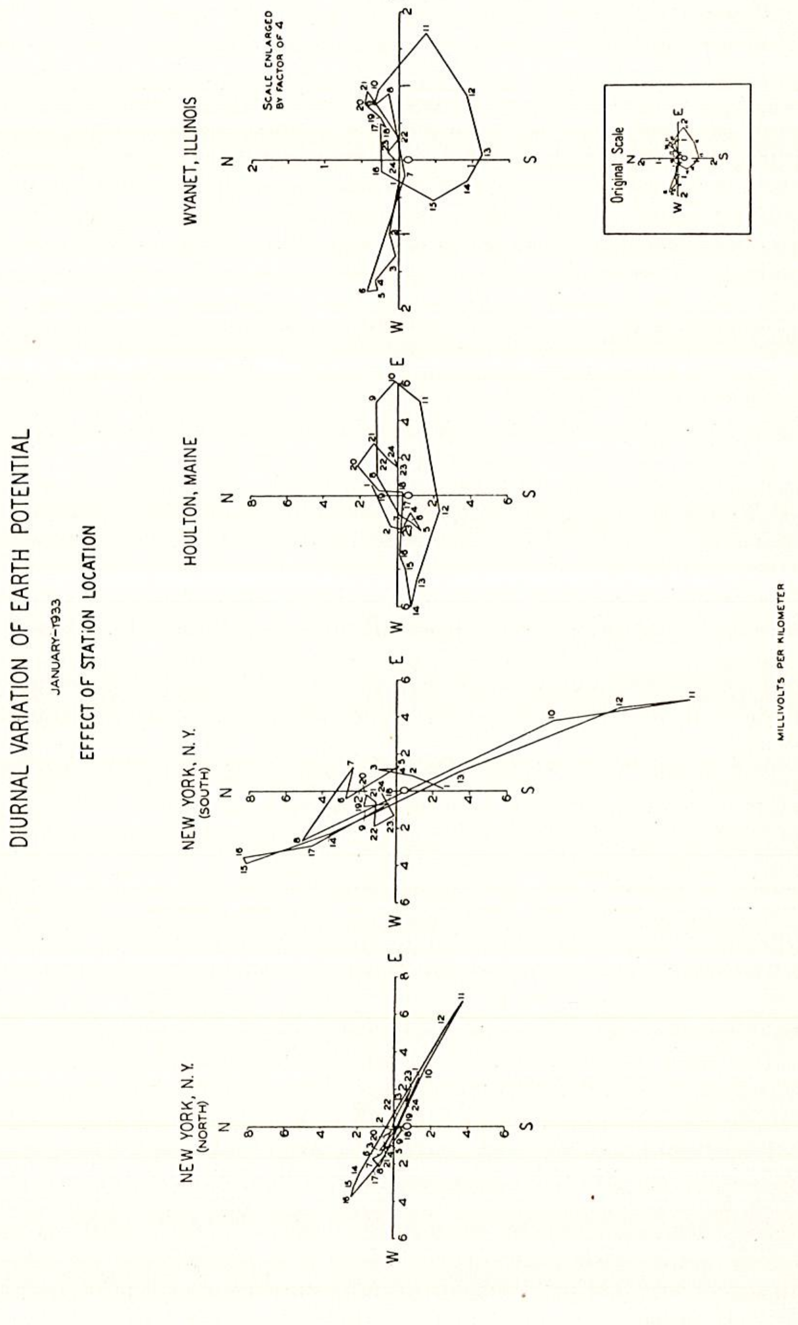
Earth Currents

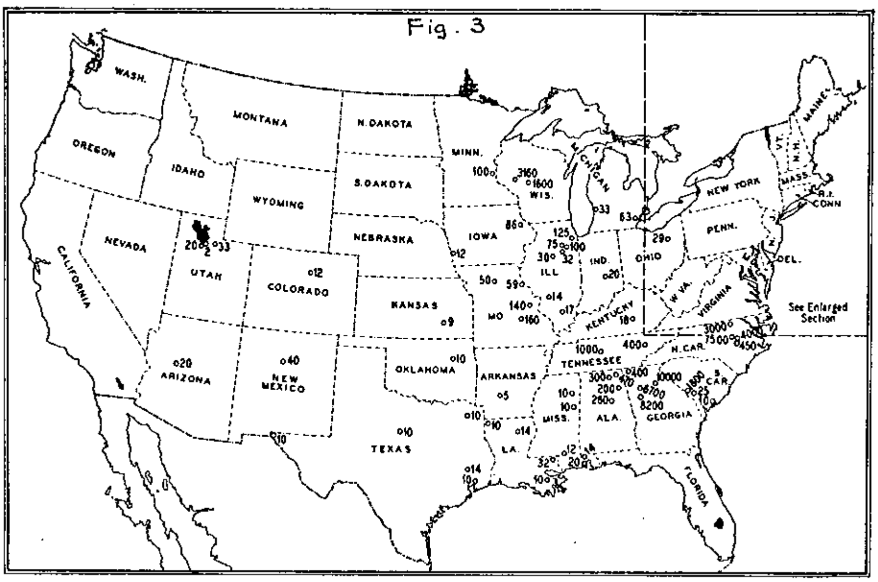
The registration of earth potential disturbances has been in progress near New York City since 1927. For some time this was used as one of the factors in the correlations discussed above (25). Later the work was extended somewhat and was directed more especially at obtaining data on the normal earth potential effects for use in connection with the International Polar Year. A preliminary report has been prepared on the latter phase of this work (41).

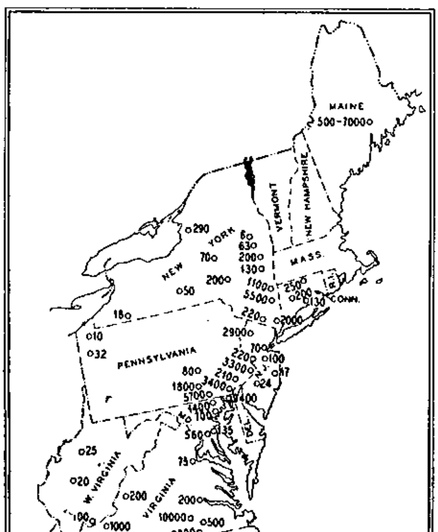
In this connection, earth current measurements have been made at a number of locations at intervals along the Atlantic Coast of the United States and at one location in the state of Illinois. Attention has been given to measuring both the magnitude and direction of flow. In Fig. 2, vector representations of the averages for a month are shown as hodographs for each of several locations. These hodographs make evident the extreme differences that exist between the magnitudes and directions of voltages prevailing at different locations. These diagrams are all drawn to the same scale except that of the large figure for Wyanet, Illinois, which has been magnified by a factor of four to make its detail more readily comparable with the neighboring diagram for Houlton, Maine. The small Wyanet diagram, shown in the lower right corner of the figure, retains the original scale. It will be observed that the successive vectors tend to rotate clockwise through 720 degrees in the 24-hour period.

It will be noted that the smallest diurnal variations shown are measured in Illinois where the soil is deep and the geological formation is homogeneous, and the largest in the region between eastern Pennsylvania and Virginia where the conditions are generally the reverse. It will also be noted that the diagrams for Wyanet, Illinois, and Houlton, Maine, are very similar in form and are only moderately elongated, whereas those for New York, N. Y., north, and New York, N. Y., south, are very much elongated, suggesting that, although similar outside influences may be present at all places, there is some distinctly local influence present near each of the latter points which restricts

Fig. 2.


DIURNAL VARIATION OF EARTH POTENTIAL
JANUARY-1933
EFFECT OF STATION LOCATION
WYANET, ILLINOIS
SCALE ENLARGED BY FACTOR OF 4
Original Scale
HOULTON, MAINE
NEW YORK, N. Y. (SOUTH)
NEW YORK, N. Y. (NORTH)
MILLIVOLTS PER KILOMETER





TEST LOCATIONS AND RESULTS OF EARTH RESISTIVITY MEASUREMENTS
(RESISTIVITIES IN METER-OHMS)

the voltages to the northwest and southeast directions. This same local influence appears to affect the magnitudes and directions at times of abnormal earth currents in a way similar to that in which it affects the diurnal characteristics.

A factor which may have considerable bearing on the magnitude and direction of the earth currents at various locations is the earth resistivity. A great many measurements have been made of earth resistivity throughout the United States (38). These measurements indicate the presence of a zone of high resistivity (Fig. 3), running approximately northeast-southwest through the eastern part of the state of Pennsylvania and extending down into the state of Georgia. This zone of high resistivity may account for the fact that around New York the earth currents are usually confined to a northwest-southeast direction.

It is an interesting fact that many of the observatories of the world where earth potentials are recorded are located either in mountainous regions or where the geological structure otherwise lacks homogeneity. It is also true that the data so obtained show marked directional effects. It would appear from the data above that such effects are of local origin and that they may be avoided by suitable choice of sites.

Musical Atmospherics

Observations of audio-frequency atmospherics of a tonal character received on long antennas and loop aerials were first noted in military communications at the front during the World War and were reported by H. Barkhausen in 1919. T. L. Eckersley has since reported similar observations. In connection with a study of telephone transmission problems, with particular reference to submarine cables, a study of musical and non-musical atmospherics occurring within the frequency range between 150 and 4000 cycles has been made by E. T. Burton and E. M. Boardman (18, 34, 46) of the Bell Telephone Laboratories during the period since 1928. Musical atmospherics, i. e., those which possess a definite tonal quality, are of considerable interest because of their extraordinary character. While a large variety of these tones exist, they appear to fall into two general classes. One type, a short damped oscillation, has been termed a "tweek" because of its characteristic tone; the other, a slowly varying tone of comparatively long duration, has been described as a "swish". A tweek is a night-time phenomenon appearing as a damped oscillation usually trailing a static impulse and almost invariably reducing rapidly in frequency. It is explained on the theory of multiple reflection of a static impulse by the lower portion of the Kennelly-Heaviside layer (16). Based on this theory their observations indicate the effective height of the audio-frequency reflecting layer to be approximately 61 kilometers near sunrise and sunset and 87 kilometers during complete darkness.

The second general type of musical atmospheric, identified by the name "swish", consists usually of a rushing sound, but sometimes appears as a clear whistle, and lasts from a fraction of a second up to four seconds. The frequency may range from 4000 cycles to 400 cycles, although many of the tones occupy only a portion of this range, and the tone may progress either upward or downward. In so far as tonal qualities are concerned the swishes appear to be free from diurnal and seasonal variations. Observations by these and other investigators have indicated a correlation between the intensity of swishes and that of magnetic storms. There are indications also that swishes may originate in the aurora or that certain auroral phenomena and swishes may be controlled from a common source. These authors conclude that if subsequent investigation shows the origin to be located at a high altitude it appears possible that observations of swishes might be applied in connection with studies of atmospheric ionization and terrestrial magnetic fields.

Phonographic records of both the tweek and swish tones have been obtained.

Atmospherics of Extraterrestrial Origin

As a result of directional studies of atmospherics at high frequencies, K. G. Jansky (31) reported in 1932 the detection of three separate groups of static: Group 1, static from local thunderstorms; Group 2, static from distant thunderstorms; and Group 3, a steady hiss type of static of unknown origin. These measurements were made on a wavelength of 14.6 meters. Further investigations of the third group carried out over the whole of 1932 (39, 40) have revealed a remarkable characteristic of these waves. The data obtained show that the horizontal component of the direction of arrival changes approximately 360 degrees in about 24 hours in a manner that is accounted for by the daily rotation of the earth. Furthermore, the time at which the waves are a maximum and the direction from which they come at that time change gradually throughout the year in a way that is accounted for by the rotation of the earth about the sun. These facts lead to the conclusion that the direction of arrival of these waves is fixed in space, i. e., that they come from some source outside the solar system. The coordinates of this direction are a right ascension of 18 hours and a declination of -10 degrees. This is approximately the direction of Sagittarius in the Milky Way.

Miscellaneous

In addition to the gross effects on radio transmission mentioned above under the heading of correlation, there are many more detail effects such as selective fading, variation in the angle of arrival of distant signals and distribution of atmospheric noise which have been observed and measured by research engineers of the Bell System. Space does not permit an extended discussion of this phase of the work at this time. These matters are covered rather fully in the articles included in the appended bibliography.

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E. ÉLECTRICITÉ ATMOSPHÉRIQUE ET TERRESTRE

SUR LA NÉCESSITÉ D'INTENSIFIER LES ÉTUDES RELATIVES A L'ÉLECTRICITÉ ATMOSPHÉRIQUE ET AUX RADIATIONS COSMIQUES

Par Ramos da COSTA

Après avoir adressé une courte allocution aux congressistes, M. Ramas da Costa donne une communication dans laquelle il souligne l'importance d'intensifier l'étude de l'électricité terrestre sur tout le globe et en particulier au Portugal.

LES FLUCTUATIONS DU CHAMP ÉLECTRIQUE TERRESTRE

Par A. DUPERIER et G. COLLADO

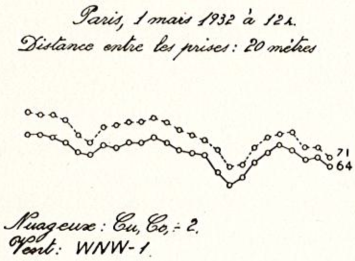
Note de la Rédaction: Cet article a paru dans les Comptes Rendus de l'Académie des Sciences, Paris, t. 197, 1933, p. 422-423.

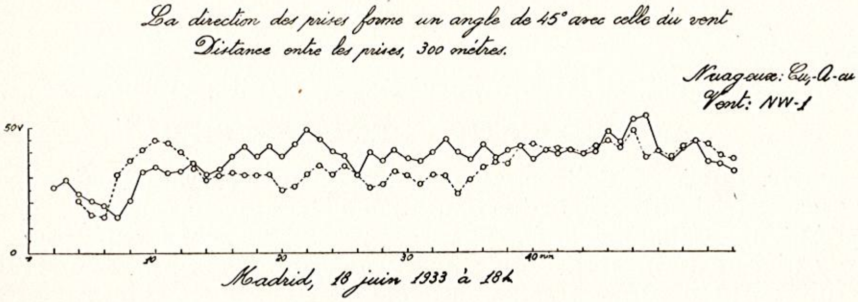
Résumé:

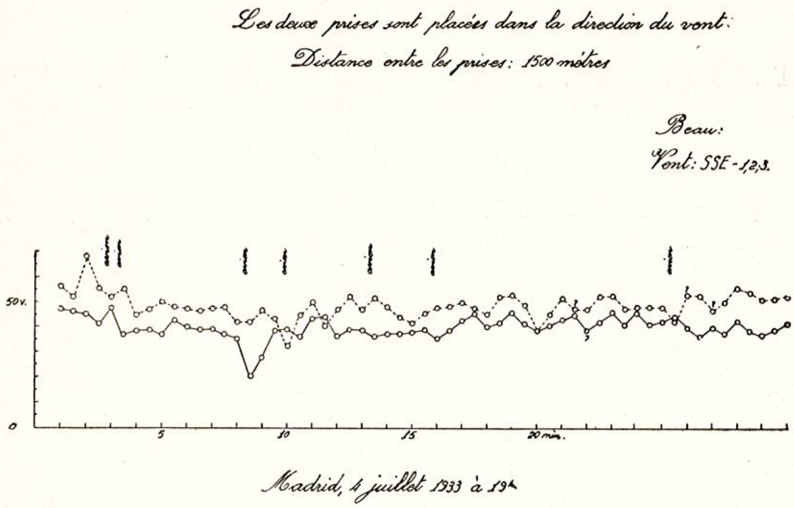
Les fluctuations irrégulières du champ électrique terrestre ont été étudiées par des observations faites simultanément à deux stations situées à une distance progressive de 15 à 1500 mètres l'une de l'autre. Les observations ont été commencées à la station géeophysique du Val-Joyeux et poursuivies à l'aérodrome de Barajas près de Madrid. Les résultats montrent que

les perturbations irrégulières ne sont pas des perturbations locales seulement, mais mettent peut-être aussi en vue une manifestation de la variation universelle du champ terrestre.

Les figures ci-contre donnent quelques exemples inédits des résultats obtenus qui seront d'ailleurs publiés en entier dans les *Annales de l'Institut de Physique du Globe de Paris.*







REMARQUES DE M. JEAN LUGEON AU SUJET DE LA COMMUNICATION DE M. DUPERIER

Au sujet de l'importante communication du Prof. Duperier, Mr. Jean Lugeon relève qu'il serait utile de répéter ces recherches en altitude. Chauveau avait fait des enregistrements simultanés entre le sommet de la Tour Eiffel et le Bureau Central Météorologique. Il n'avait trouvé, sans erreur, aucune similitude dans les courbes. J. Lugeon, également, n'a pas remarqué de parallélisme pour des lectures simultanées qu'il avait faites en 1928 au Mont Blanc aux altitudes de 4358 m. 3300 m et 2450 m. Il y aurait donc lieu d'utiliser les procédés Duperier pour des différences d'altitudes plus faibles de l'ordre de quelques dizaines de mètres.

REMARQUES DE M. SMOSARSKI AU SUJET DE LA COMMUNICATION DE M. DUPERIER

Mr. Smosarski fait remarquer l'importance extraordinaire des mesures simultanées du champ électrique considérées par l'Auteur, étant donné qu'après les recherches théoriques dernièrement apparues, on pourrait tirer de ces mesures, surtout faites à points très distants, des conclusions sur les changements en l'intensité de la source d'électricité, actuellement inconnue, qui maintient la charge négative du globe terrestre.

ÉTUDE DE LA COMPOSANTE DIURNE DU GRADIENT DE POTENTIEL

Par R. GUIZONNIER

(voir le texte de cette communication plus haut, p. 295).

SUR LA CORRÉLATION DU CHAMP ÉLECTRIQUE TERRESTRE ET DE LA CONDUCTIBILITÉ DE L'AIR

Par W. SMOSARSKI

Les moyennes mensuelles ou horaires du champ électrique F au sol et de la conductibilité de l'air λ variant à peu près en sens inverse dans la marche annuelle ou diurne, leur corrélation semble considérable, et on peut constater que le courant vertical $I = F\lambda$ ne varie pas beaucoup dans les conditions moyennes et aux jours calmes qu'on choisit à l'ordinaire pour déterminer la marche annuelle ou diurne. Mais si l'on suit de la conductibilité d'un jour à l'autre, la corrélation n'apparaît que très réduite. C'est ce qu'on pouvait attendre d'avance, étant donné que la conductibilité n'est déterminée que par la constitution chimique et physique de la masse d'air examinée et par les facteurs qui l'ionisent à un moment donné, tandis que la force électrique au sol dépend des conditions beaucoup plus générales. En effet, d'après la théorie de M. H. *Benndorf* (C. R. de l'Ac., Vienne, IIa, 136, 1927, p. 175) la force électrique au sol $F = 4\pi\sigma = 4\pi\,(\sigma_0 + \eta - \eta_k)$ peut être décomposée en trois parties, dont l'une est déterminée par la densité σ_0 de la charge propre superficielle du globe terrestre, l'autre — par la densité η de l'électricité qui y est développée par l'influence des charges électriques répandues dans toute l'atmosphère au-dessous de la couche conductrice, et la troisième est déterminée par la densité $-\eta_k$ influencée par les charges électriques contenues dans la colonne d'air qui surmonte l'endroit considéré. Les deux premières composantes de la force électrique restent les mêmes sur toute la surface du globe et ne varient qu'avec le temps, seule la troisième partie conservant le caractère local.

On conçoit donc bien que le champ électrique au sol peut subir des changements dans une échelle beaucoup plus large que la conductibilité observée dont il ne dépend que partiellement.

Pour faire l'étude de la corrélation, je me suis servi de valeurs de la conductibilité relative qui étaient observées tous les jours à la campagne près de Poznan à 1 heure de l'après-midi à l'aide de l'appareil de *Gerdien* et du gradient du potentiel électrique mesuré quelques instants après, en éliminant toutefois les valeurs très saillantes du gradient. Le coefficient de corrélation, que j'ai déterminé pour chaque mois particulier de deux années, depuis l'été 1931, se montrait variable entre 0,03 et — 0,52 et ne s'élève en moyenne qu'à — 0,30.

Le dépouillement statistique du nombre des jours, auxquels la variation interdiurne du gradient du potentiel se produisait en sens inverse et en sens concordant avec celle de la conductibilité, a conduit aux résultats qui sont présentés dans le tableau suivant:

Fréquence des jours	*Hiver*	*Printemps*	*Eté*	*Automne*	*Année*
à variation interdiurne en sens inverse:	57%	63%	53%	63%	59%
à variation interdiurne en sens concordant:	43	37	47	37	41

On remarque que les variations en sens inverse sont plus fréquentes, conformément au signe négatif de la corrélation indiquée, et que leur nombre n'est pas indépendant de la saison de l'année. Cependant, j'ai pu constater aussi qu'il y a des périodes de plusieurs jours, jusqu'à une dizaine de jours, ou les variations se suivent avec une grande régularité en sens concordant, le gradient du potentiel augmentant ou diminuant quand la conductibilité augmente ou diminue aussi.

Si l'on admet que ce n'est pas par hasard — cette probabilité serait d'ailleurs parfois très petite — que ces coïncidences persistantes se produisent, on peut en conclure qu'il y a des conditions dans la nature qui tendent à augmenter ou à diminuer le champ électrique en même temps que la conductibilité et qui peuvent prévaloir pendant plusieurs jours consécutifs.

Bien qu'il soit difficielle d'établir en détails, quelles sont les conditions qui en sont responsables, on peut néanmoins entrevoir la possibilité de leur existence. Si, par exemple, la poussière chargée négativement est apportée à un endroit par un vent fort, le champ électrique au sol y diminuera; en même temps les particules de la poussière, en attirant quelques ions de l'atmosphère et les immobilisant, réduisent la conductibilité de l'air, comme on peut avoir parfois l'occasion de le constater en réalité.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting ...... (Correlation of the terrestrial-electric field with conductivity of the air, by O. W. TORRESON).

SUR LA CARACTÉRISATION ÉLECTRIQUE DU JOUR

Voir la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Electric character - numbers and means of atmospheric-electric data for publication, by O. H. GISH;

On the characterization of days in the publication of atmospheric-electric data, by O. W. TORRESON;

Comments on the agenda for the Lisbon meeting .... (Numerical characterization of electric field, by O. W. TORRESON, H. F. JOHNSTON, and J. A. FLEMING).

SEASONAL VARIATION IN THE NUMBER OF LARGE IONS AT WASHINGTON, D. C.

By G. R. WAIT and O. W. TORRESON

Voir la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie.

DIURNAL VARIATION OF EARTH-CURRENT POTENTIALS ON MAGNETICALLY DISTURBED AND MAGNETICALLY CALM DAYS

By W. J. ROONEY

Voir la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie.

NOUVELLES RECHERCHES SUR LA MATIÈRE FULMINANTE

Par E. MATHIAS

Note de la Rédaction: Cet article a paru dans le Supplément au Bulletin No. 6, 1933, de l'Institut et Observatoire de Physique du Globe du Puy-de-Dôme.

Résumé.

Une discussion approfondie des hypothèses qui forment la base de la théorie de l'auteur montre que celle-ci est bien vérifiée par l'observation.

Au chapitre II, il est démontré que la tension superficielle de la matière fulminante est proportionelle au carré du poids moléculaire et en raison inverse du cube de la température absolue, d'où il s'ensuit que la tension superficielle de la matière fulminante est, toutes choses égales, cent fois plus grande que celle de l'air ordinaire à la même température.

Le chapitre III, traitant l'augmentation du volume de la matière fulminante qui se décompose, établit que lorsqu'une foudre sphérique se détruit à pression atmosphérique constante, sa température finale étant identique à sa température initiale, son rayon double.

Au chapitre IV sont mentionnées quelques foudres sphériques de dimensions énormes observées de temps en temps. La réalité de ces foudres est établie.

Le chapitre V expose des phases colorées de l'explosion par refroidissement de la matière fulminante.

En traitant quelques cas d'éclairs globulaires sortis d'un appareil télégraphique ou téléphonique, on a essayé, dans le chapitre VI, de formuler les conditions à remplir pour réaliser la synthèse de l'éclair globulaire.

Au chapitre VII est établi comment la théorie de l'auteur peut rendre compte des phénomènes de la foudre observés en montagne et sur des plateaux élevés et on met en évidence une relation simple entre l'altitude et la couleur de la matière fulminante.

Le dernier chapitre traite des recherches récentes sur l'origine des décharges fulgurantes et sur la polarité des nuages à foudre et leur relation aux deux théories différentes de C. T. R. Wilson et du Dr. Simpson. Il semble que les deux types de polarité des nuages orageux se rencontrent, mais avec des fréquences très dissemblables dans les différentes parties du monde, les observations des Etats-Unis et de l'Afrique du Sud étant en faveur de la théorie de C. T. R. Wilson, celles de l'Europe plutôt en faveur de la théorie du Dr. Simpson.

ÉTUDE SUR LES ORAGES ET LA FOUDRE

Par C. DAUZÈRE

Les manifestations les plus remarquables de l'Electricité atmosphérique sont celles que fournissent les orages. La foudre est la principale: *c'est une décharge électrique, consistant dans un transport d'ions animés d'une grande vitesse, entre deux nuages, ou bien entre un nuage et le sol.* Une décharge d'un autre caractère est le transport d'électricité par les gouttes de pluie, les grêlons et les flocons de neige.

L'origine des charges électriques, transportées par les précipitations atmosphériques et par la foudre, est imparfaitement connue. La théorie de Simpson admet que cette origine est la même, dans les deux cas, et que le sens du transport d'électricité est également le même: la plupart des pluies, des grêles et des neiges, la plupart des éclairs transportent de l'électricité positive des nuages vers le sol.

On sait que Simpson attribue la production de toutes ces charges électriques à la rupture des grosses gouttes de pluie. Je n'insisterai pas sur cette théorie bien connue; cependant, je signalerai le complément que je lui ai apporté, pour expliquer la genèse des grosses gouttes et la formation de la grêle.

J'ai fait intervenir à cet effet: d'une part les charges électriques positives des cristaux de glace des cirrus, qui résultent de la photoélectricité de la glace sèche, excitée par les rayons solaires ultra-violets; d'autre part les charges négatives des gouttelettes en surfusion du cumulo-nimbus, qui se sont formées sur les ions négatifs de l'air agissant comme germes, et qui sont apportées au niveau des cirrus par le violent courant d'air ascendant du nuage orageux. Ce sont les attractions mutuelles, entre ces deux sortes de particules, qui donnent naissance aux grêlons, à haute altitude; ces grêlons sont électrisés positivement ou sont à l'état neutre, ils sont parfois très volumineux à cause de la grandeur relative de la charge positive des cristaux de glace. Les grosses gouttes de pluie sont produites par la fusion des grêlons, elles sont aussi électrisées positivement; leur charge est augmentée par la rupture des gouttes, d'après le mécanisme de Simpson, à la base du nuage où ces gouttes sont retenues par la force du courant d'air ascendant. Lorsque les gouttelettes négatives surfondues sont très nombreuses au sommet du cumulo-nimbus, les grêlons sont très gros et atteignent le sol sans être fondus. Il en est ainsi au-dessus des terrains qui produisent en abondance des ions négatifs; d'où résulte l'influence sur la grêle de la composition et des propriétés des différents terrains.

D'après Simpson, la plupart des éclairs prennent naissance dans la région du nuage orageux où sont retenues les grosses gouttes positives; ces éclairs transportent des ions positifs loin du nuage dans lequel ils prennent naissance; ils font leur chemin en ionisant l'air par choc, et leur passage est favorisé par une ionisation négative préalable de l'air. Les lieux où les ions négatifs sont très abondants doivent donc attirer la foudre.

Pour vérifier les idées précédentes, nous avons recherché, dans les Pyrénées Centrales et la Région voisine, les lieux de prédilection de la foudre et ceux où tombe la grêle. Nous avons mesuré la conductibilité électrique de l'air, dans ces lieux et dans d'autres lieux voisins qui n'ont jamais été foudroyés de mémoire d'homme. Ces études nous ont conduits aux lois suivantes:

1°. — *Les lieux de prédilection de la foudre se confondent avec ceux où l'ionisation de l'air au voisinage du sol est maxima, c'est-à-dire habituellement plus élevée qu'aux alentours. Dans les lieux à ionisation maxima, les ions négatifs sont ordinairement plus nombreux que les ions positifs, contrairement à ce qui se passe partout ailleurs.*

2°. — *La grêle se forme principalement au-dessus des lieux à ionisation maxima;* autrement dit, *les lieux dangereux pour la foudre le sont aussi pour la grêle.* Après s'être ainsi formée, la grêle est le plus souvent emportée par le vent, sur une bande de territoire de faible largeur et de grande longueur (ruban de grêle).

3°. — *La situation topographique des lieux dangereux pour la foudre et pour la grêle dépend essentiellement de la constitution géologique du sol.*

Je me propose de développer quelque peu cette dernière loi. On sait que la majorité des ions, qui se trouvent dans l'air au voisinage du sol, est produite par les rayons α, β, γ, dont l'émission accompagne la désintégration des atomes radio-actifs. Par conséquent, *la présence, dans un lieu, de substances radio-actives, en quantité plus grande qu'ailleurs, doit donner à ce lieu un caractère dangereux.*

Les roches les plus riches en éléments radio-actifs doivent être les plus dangereuses. Ce sont d'abord les minerais d'uranium, de radium, de thorium; l'observation de leur caractère dangereux pour la foudre a été faite récemment à Madagascar et au Katanga. Viennent ensuite les roches ignées, particulièrement les granits et les argiles qui proviennent de leur décomposition; de nombreux accidents mortels dans les pays granitiques, ont démontré tragiquement, dans ces dernières années, le caractère dangereux de ces roches pour la foudre. Les schistes cristallins, les schistes ardoisiers, les grès, ont une teneur moindre en atomes radio-actifs, ils sont par suite moins dangereux en général. Le dernier rang, dans le tableau des roches radio-actives, appartient aux calcaires, qui sont en effet les roches les moins exposées à la foudre, sauf une exception que nous examinerons tout à l'heure.

Le radon et le thoron sont solubles dans l'eau; ils sont donc entrainés par les eaux souterraines qui, pour cette raison, ont fréquemment une radio-activité notable; il en est ainsi principalement pour les eaux minérales et thermales, qui viennent de grandes profondeurs et à un moindre degré pour les eaux de source ordinaires. En outre, les eaux souterraines entrainent mécaniquement des parcelles de matières radioactives insolubles, qui ajoutent leur effet à celui des émanations dissoutes. C'est pourquoi les points d'émergence des sources sont souvent des lieux d'attraction de la foudre.

Les failles, les surfaces de contact de deux terrains offrent aux eaux souterraines une circulation facile; les matières radio-actives solides entrainées, ou celles qui proviennent de la désintégration des émanations dissoutes, se déposent, ou se sont déposées autrefois, le long de ces surfaces. C'est pourquoi, les lignes d'affleurement de ces dernières déterminent une ionisation intense de l'air à leur contact. Il en résulte que: *les lieux les plus exposés à la foudre sont souvent situés sur les lignes de contact de deux terrains différents.*

On sait que les eaux de pluie dissolvent les calcaires et y produisent des fissures; d'autre part les matières radio-actives insolubles sont entrainées par ces eaux et se retrouvent dans les limons qu'elles déposent; ces limons sont donc plus riches en matières radio-actives et par suite plus dangereux que les calcaires restants. Les eaux qui pénètrent à travers les fissures des calcaires se rassemblent dans des cours d'eau souterrains qui creusent des grottes où ils déposent les limons dangereux; ceux-ci donnent à l'air des grottes une ionisation intense. C'est pourquoi les ouvertures de certaines grottes, de certains gouffres, sont souvent foudroyés .

La connaissance des lieux dangereux pour la foudre et pour la grêle aurait une grande importance scientifique et pratique. C'est pourquoi le Ministère Français des Travaux Publics a prescrit récemment, à ses Services, de rechercher ces lieux dans toute la France, et de reporter sur la carte les résultats de cette investigation. Cette opération a été exécutée dans une partie du Sud-Ouest de la France, et les cartes de la grêle et de la foudre pour cette région ont été tracées, du moins à l'état d'ébauche, grâce à une collaboration entre les Services des Ponts-et-Chaussées et moi-même. La généralisation d'une telle opération serait d'une utilité évidente; aussi, nous souhaitons que la carte de la foudre et de la grêle soit établie de la même manière dans toutes les nations.

Les faits que nous venons d'exposer sont susceptibles d'être appliqués utilement à la défense contre la foudre: on doit éviter la construction d'un édifice sur un lieu dangereux, on doit écarter d'un tel lieu le tracé d'une ligne électrique; qand il n'est pas possible d'agir ainsi, on doit protéger soigneusement l'édifice ou la ligne électrique qui se trouve dans un lieu dangereux. Ces considérations ont attiré surtout l'attention des Ingénieurs Electriciens en France, en Italie, en Belgique, et en U.R.S.S.

Les études que je viens de résumer rapidement n'apportent qu'une contribution fort restreinte à la solution du problème de l'orage; celui-ci reste encore enveloppé d'un profond mystère. Parmi les questions à résoudre, les plus importantes me paraissent être les suivantes:

1°. — Formation des charges électriques dans un nuage orageux.

2°. — Naissance et propagation de l'éclair.

3°. — Quel est le sens du courant de l'éclair, autrement dit, quel est le signe de l'électricité transportée vers le sol par la plupart des éclairs?

4°. — Peut-on dire que la foudre tombe? — La foudre ascendante existe-t-elle? — L'éclair ne comprend-il pas généralement deux parties, une descendante, une autre ascendante?

5°. — Diverses sortes d'éclairs.

6°. — Foudre en boule.

7°. — Comment s'expliquent les différents effets de la foudre, en particulier les effets d'explosion souvent constatés?

8°. — Forme et durée de la décharge. — Grandeur de la différence de potentiel maximum et de la quantité d'électricité transportée.

9°. — Propriétés des points d'attraction de la foudre.

10°. — Formation de la grêle; pourquoi certains territoires sont-ils plus souvent grêlés que d'autres?

Ces deux dernières questions sont celles que nous avons traitées; nous les avons rattachées à la question plus générale suivante:

11°. — Relations entre l'ionisation de l'air et les phénomènes orageux (foudre et grêle).

12°. — Cartes de la foudre et de la grêle.

13°. — Protection contre les phénomènes orageux.

Voir aussi la note du Department of Terrestrial Magnetism, Carnegie Institution of Washington, au début de la Ve partie: Comments on the agenda for the Lisbon meeting ..... (Study of storms and lightning, by A. G. McNISH and O. W. TORRESON).

CONTINUOUS RECORDS OF POINT-DISCHARGE

By F. J. W. WHIPPLE

1. *Introduction*

The importance of point-discharge as a factor in the exchange of electricity between the earth and the atmosphere was pointed out*) by C. T. R. Wilson in 1920.

*) Phil. Trans. A. 221 (1920) 74.

Measurements of the discharge from a small tree have been made by B. F. J. Schonland, whilst T. W. Wormell has investigated the discharge from a single point at the top of an isolated pole. Wormell developed two methods; he made continuous records for short periods by charging a condenser and he measured the total flux, day by day, by means of a specially designed microvoltameter.

At Kew Observatory an installation similar to Wormell's has been utilised. After trials with voltameters it was found more satisfactory to obtain continuous records of the deflection of a galvanometer. The needle point from which the discharge takes place is at the top of a pole 10 metres high. By means of insulated cable the needle point is connected to the terminal of the galvanometer, the other terminal of which is earthed. The galvanometer is shunted by a suitable resistance, which makes the instrument 'dead-beat'. Movements of the galvanometer coil, due to currents entering or leaving the needle point, are recorded photographically on a traversing clock drum, rotating once every two hours. Minute and hour marks are added by the intermittent lighting of a small lamp.

2. *A Specimen Record*

As will be seen from the specimen reproduced as Fig. 1, the record consists of a series of twelve lines with short transverse time marks. The record is to be read from bottom to top and from left to right. On this particular record, that for the period from 9.33 on 1933 July 15th to 9.30 the next day, the first discharge began at 18.1. (The critical potential gradient is about 1200 volts per metre). The deviation from a straight line on the record is downwards. This indicates that the potential gradient was negative and the current was upwards — i. e. an outflow of positive electricity. The flow was reversed for a few minutes at 18.48. Subsequently the sign changed several times, but outflow predominated. Discharge ceased about 20.50. There was heavy rain during most of this period of discharge. There was also a slight shower about 22.0 which was accompanied by inflow of electricity, the potential gradient being negative.

Lightning shows as a discontinuity of the trace. There are two conspicuous discontinuities on this record, at 18.26 and at 18.33. In each case the negative potential gradient was interrupted, probably by the discharge of negative electricity from cloud to earth.

The scale of the original record is such that 1 cm represents a current of 4.8 microamperes. The maximum discharge, which occurred at 19.56, was an outflow of 6.0 microamperes. The integrated discharge has been estimated for periods of two hours as in the following table (p. 337).

Fig. 1.

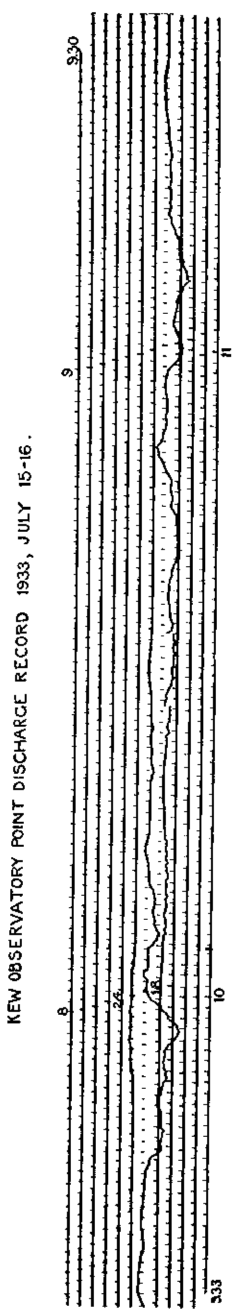


Fig. 2.

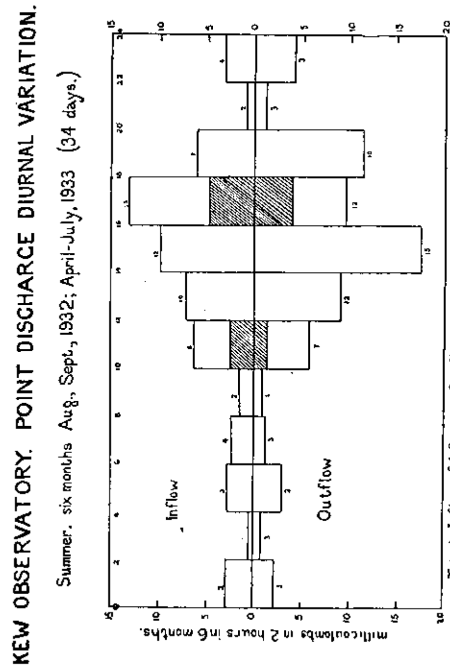
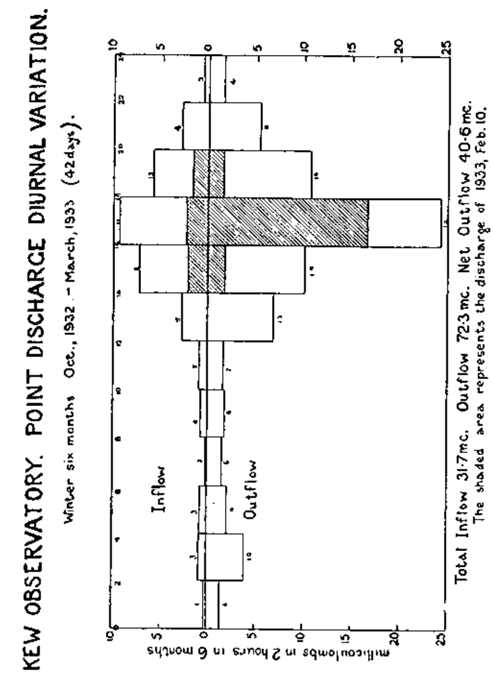


Fig. 3.



Date	*Time G.M.T.*	*Discharge in Millicoulombs* *Inflow*	*Outflow*	*Net Outflow*
1933 July 15th	18.0 to 20.0	.98	7.03	6.95
	20.0 to 22.0	.67	.44	—.23
	22.0 to 24.0	.14	.00	—.14
	Total	1.79	7.47	5.68

The integral is given in millicoulombs. It will be realized that a flow of one microampere for an hour would transfer a charge of 3.6 millicoulombs.

On the date in question the net outflow of electricity was 5.68 millicoulombs.

This quantity is much less than measured in a notable storm on February 10th, in which the maximum discharge current was 16 microamperes. On that occasion*) the net outflow was 13.93 millicoulombs.

3. *Results of the Analysis of Records*

The records from July 1932 onwards have been analysed by Mr. Starr. The inflow and outflow are estimated separately for periods of two hours, 0 to 2, 2 to 4, etc.

The statistics for twelve months, August 1932 to July 1933, are summarized in Table I, the months being grouped as six summer months and six winter months. The inflow and outflow for the two-hour periods are represented in Figures 2 and 3.

It will be seen that in both halves of the year the diurnal variation is well marked, the maximum discharge taking place in the afternoon. The fluctuation between 20 h. in the

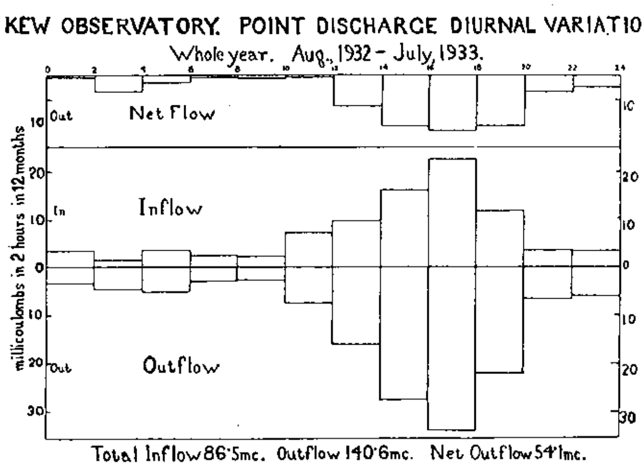


Fig. 4.

*) L. H. Starr, Meteorological Magazine 68 (1933) 35.

TABLE I

Point Discharge. Kew Observatory. August 1932 - July 1933

Totals (for months, seasons and year) derived from measurements of amounts passing in periods of two hours.

Millicoulombs.

	00–02		02–04		04–06		06–08		08–10		10–12		12–14		14–16		16–18		18–20		20–22		22–24		Total	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1932 Oct.		.75	.33	1.07	.58	.67	.05	.53		.26	.03	.18		.90	2.92	4.57	1.14	2.70	.33	.36	2.60	4.99	.26	1.27	8.24	18.25
Nov.													.31	.38			.04		.06	.11					.41	.49
Dec.														.01				.04		.12	.01	.01			.01	.18
1933 Jan.		.24		1.71	.03	.56		.27				.27		.67	.09	.38				1.44					.12	5.54
Feb.	.30	.37	.01	.24		.79	.03	.79	.44	.96	.22	.73		.54	3.09	3.53	5.17	17.18	4.48	7.38	.06	.51	.23	.45	14.03	33.47
Mar.		.03	.46	.96	.14	.11			.32	.57	.69	.57	2.28	4.39	1.12	1.76	3.00	4.50	.88	1.53					8.89	14.42
Winter	.30	1.39	.80	3.98	.75	2.13	.08	1.59	.76	1.79	.94	1.75	2.59	6.89	7.22	10.24	9.35	24.42	5.75	10.94	2.67	5.51	.49	1.72	31.70	72.35
» net		1.09		3.18		1.38		1.51		1.03		.81		4.30		3.02		15.07		5.19		2.84		1.23		40.65
1933 Apr.											.47	1.45	1.18	1.33	.48	1.35	1.10	.58	1.53	1.41	0.3				4.79	6.12
May	2.53	1.04			.98	.99	.89	.08	1.27	1.06		.02	.68	3.43	2.29	5.66	1.50	2.51	1.32	.97			.26	.35	11.72	16.11
June									.03		3.52	2.62	1.29	2.72	3.80	4.24	5.87	5.27	1.04	1.73		.11			15.55	16.69
July		.92		.06			.38	.81			1.72	1.76	2.78	.94	1.86	1.76	4.56	1.34	.98	7.03	.67	.44	1.20	2.27	14.15	17.33
1932 Aug.	.33	.38	.50	.86	1.69	2.05	.89	.49			.41	.04	1.10	.81	1.22	4.17			.17	.11		.85	1.47	1.73	7.78	11.49
Sept.															.03	.30			.83	.30					.86	.60
Summer	2.86	2.34	.50	.92	2.67	3.04	2.16	1.38	1.30	1.06	6.12	5.89	7.03	9.23	9.68	17.48	13.03	9.70	5.87	11.55	.70	1.40	2.93	4.35	54.85	68.34
» net		-.52		.42		.37		-.78		-.24		-.23		2.20		7.80		-3.33		5.68		.70		1.42		13.49
Year	3.16	3.73	1.30	4.90	3.42	5.17	2.24	2.97	2.06	2.85	7.06	7.64	9.62	16.12	16.90	27.72	22.38	34.12	11.62	22.49	3.37	6.91	3.42	6.07	86.55	140.69
» net		.57		3.60		1.75		.73		.79		.58		6.50		10.82		11.74		10.87		3.54		2.65		54.14
Percentage		1.1		6.7		3.2		1.3		1.5		1.1		12.0		20.0		21.7		20.0		6.5		4.9		100

evening and 10 h. in the morning is insignificant. For the whole year the total discharge during the hours from 10 h. to 22 h. is more than five times the total during the remaining twelve hours. At all times of the day the outflow exceeds the inflow, the ratio of the currents being about 5:3. The numbers of occasions of outflow and inflow are shown for each two-hourly period in the diagrams for summer and winter by the numerals. It will be seen that discharge is more frequent in the afternoon as well as greater in amount.

The contributions to the total by the exceptional discharge of February 10th are represented in Figure 3 by shading. This indicates that the maximum in the period 16 h. to 18 h. is largely due to the one storm.

For comparison with Wormell's statistics*) the numbers of days on which the predominating flow, in or out, falls between certain limits have been counted.

TABLE II

Frequency of Days with Discharge between Specified Limits

The greater discharge, inflow or outflow. Millicoulombs.	Kew Observatory August 1932 to July 1933						Cambridge		
	Summer		*Winter*		*Year*		*Year*		
	In	Out	In	Out	In	Out	In		Out
> 20	0	0	0	1	0	1	½	2	0
10 to 20	0	0	0	0	0	0	0	4	0
5 to 10	2	3	0	1	2	4	½	7½	½
4 to 5	1	1	0	2	1	3	} 3½	9	1
3 to 4	2	1	0	3	2	4			
2 to 3	1	4	2	4	3	8	} 7	16	1½
1 to 2	1	7	0	6	1	13			
< 1	7	4	2	21	9	25	5½	13	2
Total	14	20	4	38	18	58	17	51½	5

As will be seen from Table II, the predominance of outflow is more conspicuous in winter than in summer. It is most marked with the small discharges in showery weather in winter. The final result is that there were eighteen days with predominating inflow and fifty-eight with predominating outflow. The agreement with Wormell's figures (the averages for two years), seventeen days with predominating inflow, fifty-one and a half with outflow and five indeterminate, is striking.

*) Royal Soc. Proc. A127 (1930) 575.

TABLE III

The total Discharge for a Year

	Millicoulombs			Ratio
	Inflow	Outflow	Net Outflow	Out/In
Cambridge 1927	142	284	142	2.0
1928	116	237	121	2.0
Kew 1932-33	87	141	54	1.6

In Table III, the total discharge recorded at Cambridge is compared with that at Kew.

The net outflow at Cambridge in each of the years 1927 and 1928 was more than twice that at Kew in the twelve months under review. This may be due in part to meteorological causes but the exposure at Cambridge is much better than that at Kew where the discharge point at 10 metres above ground is only 50 metres from the Observatory building, which is surmounted by a wind vane at a height of 23 metres.

At Kew the ratio of outflow to inflow during the year was 1.6 to 1. According to Wormell's statistics, the ratio is decidedly higher at Cambridge — namely 2.0 to 1. It must be remembered, however, that Wormell worked with a voltameter and depended on measurements under the microscope of the sizes of bubbles of gas. The accuracy claimed for the daily totals in only within $\pm$ 0.5 millicoulombs and systematic errors may have occurred owing, for example, to the solubility of oxygen and hydrogen in water. The Kew value for the ratio in question is, therefore, to be regarded as the more reliable.

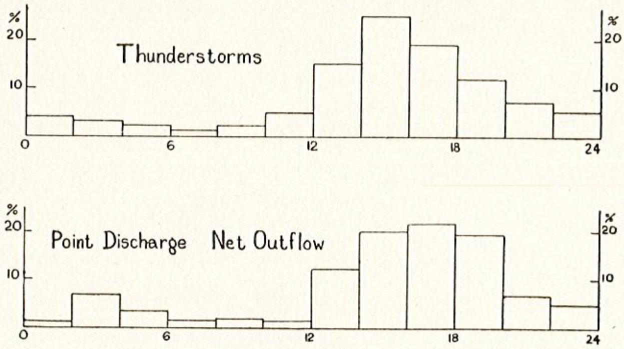
4. *Point Discharge as a Factor in the Circulation of Electricity through the Atmosphere*

In a paper written*) in 1928, I had occasion to consider the diurnal variation in the frequency of thunderstorms. The statistics utilized were based on observations in South India and Central Europe. The means, which were accepted as applying to land stations in all parts of the world between latitude 60° North and 60° South, were as follow.

Local Time	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
Relative frequency of Thunderstorms	4	3	2	1	2	5	15	25	19	12	7	5

*) R. Meteor. Soc. Q. J. 55 (1929) 1.

In the upper part of Figure 5 these numbers are represented by the areas of the rectangles. In the lower diagram in the figure the relative frequency of the net point-discharge at Kew is exhibited in the same way. It will be admitted that the resemblance between the two diagrams is striking.



Comparison of the diurnal variation of thunderstorms (according to statistics) & of net point discharge (according to one year's observations at Kew.)

Fig. 5.

This resemblance strengthens the argument of my 1928 paper, in which I showed that the variations of potential gradient in fair weather over the Oceans, as determined by Mauchly, could be explained on Wilson's hypothesis. According to this hypothesis, electricity discharged from points in places where conditions are disturbed passes through the upper atmosphere, to the Kennelly-Heaviside layer, and returns to the ground as the normal air-earth current.

To place the theory on a firmer basis we require more estimates of the amount of electricity transferred from the ground to the atmosphere, not only by point-discharge but also by precipitation and by lightning. The principal difficulty is to pass from the measurements of discharge from a single point to an estimate of the total discharge over a large area. There is, however, reason to believe that it will be possible to determine the total discharge by discussing the records of the fluctuation of potential gradient.

5. *Acknowledgments*

The experiments which led to the installation in its present form of the apparatus used in this investigation were conducted by Mr. P. A. Sheppard. During the whole of the period of continuous records, Mr. L. H. Starr has been responsible for the apparatus. He has made all the measurements utilized in the foregoing paper and I am much indebted to him for placing the data at my disposal.

SIXIÈME PARTIE

RÉSOLUTIONS, COMMISSIONS ET RAPPORTEURS

A. — RÉSOLUTIONS ET VŒUX

(Séance du Mercredi 20 Septembre 1933)

1) *Atlas des aurores.* — L'Association est d'avis que la Commission des aurores, dont le président est M. Störmer, soit invitée à présenter un projet précis relativement à un deuxième supplément de l'Atlas, et que le Comité exécutif ait qualité pour décider les dépenses à engager éventuellement à ce sujet.

2) *Commissions.* — L'Association décide que les Commissions anciennes seront renouvelées à chaque Assemblée, avec une composition qui pourra être différente de la composition ancienne.

3) *Aurores. Observations d'amateurs.* — Il est décidé que cette question sera examinée par la Commission des aurores.

4) *Catalogues d'aurores.* — L'Association souligne que les Directeurs des Services météorologiques rendraient grand service en s'arrangeant de manière que les Stations climatologiques notent les aurores de manière régulière, et réunissent pour chaque contrée l'ensemble annuel de ces renseignements sous une forme accessible à tous.

5) *Caractérisation numérique.* — Il est décidé que la publication sera continuée sous la forme adoptée, qu'une subvention annuelle de 10.000 francs français sera affectée aux frais de cette publication, et que, si des observations dans des observatoires additionnels sont ajoutées, le Comité exécutif aura qualité pour décider l'engagement de dépense correspondant.

Le Comité exécutif aura qualité pour décider la monnaie dans laquelle sera évaluée la subvention annuelle, si les variations dans les changes rendent cela nécessaire.

6) *Comparaison des magnétomètres à bobines.* — L'Association est d'avis que des comparaisons des étalons nationaux à

bobines doivent être effectuées où et quand il est possible, et que dans certains cas cela puisse être réalisé au moyen de comparaisons indirectes; de plus, que toute contrée désirant une comparaison de ses étalons nationaux avec ceux d'autres contrées ou organisations s'adresse au Secrétaire de notre Association, qui pourrait les mettre en relation avec d'autres organismes ayant le même désir.

7) *Détermination des constantes de Gauss relatives au champ magnétique terrestre.* — a) L'Association est d'avis qu'il est très désirable qu'il soit fait une nouvelle détermination des constantes de Gauss fondée sur les nouvelles données, et tenant compte en particulier des résultats des observations faites pendant l'Année Polaire Internationale 1932—1933. b) De plus, l'Association prierait l'Institution Carnegie de Washington de compléter la publication de l'analyse du Dr. Bauer pour l'époque 1922.

8) *Activité solaire.* —

1°) L'Association exprime sa satisfaction à l'Union astronomique Internationale et aux Observatoires astrophysiques intéressés, pour l'organisation d'observations solaires systématiques dont les résultats ont été rendus accessibles à tous. L'Association est particulièrement heureuse de savoir que le Quarterly Bulletin of the Union, édité par l'Observatoire Fédéral de Zurich, contiendra une publication détaillée des observations spectrohélioscopiques, et elle est convaincue que l'observation continue des phénomènes solaires conduira au progrès de l'étude du mécanisme spécifique produisant certains phénomènes dans les couches les plus élevées de l'atmosphère, spécialement ceux pour lesquels les observations magnétiques terrestres ont déjà démontré l'origine dans des aires plus ou moins persistantes de la surface en rotation du soleil.

2°) L'Association exprime ses remerciements au professeur Hale pour les engagements pris pour assurer les observations spectrohélioscopiques en une série de stations largement distribuées.

9) *Rayons cosmiques.* — L'Association exprime ses remerciements pour les travaux faits jusqu'aujourd'hui sur le rayonnement cosmique, spécialement ceux entrepris par l'Institution Carnegie de Washington avec l'aide de subventions de la Corporation Carnegie.

L'Association est de plus d'avis que toute aide possible soit apportée par les institutions et organismes intéressés afin de réaliser les plans projetés pour l'installation et le maintien d'appareils dans certains observatoires fixes pour l'enregistrement photographique continu du rayonnement cosmique.

10) *Phénomènes de la haute atmosphère.* —

1°) L'Association exprime à l'Union Radio-Scientifique Internationale son appréciation de l'importance des mesures de la hauteur et de l'intensité de l'ionisation dans la haute atmosphère.

2°) L'Association a appris avec beaucoup d'intérêt l'installation par l'Institut Carnegie de Washington d'appareils pour l'enregistrement photographique de ces phénomènes aux observatoires de Watheroo et de Huancayo dans l'hémisphère sud.

11) *Tables crépusculaires.* — L'Assemblée exprime l'intérêt qui s'attache à la publication de Tables crépusculaires entreprise par l'Institut météorologique de Pologne.

12) *Observations relatives à la forme de l'éclair.* — L'Association émet le vœu que les personnes qui font de nouvelles observations ou de nouvelles expériences, ou les professeurs qui, dans leurs recherches propres rencontrent des indications bibliographiques nouvelles ou peu connues sur ce sujet, veuillent bien les communiquer au professeur E. Mathias.

(Séances des 21 et 22 Septembre 1933)

13) *Etablissement de cartes magnétiques du globe en coordonnées magnétiques.* — L'Assemblée émet le vœu qu'il soit établi des cartes en coordonnées magnétiques.

14) *Variation diurne des débuts brusques d'orages magnétiques.* — Le P. Rodés ayant attiré l'attention sur l'intérêt de cette étude, la question est soumise à la Commission des Orages magnétiques à début brusque.

15) *Année Polaire.* —

1°) L'Association décide le maintien de la Sous-Commission de l'Année Polaire. Cette Sous-Commission sera chargée de prendre des décisions relativement à la destination des appareils photographiques et spectroscopiques construits en vue de l'étude des aurores polaires, dans le même mode que la Commission internationale de l'Année Polaire.

2°) L'Association exprime ses remerciements à la fondation Rockefeller pour les subventions qu'elle a accordées en faveur de l'Année Polaire et de l'avancement des études sur le magnétisme terrestre.

3°) L'Association, considérant la grande importance des résultats des observations faites pendant l'Année Polaire, décide de contribuer à leur mise en œuvre et à leur publication. Le

Comité exécutif est chargé de fixer l'aide matérielle qui sera apportée à cet effet par l'Association.

4°) L'Association approuve les résolutions et vœux émis par la Commission internationale de l'Année Polaire dans sa réunion à Copenhague en mai 1933.

16) *Remise au point des magnétographes à marche rapide de l'Année Polaire.* — Vu le fait que, faute de temps, la participation aux travaux de l'Année Polaire n'a pas partout permis d'acquérir une grande expérience relativement au montage et à l'exploitation des appareils enregistreurs magnétiques à marche rapide, et dans le but d'obtenir à l'avenir des enregistrements aussi nets et complets que possible et propres à la reproduction, l'Association recommande de remettre au point les variomètres et les enregistreurs dont le fonctionnement n'est pas tout à fait satisfaisant. A cette fin, l'Association charge son Bureau de faire parvenir à tous les observatoires où fonctionnent des appareils magnétiques à marche rapide du type de l'Année Polaire:

1°) des copies d'enregistrements corrects pour la comparaison,

2°) des indications pour obtenir l'exactitude la plus grande des indications de temps et aussi des résultats certains. L'Association considère comme fort désirables de tels remontages et remise au point des variomètres et des enregistreurs malgré la discontinuation imposée, et, dans le but d'obtenir au moins à quelques observatoires bien répartis l'enregistrement des phénomènes intéressants éventuels, elle charge son Secrétaire de suggérer à chaque observatoire en particulier le mois à choisir pour la réorganisation.

17) *Publication des communications spéciales.* — L'Association autorise le Comité exécutif, si celui-ci le juge désirable de manière urgente, à décider si certaines communications doivent être publiées par l'Association avant que paraissent les prochains Comptes Rendus de l'Assemblée Générale, et à s'arranger à ce sujet avec le périodique «Terrestrial Magnetism and Atmospheric Electricity».

18) *Rédaction et publication des Comptes-Rendus.* — Etant données les conditions économiques et la nécessité de réduire les dépenses comme cela a été exprimé par le Bureau de l'Union, l'Association décide que la publication des Comptes Rendus de l'Assemblée de Lisbonne doit être limitée aux points suivants:

a. Procès-verbaux et résolutions de l'Assemblée.

b. Rapports reçus des Comités Nationaux et des Organismes consacrés aux recherches de magnétisme et d'électricité

terrestres, qui pourront être remaniés et abrégés si cela est nécessaire.
c. Rapports des Commissions et Sous-Commissions spéciales.
d. Communications in extenso choisies par un Comité de rédaction nommé par le Comité exécutif.
e. Résumés des communications présentées qui ne seront pas imprimées in extenso. Les questions relatives aux résumés sont confiées au Comité de rédaction.

19) *Publication et distribution des Comptes-Rendus.* — L'Association décide que le nombre et le mode de distribution des Comptes Rendus de l'Assemblée soient fixés de la manière suivante:

a. Le Secrétaire demandera au Comité National de chaque pays d'indiquer le nombre d'exemplaires qui lui sont nécessaires en vue d'être distribués aux organismes intéressés, aux personnes et aux bibliothèques spéciales dans le Pays. Il fera une demande analogue aux organismes qui correspondent aux Comités Nationaux dans les pays qui n'adhèrent pas à l'Union.
b. Le Secrétaire dressera une liste des Délégués présents à l'Assemblée de Lisbonne.

Le nombre d'exemplaires des Comptes Rendus qui devront être imprimés sera la somme de a. et de b., augmentée de 20 %.

20) *Magnétographe à marche rapide à Reykjavik.* — Vu la proximité de l'Islande près de la zone des aurores et sa situation entre la Scandinavie et le Groenland, l'Association estime fort désirable que les enregistrements magnétiques à marche rapide entrepris à Reykjavik pendant l'Année Polaire par M. le Directeur Thorkelsson, soient continués au moins 3 ans et elle demande au Gouvernement islandais de rendre ceci possible.

21) *Maintien et établissement d'observatoires.* —

a. 1°) L'Association considère que le maintien d'un programme complet concernant les observatoires magnétiques et électriques existant et l'établissement d'observatoires additionnels en des emplacements bien choisis dans le monde entier est de la plus grande importance pour l'étude des phénomènes magnétiques et aussi d'autres phénomènes géophysiques.

2°) L'Association approuve en principe le Rapport de son Comité spécial sur le maintien d'observatoires existants et l'établissement, autant que possible, de nouveaux observatoires en des emplacements recommandés dans le Rapport du Comité.

3°) L'Association charge son Bureau d'intervenir auprès de chaque gouvernement intéressé, en soulignant l'utilité et la nécessité du maintien d'observatoires existants permanents pour l'exécution de recherches scientifiques et théoriques, et l'importance des résultats pour les applications pratiques à la navigation maritime et aérienne et l'amélioration des communications radioélectriques.

4°) De plus, elle recommande que des communications soient adressées aux Gouvernements ou organismes intéressés en soulignant combien il est désirable d'établir d'urgence de nouveaux observatoires dans des régions choisies.

b. L'Association exprime sa satisfaction aux gouvernements qui ont établi de nouveaux observatoires pour l'Année Polaire Internationale, et adopte les résolutions prises à Copenhague par la Commission de l'Année Polaire de l'Organisation Météorologique Internationale en ce qui concerne le maintien de certaines de ces stations, notamment Cape Town, Jan Mayen, Chesterfield Inlet, Mogadiscio, College-Fairbanks, Thule et Magallanes, comme observatoires magnétiques permanents, le maintien des stations magnétiques de Kajaani, Julianehaab et Lycksele pendant au moins une année après la fin de l'Année Polaire.

c. L'Association exprime sa satisfaction au Gouvernement de l'Australie pour la belle série d'observations magnétiques en cours à Toolangi; eller considère comme hautement désirable que le Gouvernement de l'Australie envisage la possibilité d'établir un autre observatoire magnétique aux environs de Port Darwin, où il y a un besoin particulier d'observations géophysiques aux points de vue scientifique et pratique.

d. L'Association exprime sa grande satisfaction au Gouvernement de la Nouvelle Zélande pour avoir permis l'obtention des conditions géophysiques particulièrement intéressantes de son territoire par le maintien des deux observatoires géophysiques d'Amberley et Apia. Elle considère comme de la plus haute importance aux points de vue scientifique aussi bien que pratique le maintien intégral de ces deux observatoires dans leur présent état d'activité.

e. L'Association exprime sa grande satisfaction à M. le Ministre français des Colonies pour l'établissement d'un observatoire géophysique complètement équipé à La Martinique, et considère comme hautement désirable que cet observatoire soit maintenu comme permanent à cause de sa situation unique dans le voisinage d'un volcan actif.

L'Association exprime aussi ses remerciements à M. le Ministre français des Colonies pour la remise en fonctionnement et le maintien de l'observatoire de Tananarive.

En même temps, l'Association se permet d'exprimer l'espoir que le Gouvernement français puisse trouver le moyen d'établir des observatoires magnétiques dans les Colonies françaises en deux points de la plus grande importance pour la poursuite de problèmes géophysiques du plus grand intérêt scientifique et pratique, Dakar et Tahiti.

f. L'Association exprime sa grande satisfaction au Gouvernement du Brésil pour l'établissement d'un observatoire magnétique à Belem, et considère comme hautement désirable que cette station soit maintenue comme permanente, à cause de sa situation dans le voisinage immédiat de l'Equateur, dans une région où la connaissance des conditions géophysiques est particulièrement utile aux points de vue scientifique et pratique.

g. L'Association se félicite d'apprendre qu'il est projeté de maintenir et d'étendre les travaux d'observatoire au Japon. Elle regarde comme hautement désirable qu'un observatoire permanent soit établi à Toyohara, à cause de sa situation dans une région où la connaissance des conditions géophysiques est particulièrement utile aux points de vue scientifique et pratique.

h. L'Association exprime sa satisfaction au Gouvernement Belge pour l'établissement d'un observatoire magnétique à Elizabethville (Rutshuru), et considère comme hautement désirable que cette station soit maintenue comme observatoire permanent parce que les résultats qui y sont obtenus constituent la seule information disponible en ce qui concerne les conditions magnétiques de l'Afrique Centrale, et ont de ce fait une importance particulière aux points de vue scientifique et pratique.

i. L'Association exprime sa grande satisfaction à l'Université de Capetown pour la remise en fonctionnement des observations magnétiques et électriques à Capetown, dans une région qui a été reconnue comme d'un intérêt géophysique particulier, depuis le temps où elle a été choisie comme siège d'un des plus anciens observatoires magnétiques du monde. L'Association considère qu'il est de la plus haute importance que cet observatoire soit maintenu comme permanent, parce que ses résultats donnent les conditions géophysiques dans une partie du Globe où le défaut d'information a beaucoup nui au progrès de la Géophysique scientifique et pratique depuis que la première série d'observations a été arrêtée.

j. L'Association exprime sa grande satisfaction au Gouvernement Général de l'Algérie pour l'établissement d'un observatoire magnétique et électrique à Tamanrasset (Hoggar) et considère comme hautement désirable que cette station soit maintenue comme observatoire permanent, parce que sa situation a été excellemment choisie dans une région qui constituait une grande lacune dans le réseau des observatoires existants.

k. L'Association exprime sa grande satisfaction au Gouvernement Argentin pour la bonne continuation et le maintien des observations magnétiques à La Quiaca, Pilar et aux Orcades du Sud, et considère qu'il est de la plus haute importance pour le progrès de la Géophysique théorique et pratique que tous ces observatoires soient maintenus avec un plein fonctionnement de leur programme actuel.

l. L'Association soumettrait à la considération du Gouvernement de l'Est Africain Britannique la nécessité d'établir un observatoire magnétique et géophysique dans un emplacement convenable de son territoire. Ce territoire est une région pour laquelle on manque sérieusement d'informations sur les conditions géophysiques, et l'établissement d'un observatoire géophysique aiderait beaucoup au progrès de ces sciences et de leurs applications aux buts pratiques.

m. L'Association désire attirer l'attention du Secrétaire d'Etat pour les Colonies, à Londres, sur le besoin urgent d'établir un observatoire magnétique sur l'île de Sainte Hélène. Aux premiers temps de la science du magnétisme terrestre, les observations faites dans cette station se sont montrées de la plus haute importance et ont servi comme base de conclusions importantes. Aujourd'hui existe un grand besoin d'informations relatives aux conditions magnétiques et électriques terrestres dans les régions tropicales, et la situation de Sainte Hélène est admirable à cet effet.

n. L'Association est fortement d'avis qu'il y a un besoin urgent d'établir un observatoire magnétique aux Indes, au Cap Comorin où dans son voisinage, et voudra exprimer l'espoir que le Gouvernement de Travancore sera conduit à la possibilité de réaliser ce projet. L'observatoire magnétique qui était maintenu à Trivandrum par les soins du regretté M. J. A. Broun a fait beaucoup d'excellent travail en établissant les conditions fondamentales relatives à la science magnétique terrestre; sa situation spéciale a toujours été considérée comme importante par suite de sa situation non loin de l'équateur magnétique. L'Association est d'avis que la remise en fonctionnement de l'observatoire dans le voisinage du Cap Comorin donnerait de nouveau des résultats de grande importance pour la science.

o. L'Association est fortement d'avis que l'établissement d'un observatoire magnétique dans le Sud de l'Italie est de grande importance pour l'avancement de la science du magnétisme terrestre et pour la réunion des données relatives à la région méditerranéenne. Etant donné que l'Europe Centrale est déjà munie d'un large réseau d'observatoires, l'Association suggérerait l'établissement d'un tel observatoire aussi loin que possible vers le Sud dans la péninsule italienne plutôt que dans le Nord de l'Italie. L'Association attire respectueusement l'attention du Gouvernement Italien sur cette question.

p. L'Association apprend avec grand intérêt l'accroissement de l'activité des études géophysiques en Chine sous les auspices du Conseil National de Recherches. L'Association suggérerait que des observations de valeur seraint obtenues par l'établissement d'un observatoire magnétique dans le Nord-Ouest de la Chine, région pour laquelle on manque actuellement presque totalement d'informations sur les conditions magnétiques et géophysiques.

q. L'Association se permet de représenter au Gouvernement de Finlande qu'il est désirable d'établir un observatoire magnétique aux environs d'Helsinki, équipé avec des appareils enregistreurs à marche rapide, et qu'il y a lieu de le maintenir en fonctionnement continu pendant au moins quelques années.

r. L'Association regarde comme de grande importance que, à mesure que l'opportunité s'en présente, des données relatives au magnétisme et à l'électricité terrestre se rapportant à des périodes d'au moins un an soient obtenues aux Stations polaires de haute latitude, particulièrement au Spitzberg et à Little America.

s. L'Association est d'avis qu'il est désirable qu'un observatoire magnétique et électrique complètement équipé soit établi dans le voisinage de Stamboul, et attire l'attention du Gouvernement Turc sur l'importance scientifique et pratique d'une telle station.

22) *Variation séculaire.* —

a. L'Association, considérant la nécessité du point de vue théorique et pratique, d'observations plus systématiques pour déterminer la variation séculaire magnétique, regarde au moins comme un programme minimum d'un tel travail ce qui est recommandé dans le Rapport du Comité Spécial de la Variation Séculaire de l'Association, et exprime l'espoir que les Gouvernements de tous les pays qui font ou ont fait des Réseaux magnétiques comprenant des stations où les mesures sont répétées, de manière à permettre de manière adéquate la détermination de la variation séculaire, veuillent bien maintenir et si possible étendre ces réseaux, non seulement dans leurs propres limites géographiques, mais aussi dans leurs colonies et pays sous mandat, et que les Gouvernements qui n'ont pas encore de tels réseaux veuillent bien en entreprendre.

b. La perte du «Carnegie» ayant eu comme conséquence l'interruption des mesures mondiales sur mer et dans certaines îles isolées, et de ce fait la plus grande partie des océans n'ayant pas de stations à mesures répétées, l'Association considère comme très désirable que des fonds soient trouvés pour la construction et le maintien d'un autre navire analogue au «Carnegie», avec des facilités non seulement pour les mesures magnétiques et électriques, mais aussi pour d'autres observations géophysiques, spécialement pour l'océanographie et la météorologie, telles qu'il en a été exécuté dans les dernières croisières du «Carnegie».

c. Etant donné qu'il y a aussi beaucoup d'îles isolées ou rarement visitées où des observations magnétiques répétées ont été faites ou pour lesquelles de telles observations sont désirables, l'Association prie instamment les organisations gouvernementales ou privées, y compris les personnes, entrepenant des expéditions dans de telles îles, d'étendre les facilités pour le transport des observateurs magnétiques et des appareils, afin d'obtenir des observations relatives à la variation séculaire magnétique.

23) *Remerciements.* — L'Association exprime sa gratitude au Comité National Portugais et à ses collaborateurs des dispositions excellentes prises, qui ont tellement facilité et favorisé le travail de l'Association pendant l'Assemblée de Lisbonne.

B. — COMPOSITION DU COMITÉ EXÉCUTIF

Président: M. Jno. A. FLEMING, 5241, Broad Branch Road, N. W., Washington, D. C., Etats-Unis;

Vice-Présidents: M. V. CARLHEIM-GYLLENSKÖLD, 22, Sibyllegatan, Stockholm, Suède;

M. CH. MAURAIN, 191, Rue Saint-Jacques, Paris, 5^e, France;

Secrétaire et Directeur du Bureau Central: M. D. LA COUR, Toldbodvej 15, Copenhague, K, Danemark;

Membres:

MM J. AGOSTINHO,
S. CHAPMAN,
A. CRICHTON MITCHELL,
C. STÖRMER,
A. TANAKADATE.

C. — CONSTITUTION DE COMMISSIONS

1° Dans la séance du 18 a été constituée une Commission chargée de rédiger un projet de Statuts pour l'Association. Elle comprend:

MM FLEMING, *Président,*
MAURAIN,
CRICHTON MITCHELL.

2° Dans la séance du 18 une Commission de quatre membres a été formée pour l'étude des orages magnétiques à début brusque; ont été désignés:

MM TANAKADATE, *Président,*
CHAPMAN,
LA COUR,
RODÉS.

3° La Commission des aurores polaires a été renouvelée avec les membres suivants:

MM STÖRMER, *Président,*
CARLHEIM-GYLLENSKÖLD,
LA COUR,
HECK,
MELANDER,
STAGG.

4° La Commission chargée de l'étude de la caractérisation numérique des jours au point de vue magnétique a été renouvelée avec la composition suivante:

MM CRICHTON MITCHELL, *Président,*
CHAPMAN,
VAN DIJK,
VAN EVERDINGEN,
MAURAIN,
TANAKADATE.

5° Dans la séance du 20, une Commission a été nommée pour l'étude des relations entre l'activité solaire et le magnétisme terrestre. Elle comprend:

MM FLEMING, *Président,*
BARTELS,
CHAPMAN,
MAURAIN.

6° La Sous-commission de l'Année Polaire a été maintenue sans changement:

MM STÖRMER, *Président,*
CHAPMAN,
LA COUR,
MAURAIN,
WEHRLÉ.

7° La Commission chargée du choix des emplacements de nouveaux observatoires pour le magnétisme et l'électricité terrestres a été renouvelée, avec les mêmes membres:

MM FLEMING, *Président,*
CHAPMAN,
LA COUR,
MAURAIN,
RODÉS.

8° De même, la Sous-commission s'occupant de la répartition des travaux d'observatoires en Europe, composée de:

MM LA COUR, *Président,*
CHAPMAN,
MAURAIN.

9° La Commission chargée d'étudier les dispositions à prendre pour assurer les observations en vue de l'étude de la variation séculaire a été renouvelée et comprend:

MM HECK, *Président,*
CARLHEIM-GYLLENSKÖLD,
CHAPMAN,
LA COUR,
FLEMING,
JOLLY,
KALINOWSKI,
MATHIAS,
MAURAIN.

10° Dans la séance du 22, une Commission a été constituée en vue de l'étude de la caractérisation électrique des jours; en font partie:

MM GISH, *Président,*
RODÉS,
SALLES,
TORRESON,
WHIPPLE.

NOTA. Pendant le Congrès avaient été constituées: une *Commission des Vœux et Résolutions,* comprenant MM Fleming, Crichton Mitchell et Maurain, et une *Commission des Finances,* comprenant MM van Dijk, Harradon et Keränen.

D'autre part avaient été désignés: comme Représentant de l'Association à la Commission chargée d'étudier la question des votes par pays et des cotisations, M. Fleming; comme membre de la Commission mixte s'occupant de la constitution du Globe terrestre, M. Chapman.

D. — DÉSIGNATION DE RAPPORTEURS

1° M. Chapman est maintenu comme Rapporteur sur le projet de collaboration internationale pour avancer l'étude des effets de la Lune sur les phénomènes géophysiques.

2° M. Wait est maintenu comme Rapporteur sur les Compteurs d'ions.

Remarque. Toutes les nominations de Commissions et de Rapporteurs sont faites pour trois ans.

PUBLICATIONS

de

L'ASSOCIATION INTERNATIONALE DE MAGNÉTISME ET ÉLECTRICITÉ TERRESTRES

Bulletins

N° 1. Organization, Minutes, and Proceedings of the Brussels Meeting, 1919. £ 0.1.0.

N° 2. General Report of the Rome Meeting, 1922. £ 0.1.0.

N° 3. Transactions of the Rome Meeting, 1922. £ 0.14.0.

N° 4. General Report of the Madrid Meeting, 1924. £ 0.1.0.

N° 5. Transactions of the Madrid Meeting, 1924. £ 0.14.0.

N° 6. Preliminary Reports on Subjects of Investigation. 1926. £ 0.2.0.

N° 7. Comptes Rendus de l'Assemblée de Prague, 1927. £ 0.18.0.

N° 8. Comptes Rendus de l'Assemblée de Stockholm, 1930. £ 1.6.0.

N° 9. Comptes Rendus de l'Assemblée de Lisbonne, 1933. £ 1.0.0.

Photographic Atlas of Auroral Forms and Scheme for Visual Observations. 1930. £ 1.1.0.

Procès-Verbaux de l'Assemblée de Stockholm, 1930. £ 0.0.6.

Supplements to the Photographic Atlas of Auroral Forms, I. 1932. £ 0.16.0.

Caractère Magnétique Numérique des Jours (depuis 1er janvier 1930). Tomes I—IX. £ 0.15.0.

Rapport Préliminaire de l'Assemblée de Lisbonne, 1933. £ 0.1.0.