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M.O. No. 195.

REPORT

OF THE

INTERNATIONAL METEOROLOGICAL CONFERENCE AT INNSBRUCK,

SEPTEMBER, 1905.

Published by Authority of the Meteorological Committee.



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LIST OF MEMOIRS AND OTHER OCCASIONAL
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Harmonic Analysis of Hourly Observations of Air Temperature
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London Fog Inquiry. 1901-1903. (No. 160, 1904.) Report of
the Council, with Report by R. G. K. Lempfert, M.A. 1904.
2s. 6d. Report by Captain Alfred Carpenter, R.N., D.S.O.
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The Beaufort Scale of Wind-Force. Report of the Director of
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G. C. Simpson, M.Sc., and Notes by Sir G. H. Darwin, K.C.B.,
F.R.S., W. H. Dines, F.R.S., and Commander Campbell
Hepworth, C.B., R.N.R., Marine Superintendent. (No. 180,
1906.) 1s. 6d.

Barometric Gradient and Wind-Force. Report to the Director
of the Meteorological Office, by E. Gold, M.A., Fellow of St.
John's College, Cambridge, Superintendent of Instruments.
(No. 190, 1908.) Price 2s. 6d.

Life-History of Surface Air Currents. A Study of the Surface
Trajectories of Moving Air. By W. N. Shaw, ScD., F.R.S.,
Director of the Meteorological Office, and R. G. K. Lempfert,
M.A. (No. 174, 1906.) 7s. 6d.

Barometer Manual for the Use of Seamen. With an Appendix
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Edition, extensively revised, 1905. (No. 61.) 3d.

The Observers' Handbook. (No. 191, 1908.) A New Edition of
Dr. Scott's Instructions in the Use of Meteorological Instru-
ments. 3s.

Hints to Meteorological Observers in Tropical Africa, with
Instructions for taking Observations and Notes on Methods
of Recording Lake Levels. Second Edition, revised 1907.
(No. 162.) 9d.

FOREIGN AND COLONIAL STATIONS:--

Contribution to the Meteorology of Japan. By Staff-Commander
Thomas H. Tizard, H.M.S. "Challenger." (No. 28, 1876.)
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Meteorological Observations at the Foreign and Colonial Stations
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1852-1886. (No. 83, 1890.) 23s.

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Report on the Meteorology of Kerguelen Island. By Rev. S. J.
Perry, S.J., F.R.S. (No. 37, 1879.) 3s.

Climatological Observations at Colonial and Foreign Stations.
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E. G. Ravenstein, F.R.G.S. (No. 165, 1904.) Price 6s.

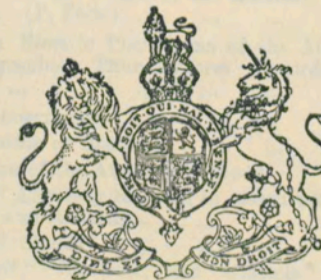
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W. N. SHAW.

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July 27, 1908.

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REPORT

OF THE

INTERNATIONAL METEOROLOGICAL CONFERENCE AT INNSBRUCK,

September, 1905.

INTRODUCTION.

On February 6th, 1905, the President of the International Meteorological Committee officially notified all Directors of meteorological institutions that an International Conference of representatives of meteorological Systems and Institutions would be opened at Innsbruck on September 9th, 1905, in the "Aula" of the University. The first part of a provisional programme of subjects for discussion was issued simultaneously, and this was followed in due course by the second and third parts. A complete list of the subjects discussed at the meeting is given herewith under the title "Provisional Programme."

PROVISIONAL PROGRAMME OF SUBJECTS FOR DISCUSSION.

1. Request by M. Violle that the proposals made by him in a communication [regarding solar radiation] to the International Meteorological Committee at their meeting in Southport in 1903, be considered. (Appendix I.) Radiation.
2. In the interest of hydrographic work the Conference is requested to give its attention to the causes of heavy and widespread precipitation, and to the possibility of forecasting such occurrences and particularly to the question of their periodicity. In the event of the request being acceded to, the Royal and Imperial Hydrographic Office (of the Austro-Hungarian Empire) is prepared to submit a report on the subject. (Appendix II.) Heavy and Widespread Precipitation.
E. LAUDA.
3. The origin of changes of temperature in cyclones. Reduction to Sea Level
REV. MARC DECHEVRENS.
4. Discussion of a uniform method of procedure in the reduction of barometer readings to mean sea level. (Appendix III.) Extremes of Temperature in Daily Reports.
BILLWILLER; HERZ.
5. The introduction of uniformity in the manner of publication of extremes of temperature in daily weather reports. (Appendix III.) HERZ.

Squalls, &c.

6. In connexion with the study of unusual atmospheric disturbances (hail, thunderstorms, &c.), observers should be exhorted not merely to take the readings of their various instruments as nearly simultaneously as possible but also to note the time of occurrence (to within a few seconds) of such phenomena.
E. DURAND-GRÉVILLE.

Squalls, &c.

7. Cannot arrangements be made for stations situated to the westward of their respective central offices to notify the central office by telegraph of the occurrence of heavy hail squalls in which the wind attains a velocity of 20 metres per second so that warning of approaching danger may be sent to stations situated further to the eastward?
E. DURAND-GRÉVILLE.

Isobars for
Millimetre
Intervals.

8. That the Conference advise that isobars be drawn for intervals of one millimetre in the daily weather charts of all countries.
E. DURAND-GRÉVILLE.

Aurora.

9. That observers in arctic regions be requested to specify accurately the azimuth of the summit of arc of aurora, and also its altitude above the horizon and the magnetic declination of the place of observation.
E. DURAND-GRÉVILLE.

Wireless
Messages.

10. The "Daily Telegraph" now publishes reports of the approach of disturbances from the Atlantic Ocean received by wireless telegraphy. Cannot a regular service of this nature be organised with a view to extending the area covered by daily weather charts at least 300 to 400 Kms to the westward of the coast of Europe. (Appendix IV.)
P. POLIS.

Autographic
Thunder-
storm
Recorder.

11. Systematic investigation of the phenomena of atmospheric electricity, by means of autographic thunderstorm recorders. (Appendix V.)
REV. JULIUS FÉNYI.

Classification
of Stations.

12. That the classification of meteorological stations be as follows:—

(a) *Observatories.* Stations at which, in addition to observations at fixed hours, the elements atmospheric pressure, temperature, humidity, wind direction, wind velocity or force, rainfall and duration of bright sunshine, are recorded autographically.

(b) *Stations of the First Order.* Stations at which two at least of the elements mentioned above are recorded autographically, and the remaining elements are observed either instrumentally or by estimation at fixed hours.

(c) *Stations of the Second Order* need not be provided with autographic instruments, but the pressure and temperature of the air must be observed at least three times each day at approved and fixed hours. Approved forms of mercury barometer and of thermometer screen are essential. At these stations observations must be made at the fixed hours of the humidity of the air (by psychrometer or hair hygrometer), the direction and force of the wind, and the amount of cloud (by estimation). The precipitation must be measured at the hour of morning observation.

(d) *Stations of the Third Order* are stations at which all observations enumerated under (c) with the exception of that of atmospheric pressure are made regularly at at least three approved hours each day.

(e) *Stations of the Fourth Order* differ from stations of the third order only in not being provided with instruments for determining the humidity of the air.

Stations at which thermometers are not used, and the only instrumental observation is that of rainfall are to be called *Rainfall stations.* (Appendix VI.)
J. M. PERNTER.

13. When estimating the amount of cloud, the density of the cloud should be taken into consideration. Delicate cirri should not be entered in the registers in the same manner as, for example, heavy strato-cumuli, &c. (Appendix VI.)
J. M. PERNTER.

Amount of
Cloud.

14. Rainfall amounts should be measured and recorded to the nearest tenth of a millimetre. Temperature should be read and recorded to the nearest tenth of a degree centigrade. (Appendix VI.)
J. M. PERNTER.

Degree of
Accuracy of
Temperature
and Rainfall
Measure-
ments.

15. The definitions of nimbus and strato-cumulus cloud stand in need of modification. (Appendix VI.)
J. M. PERNTER.

Cloud Forms.

16. Simple and generally intelligible definitions are required for the phenomena known by the names of rime (silver thaw) (*German* Rauhref, Duft, Rauhfrost, Anreim) and glazed frost (*German* Glatteis.) (Appendix VI.)
J. M. PERNTER AND V. CHIPTCHINSKY.

Rime, Glazed
Frost.

17. Observers are recommended to keep a "weather diary" in which the sequence of weather for each day may be briefly described in words. This register should supplement the records of instrumental observations. (Appendix VII.)
J. M. PERNTER.

Weather
Diary.

18. Observers are strongly recommended to devote special attention to optical atmospheric phenomena. Suitable instructions bearing on this branch of meteorology should be issued by the Central Offices.
J. M. PERNTER.

Optical
Atmospheric
Phenomena.

19. The symbol ☁: should be added to the list of international meteorological symbols to indicate a fog from which moisture is deposited on exposed surfaces. (Appendix VI.)
J. M. PERNTER.

Wet fog.

20. The assembled Directors should arrange to include data regarding the motion of clouds in the daily meteorological telegrams.
Dr. KARL SCHMID.

Cloud Data
in Telegrams.

21. Can the Conference adopt a resolution requesting that the direction of motion of clouds be given in the daily weather reports of all countries?
Rev. L. GANGÓITI (Havana).

22. If the publication day by day of the direction of motion of the upper, intermediate, and lower cloud layers is impracticable, the direction of motion of the lower clouds only should be stated.
Rev. L. GANGÓITI.

Conferences
of Cloud
Observers.

23. Is it practicable and desirable for all the observers of each country to meet at a selected observatory in that country for the purpose of an interchange of views regarding the forms of cloud, so as to avoid confusion in the classification of clouds?

Rev. L. GANGÓITI.

Motion of
Cyclones and
Anti-
cyclones.

24. It is a well-known fact that depressions and anti-cyclones usually move from west to east in our latitudes. The velocity and direction of progression present many unsolved problems, and should be made the subject of special study. (Appendix IX.)

Rev. ANGELO RODRIGUEZ.

Stations
for secular
investi-
gations.

25. Strictly homogeneous series of observations, extending over long periods, are essential for the study of secular changes, and at present very few such series are in existence. It is highly desirable that observations be continued with as little change of method as possible at a number of stations in each system, the number to depend on the size of the system. (Appendix X.)

G. HELLMANN.

Comparison
of Baro-
meters.

26. Further consideration of the question of the comparison of standard barometers. (Appendix X.)

G. HELLMANN.

Tabulation of
Electro-
grams.

27. A general scheme is required for the tabulation and publication of results of autographic electrical instruments (Benndorf's recorder, &c.) to obtain comparable data regarding the electrical state of the atmosphere at different places and under different meteorological conditions. (Appendix XI.)

W. KESSLITZ.

Height of
Clouds.

28. When estimating the height of clouds (or of dust particles) illuminated by the sun below the horizon, account should be taken of the circumstance which causes them to be in shadow during the quarter-of-an-hour which precedes astronomical sunrise or succeeds astronomical sunset.

E. DURAND-GRÉVILLE.

Sudden
Changes of
Pressure.

29. Cannot observers who possess barographs of sufficiently large size be requested to report all sudden fluctuations of pressure which exceed a limiting value of magnitude to be agreed upon either in amplitude or duration? (Appendix XII.)

Rev. LOUIS FROC.

Autographic
Records.

30. Can the Conference recommend a scheme for increasing the utility of records taken with autographic instruments of Richard type, seeing that such instruments are now being used very widely? (Appendix XIII.)

A. WOSNESSENSKY.

Small
Disturbances.

31. Detailed investigations of rapidly moving disturbances by comparisons of autographic records from neighbouring stations are desirable. (Appendix XIV.)

E. ROSENTHAL.

Meteoro-
logical
Summary of
19th Century.

32. Would it not be useful to prepare for publication a short summary of the principal results of the meteorological observations of the last century?

E. ROSENTHAL.

Organisation.

33.—(a) Close co-operation between the various Commissions appointed at meetings of Directors and also with the Commissions appointed by the International Association of Academies (Magnetic Commission and the Commission on Atmospheric Electricity) and

with the Carnegie Institute should be aimed at; (b) at all conferences of Directors, and also at meetings of the International Meteorological Committee, stress should be laid on the official character of the gathering. The number of meetings should be kept as small as possible.

W. VON BEZOLD.


34. Would it not be of advantage to marine meteorology (storm-warning services) to recommend to all institutions engaged in this branch of work, an improved system of signals for communicating to ships the information which they at present send to ports and semaphore stations? (Appendix XVI.)

Rev. LOUIS FROC.

35. Suggestion to add to the international weather symbols, used in meteorological publications, a symbol to indicate Zodiacal light.

International
System of
Storm
Signals.

Zodiacal
Light.

The symbol  is suggested. (Appendix XVII.)

Rev. LOUIS FROC.

36. Nimbus cloud should be defined independently of whether rain is falling or not. When rain is falling, the kind of cloud observed should always be stated. (Appendix XVIII.)

Definition of
Nimbus.

NESDÜROFF.

37. The terms "backing" and "veering" used to describe changes of wind direction require more precise definition. (Appendix XIX.)

"Backing"
and
"Veering."

T. F. CLAXTON.

38. The Conference is invited to discuss and to make recommendations on the various changes proposed to be made in the new edition of the International Cloud Atlas.

Cloud Atlas.

The EDITING SUB-COMMITTEE.

39. The International Meteorological Committee, at their meeting in Southport in 1903, requested Messrs. Hellmann and Hildebrandsson to prepare for official publication an international meteorological codex to contain all final resolutions of the various Meteorological Committees and Conferences which have met since 1872, with comments and explanatory notes thereon. The manuscript of this codex is submitted for approval.

International
Meteoro-
logical Codex.

G. HELLMANN, H. H. HILDEBRANDSSON.

The following Commissions, appointed by the International Meteorological Committee, met at Innsbruck during the Conference:—

Commissions.

- (1) The Commission on Terrestrial Magnetism and Atmospheric Electricity.
- (2) The Commission on the connexion between Solar and and Terrestrial Phenomena (Solar Commission).
- (3) The Cloud Commission.

The following attended the Conference:—

The Reverend J. Algué, S.J., *Manila*.
R. Assmann, *Lindenberg near Beeskow*.
W. v. Bezold, *Berlin*.
B. Brunhes, *Puy de Dôme*.
V. Carlheim-Gyllensköld, *Stockholm*.
E. Durand-Gréville, *Mentone*.
Sir John Eliot, *London*.

F. Erk, *Munich*.
 E. van Everdingen, *de Bilt*.
 G. Fineman, *Stockholm*.
 The Reverend L. Froc, S.J., *Zi-ka-wei*.
 G. Greim, *Darmstadt*.
 J. Hann, *Vienna*.
 G. E. Hale, *Lick Observatory*.
 G. Hellmann, *Berlin*.
 E. Hepites, *Bukharest*.
 H. Hergesell, *Strassburg*.
 H. H. Hildebrandsson, *Upsala*.
 W. Kesslitz, *Pola*.
 N. von Konkoly, *Budapest*.
 W. Köppen, *Hamburg*.
 E. Lauda, *Vienna*.
 J. Liznar, *Vienna*.
 Sir Norman Lockyer, *London*.
 W. J. S. Lockyer, *London*.
 J. H. Lyons, *Cairo*.
 E. Mazelle, *Trieste*.
 J. B. Messerschmitt, *Munich*.
 H. Mohn, *Christiania*.
 A. Mohorovičić, *Agram*.
 M. Nedelkovitch, *Belgrade*.
 A. Paulsen, *Copenhagen*.
 J. M. Pernter, *Vienna*.
 F. C. A. Pockels, *Heidelberg*.
 P. Polis, *Aix-la-Chapelle*.
 G. B. Rizzo, *Messina*.
 A. L. Rotch, *Boston*.
 M. P. v. Rudzki, *Cracow*.
 M. Rykatcheff, *St. Petersburg*.
 A. Schmidt, *Potsdam*.
 A. Schmidt, *Stuttgart*.
 Ch. Schultheiss, *Carlsruhe*.
 W. N. Shaw, *London*.
 A. Silvado, *Rio de Janeiro*.
 B. Sresneffsky, *Dorpat*.
 R. F. Stupart, *Toronto*.
 L. Teisserenc de Bort, *Trappes*.
 W. Trabert, *Innsbruck*.

The following were present as guests :—

A. Angot, *Paris*.
 F. Åkerblom, *Upsala*.
 A. Belar, *Laibach*.
 V. Conrad, *Vienna*.
 A. Defant, *Innsbruck*.
 H. v. Ficker, *Innsbruck*.
 W. Láska, *Lemberg*.
 J. Valentin, *Vienna*.

MINUTES

OF THE

METEOROLOGICAL CONFERENCE

AT

INNSBRUCK.

First General Meeting, Saturday, September 9th, 1905.

The meeting commenced at 3.30 p.m. M. H. H. Hildebrandsson, Secretary of the International Committee, read a list of names of those who had been invited to attend the Conference, and presented the following report on the work of the Committee on behalf of M. Mascart, the President of the Committee, and himself :—

REPORT OF THE COMMITTEE.

The International Meteorological Committee at its last meeting, held in Southport in September, 1903, adopted a motion by M. Pernter that a general meeting of Directors be summoned to Innsbruck during the second week of September, 1905. This meeting should be similar in character to those held in Munich in 1891 and Paris in 1896.

Gentlemen,—You have accepted the invitation of the Committee which was issued at the commencement of 1904 and repeated in more definite form on February 9th, 1905. We desire to thank you for your attendance and hope that our meeting will lead to results which will have a beneficial influence on the development of science.

Since the Conference in Paris in 1896 we have lost through death Messrs. J. C. de Brito Capello, Tacchini, and Billwiller, all of them members of the Committee; among other colleagues whose deaths we deplore we name Mr. G. J. Symons, the Director of the British Rainfall Organisation.

The Committee have had to co-opt several new members to fill vacancies which occurred from various causes.

At the meeting of the Committee in Paris on September 15th, 1900, Messrs. Palazzo and Shaw were elected members of the Committee to fill the vacancies caused by the retirement of Messrs. Tacchini and Scott. M. Hildebrandsson was appointed Secretary of the Committee in place of Mr. Scott, who had held that office since the constitution of the Committee. His work in that capacity has been greatly appreciated.

Obituary

New
Members of
Committee.

M. de Brito Capello was replaced on November 9th, 1901, by M. Chaves, the Director of the Meteorological Service of the Azores.

Early in 1903 M. von Bezold resigned his position on the Committee through reasons of ill-health. At his request the Committee elected M. Hellmann, Vice-Director of the Prussian Meteorological Institute, to take his place. The election was made by correspondence and notified by circular on April 9th, 1903. At the meeting of the Committee in Southport on September 15th, 1903, M. Snellen announced his intention of withdrawing from the Committee as he was no longer Director of the Meteorological Service of his country. In his place the Committee elected M. Lancaster, the Director of the Meteorological Service of Belgium.

Finally Sir John Eliot sent in his resignation stating that he was no longer at the head of the Meteorological Service of the Government of India. In compliance with a request of the India Office brought forward by Mr. Shaw, the Committee invited Sir John Eliot to retain his position on the Committee as representative of the Meteorological Department of the Government of India. The Committee have thus had the advantage of counting among their number a member, resident in Europe, who has had intimate personal experience of the meteorology of the tropics.

Since 1896 the Committee have held meetings in St. Petersburg 1899, Paris 1900, and Southport 1903. The reports of the proceedings have been printed and circulated to the various meteorological institutes. You are thus acquainted with the work accomplished by the Committee since your last meeting.

A resolution of the Conference of Munich, proposed by Messrs. Wild and Scott, defines the principal objects of Conferences of Directors as "discussion of concrete questions, agreement as to methods of observation and computation, and arrangement for co-operation in research." Several co-operative researches have been organised by special Commissions appointed by the International Committee.

The Conference at Munich appointed a Cloud Commission, under the presidency of M. Hildebrandsson, to publish an International Cloud Atlas and to organise observations and measurements of clouds in different countries for one year. The Cloud Atlas was published in 1896 by Messrs. Hildebrandsson, Riggenbach and Teisserenc de Bort. International observations and measurements of clouds were made at a large number of stations from May 1st, 1896, to the end of 1897, on a system agreed on by the Commission at Upsala in 1894. The observations have been published in accordance with the instructions of the Commission. The main results of the work are summarised in a Report by M. Hildebrandsson, of which the first part was submitted to the Committee at Southport. The second part is submitted to you to-day. The Commission has thus completed its work.

Several other Commissions were constituted in Paris in 1896. An Aeronautical Commission (President, M. Hergesell) was appointed to organise international researches on scientific

aeronautics and to arrange for simultaneous balloon ascents from several stations. Another Commission was appointed under the Presidency of Sir Arthur Rücker, to organise researches on Terrestrial Magnetism and Atmospheric Electricity.

These Commissions have held several meetings and have organised important researches.

A third Commission appointed in Paris for the study of Radiation and Insolation has not met. Its President, M. Violle, has submitted a report at each meeting of the Committee on the most important investigations made in each country.

At the meeting in St. Petersburg in 1899, the Committee appointed a Commission for Weather Telegraphy (President, M. Pernter), with instructions to examine what changes are desirable in the present system of weather telegraphy to make it more serviceable for forecasting.

Another Commission was appointed at the suggestion of Sir Norman Lockyer and Mr. Shaw (President, Sir Norman Lockyer), to investigate the connexion between Meteorology and Astrophysics.

The reports of the Presidents of these Commissions, which have been received by the Committee or are to be submitted to you at the present Conference, show that the appointment of Commissions to deal with special subjects has been of great value to Science. Through their agency it has been possible to organise and carry out researches which are beyond the means of individual investigators. It is of great importance that those who are interested in the same or similar problems should meet every few years for an interchange of views and for the organisation of collective researches without in any way hampering individual effort.

The numerous subjects for discussion which have been received by the Officers of the Committee have been printed and circulated. One subject which has just been sent in will be communicated to the President as soon as the Officers of the Meeting have been elected.

We are satisfied that the Conferences of Directors which have been held during the past 30 years have helped greatly to develop Science, to consolidate ideas and to facilitate the co-operation of the institutes of different countries. The appointment of an International Committee effectively promotes the continuation of these good relations and cares for the continuance of the work of the Conferences.

The present Committee have concluded their labours. It is for you to say whether they have carried out their trust satisfactorily and, if so, to reappoint them.

E. MASCART.

H. H. HILDEBRANDSSON.

Magnetic
Commission.

Radiation
Commission.

Telegraphic
Commission.

Solar
Commission.

Meetings of
Committee.

Work of
Commissions.

Cloud
Commission.

Aeronautical
Commission.

Election of
Officers.

M. Hildebrandsson announced that the Committee propose the following as officers of the meeting :—

Honorary President	...	...	M. J. Hann.
President	...	...	M. J. M. Pernter.
Vice-Presidents	...	...	Messrs. Hildebrandsson and Rykatcheff.
Secretaries	...	...	Messrs. Angot, Rotch, Trabert.

This proposal was carried by acclamation.

President's
Address.

The Honorary President thereupon delivered the following address :—

Gentlemen,

I count it a great honour to be called up to welcome so distinguished a gathering of physicists and meteorologists, and to thank you for your attendance.

I can but conclude that this duty has been entrusted to me, who am not an active member of the Conference, because I am one of the few still spared of those who met at the first International Conference of Meteorologists, held at Leipzig in 1872, and because I was a member of the International Meteorological Committee for many years.

As I am not the acting President, I enjoy the privilege of not being compelled to enter on the numerous subjects for discussion which will be brought before you. I will use my freedom to refer to some of the problems confronting meteorologists at the present day, to the solution of which your deliberations will contribute.

Recent balloon and kite ascents have brought the investigation of the upper atmosphere to a stage which was not dreamed of at the time of the International Conferences at Leipzig and Vienna.

When the International Congress of Meteorologists, which met in Rome in 1879, entrusted me with the duty of framing a programme for "Meteorological Observations in Balloons and on Mountains," the situation was but little changed. The technical advances in the manipulation of kites which subsequently enabled Rotch and Clayton to do such good work at Blue Hill had not been made, the means of sending up *ballons sondes* into the highest region of the atmosphere, by which Teisserenc de Bort has obtained such surprising information regarding the conditions of temperature there prevailing, were wanting, systematic scientific research in manned balloons was neglected, and such results as were available at the time have since been proved to be untrustworthy. It was reserved for Assmann to provide us with a trustworthy instrument for determining the temperature of the air under the special conditions which prevail in balloons, after the older experiments of Welsh had been overlooked and forgotten.

In 1879 all I could do was to recommend captive balloons for experimental investigation, but even at that early date I laid stress on the advantages which observations collected in this way have over those taken on mountains, for the reason that the influence of the ground cannot be entirely eliminated even on the highest peaks

and has a marked effect on the daily range of temperature as compared with that in the free atmosphere. The work which can be accomplished with captive balloons is necessarily of very limited scope, and for that reason I strongly advocate the establishment of observing stations on mountain tops. The latter have led to important results, even if it must be admitted that achievements have not fully come up to expectations. For instance, the hope that the establishment of mountain stations would inaugurate a new era in the science of weather forecasting has not been realised. Unfortunately this circumstance has given rise to a good deal of unjustifiable adverse criticism of the value of high level stations, which has contributed to the dismantling of the meteorological station on Ben Nevis. As balloon and kite observations will never give us continuous records of the meteorological elements (particularly of pressure) at fixed altitudes, observations on mountains, even though they may be subject to some extent to local influences, will always be of great importance; they may in fact be looked upon as indispensable for the investigation of the upper atmosphere from the historical point of view.

This brings me to another subject of research which has recently been claiming increased attention. I refer to the problem of the periodicity of weather changes and their connexion and dependence on changes going on in the sun.

We are here face to face with one of the greatest and most fascinating problems of contemporary meteorology, to solve which astronomers, physicists, and meteorologists must join hands.

Among the contributions of meteorologists to this object must be that of providing suitable observational material for bringing to light cyclic changes in the atmosphere and their relations to solar phenomena.

The observational material must satisfy two important conditions. Firstly it must be distributed, as nearly as may be, uniformly over the surface of the earth, so that we may be informed of the state of the atmosphere considered as a whole at any given epoch; and secondly, it must enable us to follow changes in that state, extending over short or long intervals of time. Observations at fixed stations should therefore supply continuous and homogeneous series of mean (and extreme) values. These two important requirements have often been overlooked. In their endeavour to secure a higher degree of accuracy, central observatories have frequently neglected to take steps to ascertain whether the old and the new observations are strictly comparable. This remark applies with special force to observations of atmospheric pressure. Records of temperature which are not free from local influences, and records of pressure made with instruments with large and unknown index errors, may become documents of great importance in the study of the history of weather changes if the same conditions of exposure and the same instruments are used throughout. They may even be more valuable for such purposes than records which approach more nearly to absolute accuracy but are not homogeneous, for systematic errors do not affect the variation in time.

These considerations have led me for many years to agitate in the pages of the "Meteorologische Zeitschrift" for the creation of homogeneous mean and extreme values of the meteorological elements extending over the largest possible periods, and for the collection and critical examination of old series of observations. From this point of view the systematic continuation of observations at mountain stations is of special value. Such records give us information regarding the changes taking place in the upper region of the atmosphere in which local conditions are less important than at the surface.

Of the results of exploration in recent years, none has impressed me more than the observation of the British Antarctic Expedition on the decrease in the amount of ice in South Polar regions. The well-known ice barrier of James Ross has retreated by 30 miles, the glaciers of Victoria Land no longer advance but retreat, and while these changes are in progress in the Antarctic, explorers report a like diminution in the size of glaciers on the snow mountains of Ecuador and East Africa.

Considered in connexion with the many indications and observations of a continual drying-up in Africa and Central Asia, we are here face to face with one of the most important questions of terrestrial physics. The problem appears all the more difficult of solution when we must confess ourselves, from the meteorological point of view, completely nonplussed by similar phenomena, though on a smaller scale, which we can survey adequately both in time and in space. I am referring to the steady retreat of the Alpine glaciers, of which you can find evidence in the immediate neighbourhood of the town in which we have met. Although these changes are taking place in a part of the world for which it might be thought that ample data are available, both in time and in space, we have not yet succeeded in proving a connexion between changes or periodicities in the meteorological elements and the variations of glaciers. High aims cannot be reached at a bound but have to be approached gradually and after adequate preparation.

You have met here, my honoured colleagues, to discuss ways and means of arriving step by step at a solution of the important problems of contemporary meteorology.

M. Pernter thanked the Conference for having elected him President. He proposed that certain questions be referred to special Commissions, which should report on them to the general meeting. He requested the Conference to appoint the following Commissions and to elect the members named to serve on them:—

1. Commission on the International Codex and on the Comparison of the Standard Barometers of different countries. Items 26 and 39 of the provisional programme. Members: Messrs. Algué, Angot, Hellmann, Hildebrandsson, Pernter, Rykatcheff, Shaw. Reporter, M. Hellmann.

* The numbers prefixed to the marginal headings refer to the numbers of the items of the provisional programme, pp. 5 to 9.

2. Commission for the preparation of a new edition of the Cloud Atlas and on questions concerning the Classification of Clouds. Items 13, 15, 19, 22, 23, 36, 38 of the provisional programme. Members: Messrs. Hepites, Hergesell, Hildebrandsson, Pernter, Rotch, Teisserenc de Bort. Reporter, M. Teisserenc de Bort.
3. Commission on methods of reducing Barometric Readings to Sea Level and on questions connected with Weather Telegraphy. Items 4, 5, 10, 20, 21, 34 of the provisional programme. Members: Messrs. Angot, Erk, Köppen, Lyons, Mohn, Pernter, Rykatcheff, Teisserenc de Bort. Reporter, M. Mohn.
4. Commission on the International Study of Squalls. Items 6, 7, 8, 29, 30, 31 of the provisional programme. Members: Messrs. Durand-Gréville, Fineman, Froc, Hellmann, Hildebrandsson, v. Konkoly, Rotch, Shaw. Reporter, M. Hildebrandsson.
5. Commission on Terrestrial Magnetism and Atmospheric Electricity. The Commission is a permanent one. Its President, Sir Arthur Rücker, is unfortunately unable to be present, and M. Rykatcheff is requested to take the chair at the meetings. Items 11, 27, and 33 are referred to this Commission.
6. The Commission on the investigation of the Connexion between Solar Activity and Phenomena occurring in the Atmosphere of the Earth is also a permanent one, and will meet with Sir Norman Lockyer, its President, in the chair.
7. The Commission on Radiation, of which M. Violle is President, has never been called together, but a report has been received on its work. There are no members of the Commission present on this occasion. It will be desirable to re-elect the Commission at the end of the meeting.

Questions which have not been referred to Commissions will be discussed at the General Meetings in the order in which they appear on the programme.

All these proposals were adopted.

M. Pernter proposed that General Meetings be held each day from 9 a.m. till noon, and that the afternoons be set aside for meetings of Commissions. Adopted.

A question for discussion forwarded to M. Hildebrandsson by M. Brunhes, too late for its inclusion in the programme, was set down for consideration at the end of the meeting (Item No. 40).

M. Pernter reminded the meeting that a resolution of the Conference of Munich limited the work of Conferences to the discussion of practical points, and that questions of a purely theoretical nature could not be discussed. He stated that Items 23 and 24 of the provisional programme were affected by this resolution.

M. Hildebrandsson supported this view, which was adopted unanimously.

Arrangement
of business
of meetings.

Discussions
limited to
practical
points.

Vote of
Thanks, &c.

M. Hellmann proposed a vote of thanks to M. Hildebrandsson for his services as Secretary of the International Meteorological Committee. He also moved that a telegram be sent to M. Mascart to express regret at his absence and hoping for his speedy recovery. Both resolutions were adopted by acclamation.

Aeronautics.

M. Hergesell submitted a copy of the report of the St. Petersburg meeting of the Aeronautical Commission and thanked M. Rykatcheff for having caused the report to be printed.

M. Rykatcheff thereupon made the following announcement:—

Observatory
at Koutchino.

"I beg leave to inform the Conference that a new aerodynamical observatory has been opened on a private estate at Koutchino near Moscow. Its provisional programme of work is as follows: 1. Investigation of the resistance of the air. 2. Practical applications of the laws of aerial resistance. 3. Scientific study of the different layers of the atmosphere. The buildings were completed and the necessary machinery and apparatus were set up in November, 1904. Since February 14th, 1905, kite ascents have been made on every day on which the atmospheric conditions made it possible to do so. The observatory has taken part in the international ascents since March. The results of the observations are to be published in special volumes, which will appear as circumstances may dictate. The initial cost for buildings and machinery (100,000 roubles) and the annual cost of maintenance (at present assessed at 36,000 roubles) will be defrayed by M. Riabouchinsky, the owner of Koutchino, who is greatly interested in the work and has assumed the duties of Director. Details of the scheme are given in a small pamphlet published by M. Riabouchinsky, of which I unfortunately have only 20 copies available for distribution. If members of the Conference who are interested in the work will kindly send me their addresses, copies of the pamphlet will be sent them from Koutchino.

"I have here printed reports on various questions included in the programme at my suggestion, which I was unable to forward to the Secretary in time for distribution. Copies of them can be obtained from the Officers after the meeting."

Times of
Meetings of
Commissions.

The President proposed that the reporters of the various Commissions confer after the close of the meeting to arrange times for the meetings of the Commissions. More than two Commissions should not sit simultaneously in order that members might have an opportunity of taking part in the discussions of several Commissions. Members of the Conference who are interested in questions which have been referred to Commissions are at liberty to attend and take part in the discussions whether they be members of the Commissions or not.

M. von Bezold moved that the meetings of the Commissions commence at 3 p.m. and that the time and hour of meeting be posted on the screen.

M. Hepites suggested that the Commissions should begin their labours on the following day (Sunday).

M. Pernter was of opinion that meetings on Sundays would not be well attended, and considered it more satisfactory to postpone them until Monday.

It was agreed that meetings of Commissions be held on Monday, September 11th, at 3 p.m., and that the next General Meeting takes place on Monday at 9 a.m.

The meeting adjourned at 4.40 p.m.

J. M. PERNTER.
W. TRABERT.

Second General Meeting, Monday, September 11th, 1905.

The President opened the meeting at 9.15 a.m. He stated that the minutes of the previous meeting would be submitted on the following day, as they had not been prepared, yesterday being a Sunday. He requested members to be brief in their remarks. Minutes.

Before proceeding to the order of the day, M. Köppen moved that the Commissions on Weather Telegraphy and on Squalls do not meet simultaneously. After a brief discussion, in which Messrs. Hildebrandsson, Hergesell, Hepites, and Durand-Gréville took part, M. Hellmann moved that the Commission on Weather Telegraphy should so arrange its meetings as to enable M. Köppen to attend the discussions on the reduction of barometric readings to sea level and to leave him free to devote the remainder of his time to the Commission on Squalls. M. Mohn assenting, the motion was adopted.

The President proceeded to the order of the day and read Item 1 of the programme, sent in by M. Violle: "That the proposals (regarding radiation) made in a communication from M. Violle to the International Meteorological Committee at their meeting in Southport in 1903, be considered." M. Violle was unfortunately unable to be present. The President requested M. Angot to read the proposals made by M. Violle. 1. Radiation.

M. Angot read the following memorandum:—

1. It is highly important to organise regular measurements of the total solar radiation at all meteorological observatories. These measurements should include hourly observations with direct reading instruments as well as continuous records with autographic instruments.

2. Ångström's Compensation-Pyrheliometer should be used for the eye observations. It has been recognised as the most suitable instrument for this purpose.

3. Various arrangements may be used for autographic records. The selected actinometer may be adapted to record mechanically, electrically, or photographically. When deciding on a form of instrument, accuracy and sensitiveness must be taken into account, as with all good measuring instruments. It goes without saying that the instrument must be calibrated, and that it must be verified from time to time by comparing its indications with those of an absolute standard.

4. To determine the loss of energy due to absorption by the earth's atmosphere, about which our knowledge is very limited at the present day, measurements should be made at different altitudes; special importance attaches to measurements at very great altitudes.

5. In addition to measurements of the total solar radiation, which are both easiest to make and of most importance, efforts should be made to assist in the fundamental researches now being made on the intensity of different parts of the spectrum. The problems of solar physics connected with variations of solar energy can only be solved in this way. (Appendix I.).

J. VIOLLE.

M. Rykatcheff stated that observations are made at the Constantine Observatory, Pawlowsk, from 11 a.m. to noon each day whenever circumstances permit, either with Ångström's compensation pyrheliometer or with Chwolsen's instrument. It was improbable that an actinograph would be set up in the near future.

M. Sresneffsky stated that hourly observations are made at Dorpat whenever the sky is not overcast. Methods must be provided for rendering observations comparable. He thought that this matter might be considered in conjunction with Items 18 (Optical Phenomena) and 33 (Organisation).

M. Hildebrandsson took the chair.

M. Pernter explained his views on the measurement of radiation. He advocated regular measurements of solar radiation and also of nocturnal radiation. To obtain comparable results, the same instruments should be used for both observations. He had no doubt as to which was the most suitable form of instrument. As M. Violle had pointed out, there was only one type of instrument for the measurement of both solar and of nocturnal radiation which satisfies all requirements in the matter of accuracy, viz., Ångström's electric compensation pyrheliometer. The measurement of the intensity of individual wave lengths could not be considered in this connexion, as that was a matter for special physical measurements. As far as meteorology was concerned, the important point was the measurement of the total solar radiation and of the total nocturnal radiation. In the case of solar radiation in particular, it is more important in meteorology to be able to follow the variations in intensity than to determine the magnitude of the solar constant.

It was true that measurements with Ångström's apparatus could only be made at large observatories, but these should take up the matter in all seriousness. There had not been a meeting of the Committee or a Conference of Directors for many years at which this had not been urged. Until recently there had been no satisfactory apparatus for the purpose, but now that Ångström's faultless and accurate instrument was available, the organisation of measurements of radiation should be no longer delayed. To call this organisation into being he moved the resolutions detailed below.

M. von Bezold agreed with M. Pernter, but hoped that efforts would be made to arrive at a method of continuously recording radiation. He also considered it essential that a definite agreement should be come to as to hours of observation. For radiation from sun to earth, the hour of noon would probably be adopted, but it was doubtful whether midnight was the most suitable hour for measuring radiation from earth to space. He also put the question whether measurements should be restricted to occasions when the sun was shining.

M. Pernter replied that the measurement of radiation to space might perhaps be made shortly before sunrise, but there would then be danger of the deposit of dew on the apparatus influencing the results. Observations during the night would probably prove more satisfactory. As to the point whether the measurement of radiation to the earth should be restricted to occasions when the sun was shining, he was of opinion that observations should always be made at the hours agreed upon, no matter whether the sun was shining or not, provided only that precipitation was not actually falling. The state of the sky should be described as concisely as possible. Even on occasions of full sunshine, the state of the sky varied greatly; he reminded the meeting of so-called "invisible clouds."

M. Rykatcheff suggested 11 a.m., possibly the period from 11 a.m. to 1 p.m. for measurement of radiation to the earth, and 10 p.m. for radiation from the earth.

M. Hann drew attention to the small number of observations now available, and put forward a plea for hourly observations to be made during a period of one year at some tropical observatory. He suggested Cairo.

M. Sresneffsky proposed 9 p.m. as the hour for the evening observation of radiation from the earth.

M. Pernter thought that this would prove practicable in winter only; in summer the long twilight would influence the observation.

M. Sresneffsky remarked that noon was an unsatisfactory time. According to observations by Crova, measurements at two hours appeared to be necessary, one in the forenoon about 11 a.m., the other in the afternoon about 1 p.m.

M. Teisserenc de Bort confirmed the fact that the maximum generally occurs in the forenoon. He had proved this from actinometric observations made in balloons. He pointed out that the neighbourhood of Mزاب in Southern Algeria was very suitable for the study of radiation. The meteorological elements were very constant there, and the atmosphere was more transparent at 600 metres than at 2,200 metres in the West of Algeria.

Mr. Shaw moved that the matter be referred to the Solar Commission.

Messrs. Silvado and Rizzo also took part in the discussion.

M. von Bezold requested that the word "exclusively" be inserted in the resolution in connexion with the use of Ångström's pyrheliometer.

M. Pernter thereupon formulated his resolutions as follows :—

“The Conference resolves—

“(1) That measurements of the total solar radiation be made at central observatories, and at other stations which possess the facilities to do so, regularly each day at 11 a.m., or from 11 a.m. to 1 p.m. Ångström's compensation pyrheliometer should be used exclusively for these measurements.

“(2) That measurements of terrestrial radiation be made each evening at 10 p.m. or from 10 p.m. to midnight, also exclusively with Ångström's compensation actinometer.”

Adopted.

M. Pernter again took the chair. He moved that the proposal put forward by M. Hann, that hourly measurements of radiation are important and be made for a period of one year at a tropical observatory, perhaps in Cairo, be recorded in the minutes.

M. Pernter read item No. 2 :—

“In the interest of hydrographic work the Conference is requested to give its attention to the causes of heavy and widespread precipitation, and to the possibility of forecasting such occurrences and particularly to the question of their periodicity. In the event of the request being acceded to, the Royal and Imperial Hydrographic Office (of the Austro-Hungarian Empire) is prepared to submit a report on the subject.”

M. Lauda read the following resolutions and gave his reasons for proposing them (Appendix II.) :—

“(1) Meteorological Institutes are recommended to carry out researches on the causes of unusually heavy and extensive precipitation occurring in the areas for which they issue forecasts, and are requested to make the results of such investigations available for general use by publishing them.

“(2) It would be useful to collect from all available historical documents of different states information regarding abnormal weather phenomena such as floods, droughts, severe winters, &c., and to publish it.”

M. Pernter interrupted the discussion to read the following telegram from M. Mascart :—

“I beg you to thank my colleagues for their kindness and wish you all success in your labours. Greatly regret my enforced absence.—Mascart.”

The discussion was then resumed.

M. Hellmann agreed cordially with M. Lauda. He stated that the summer floods in Silesia were being investigated in Prussia, and that detailed maps of the distribution of pressure were being prepared for days of heavy precipitation. He referred to the question of expense, and remarked that the investigation, which was nearly completed, did not promise to assist greatly in the preparation of forecasts, as the 36 cases which had been examined showed great differences. M. Hellmann thought that the question

2. Heavy and
Widespread
Precipitation.

Telegram
from
M. Mascart.

Discussion
resumed.

involved in the second resolution could only be dealt with adequately by a historian, and advised that it be made a subject for a prize essay by an academy.

M. Sresneffsky referred to the investigations which had been made in Livonia on the connexion between the water level in the river Embach, as observed at several stations, and the precipitation measured at a large number of rainfall stations. He was anxious to direct attention to this important question.

M. Rykatcheff expressed himself as being heartily in sympathy with the resolution, and stated that it was intended to increase the number of rainfall stations in Russia to 2,000 and to devote special attention to heavy falls of brief duration. He hoped that this would assist the project M. Lauda had in view. The establishment in Russia of about 20 autographic rain-gauges and of a large number of instruments for measuring heavy falls of brief duration was also contemplated.

M. van Everdingen thought it was essential for a meteorologist to co-operate in the preparation of the proposed catalogue of striking weather phenomena. He was further of opinion that a summary of such phenomena for previous centuries would not prove very valuable.

M. Mazelle stated that the Vienna Academy had carried out a similar proposal in the domain of seismology.

After a lengthy discussion on different types of rain-gauges and on methods of measurement, in which Messrs. Köppen, Hellmann, Teisserenc de Bort, Kesslitz, Rykatcheff, Hildebrandsson, Sresneffsky, and von Bezold took part, the President pointed out that the debate had drifted away from the subject before the meeting. He thereupon put the resolutions to the meeting.

Resolution 1 was adopted unanimously.

Resolution 2 was adopted with the addition : “The Conference is of opinion that work of this nature would form a suitable subject for the prize essay of an academy.”

Item No. 3, sent in by Rev. M. Dechevrens, was omitted provisionally on the ground that it is entirely theoretical. Items 4 to 11 inclusive had been referred to Commissions, and would be discussed by the General Meeting at a later stage. Item 12 was therefore proceeded with.

M. Hildebrandsson took the chair and read out Item 12 (Pernter) (Appendix VI.) :—

“That the classification of stations be as follows :—

(a.) *Observatories.* Stations at which, in addition to observations at fixed hours, the elements, atmospheric pressure, temperature, humidity, wind direction, wind velocity or force, rainfall, and duration of bright sunshine are recorded autographically.

(b.) *Stations of the First Order.* Stations at which two at least of the elements mentioned above are recorded autographically and the remaining elements are observed, either instrumentally or by estimation, at fixed hours.

3. Tempera-
ture changes
in Cyclones.

12. Classifica-
tion of
Stations.

(c.) *Stations of the Second Order* need not be provided with autographic instruments, but the pressure and temperature of the air must be observed at least three times each day at approved and fixed hours. Approved forms of mercury barometer and thermometer screen are essential. At these stations observations must be made at the fixed hours of the humidity of the air (by psychrometer or air hygrometer), direction and force of the wind, and the amount of cloud (by estimation). The precipitation must be measured at the hour of morning observation.

(d.) *Stations of the Third Order* are stations at which all observations enumerated under (c), with the exception of that of atmospheric pressure, are made regularly at at least three approved hours each day.

(e.) *Stations of the Fourth Order* differ from stations of the third order only in not being provided with instruments for determining the humidity of the air.

Stations at which thermometers are not used, and the only instrumental observation is that of rainfall, are called *Rain-fall stations*."

M. Pernter said that the classification of stations hitherto adopted showed inconsistencies which he proposed to correct. It seemed to him that a station possessing only one autographic instrument, for instance, a sunshine recorder or an autographic rain-gauge, should not be called a station of the first order. He considered that two autographic instruments at least should be insisted on. (Appendix VI. a.)

M. Angot pointed out that the question was one of organisation, and should be referred to the International Committee.

M. Pernter agreed to this.

M. von Bezold agreed with M. Angot, and was of opinion that stations should be classified on the basis of the information published from them.

The question was referred to the International Committee.

The Chairman read Item 14 (Pernter) :—

"Rainfall amounts should be measured and recorded to the nearest tenth of a millimetre. Temperatures should be read and recorded to the nearest tenth of a degree Centigrade."

In course of the discussion, in which Messrs. Rykatcheff, Hellmann, Pernter, Shaw, and Mohn took part, M. Hann pointed out that limits should also be fixed for the British system of units.

The proposal was adopted ultimately.

The Chairman read Item 16 (Pernter) :—

"Simple and generally intelligible definitions are required for the phenomena known as rime and glazed frost."

M. Pernter gave an explanation of the proposed nomenclature, based on his own personal observations :—

Hoar frost (German *Reif*) is a crystalline deposit of ice (for example, as blades of grass in autumn).

*Rime** (German *Duft*) is deposited (on trees, &c.) in crystalline form from fog.

Rime (German *Rauhreif*) is formed when the wind drives supercooled water droplets against exposed surfaces. It is not crystalline.

Glazed Frost (German *Glatteis*) forms when supercooled raindrops fall and coat all objects with an amorphous covering of ice.

M. Angot stated that in the French language only three terms are in common use to designate these four phenomena, viz. : *gelée blanche* = *Reif*, hoar frost ; *givre* = *rime* = *Duft* and *Rauhreif* ; *verglas* = glazed frost = *Glatteis*. [In the French edition of this report, the term "*givre transparent*" is adopted for "*Duft*"; "*givre opaque*" for "*Rauhreif*."]]

Mr. Rotch stated that he had raised the question at the Conference at Munich, and that it had been agreed that the origin of the phenomena should not be taken into account in the definitions.

The discussion, in which Messrs. Pernter, Köppen, Angot, Shaw, and Rykatcheff took part, showed that the uncertainty attaching to the use of these terms were due partly to climatic differences in different countries.

M. Hellmann moved that the matter be referred to the International Committee. M. Pernter agreed to this.

The Chairman read item 17 (Pernter, Appendix VII.) :—

"Observers are recommended to keep a "weather diary" in which the sequence of weather for each day should be briefly described in words. This register should supplement the records of instrumental observations."

7. Weather Diary.

* Considerable uncertainty attaches to the use of the corresponding English terms, at any rate, in the British Isles, where the phenomena are very rare except on mountains. The term "silver thaw" has been used as the equivalent of both "givre" and "verglas." In the English edition of the Report of the International Conference at Munich in 1891 (p. 21) "Silver Thaw" is given as the English term for the rough coating (*Rauh frost*, *givre*) and "Glazed Frost" for the smooth coating (*Glatteis*, *verglas*) and this terminology has been widely adopted. On the other hand it appears to be the practice in Scotland to use "silver thaw" as the equivalent of *Glatteis* or *verglas* (smooth coating). See a paper by R. C. Mossman on "Silver Thaw on Ben Nevis" (The Meteorology of Ben Nevis, Part II, Trans. R. Soc. Edin., Vol. XLII, p. 525) which deals exclusively with the smooth coating. The rough coating (*givre*) is of frequent occurrence on Ben Nevis ; it was referred to in the Journal by the name "fog crystals." In the "Observer's Handbook," a new edition of "Instructions in the use of Meteorological Instruments," recently issued by the Meteorological Office, the expression "silver thaw" has been avoided entirely and the word *rime* used for the rough coating (*givre*, *Rauh frost*). In the German language the word *Tau* stands for both "thaw" and "dew," and it seems not improbable that "silver thaw" originated in a translation of the German "*Tau*," and might be more correctly rendered "silver dew."

Messrs. Angot, Hellmann, Pernter, Schultheiss, Froc, Rykatcheff, Mazelle, Messerschmitt, von Bezold and von Konkoly took part in the discussion.

The general sense of the meeting was to the effect that a separate book was not desirable, but that sufficient space should be provided in the "remarks column" of meteorological forms for the inclusion of a short description of the sequence of weather changes experienced on each day.

M. Hellmann proposed the following amendment to the original resolution :—

"Observers are recommended to supplement their instrumental observations by short descriptions, in words, of the general character of each day."

M. Pernter accepted the amendment, but hoped that the descriptions would be sufficiently detailed. (*See also* p. 27.)

The Chairman read item 18 (Pernter, Appendix VIII.) :—

"All observers are strongly recommended to devote special attention to optical atmospheric phenomena. Suitable instructions bearing on this branch of meteorology should be issued by the Central Offices."

M. Pernter hoped the Conference would pass this resolution. He was particularly desirous that the colours of coronae and rainbows should be carefully described.

M. Rykatcheff promised to give attention to the point when issuing new Instructions for Observers.

M. Hellmann moved as an amendment that the word "all" be struck out.

The Resolution, as thus amended, was carried.

Items 19, 22 and 23 are assigned to the Cloud Commission; item 20 to the Commission on Weather Telegraphy.

M. Pernter again took the Chair, and brought item 24 before the meeting :—

"It is well known that depressions and anticyclones usually travel from West to East in our latitudes. The direction and velocity of progression present many unsolved problems and should be made the subject of special study." (Rev. A. Rodriguez, Appendix IX.)

M. Angot agreed that these were matters of great interest, but he was of opinion that the subject could only be advanced by the co-operation of individual investigators.

The view was also that of the Conference.

M. Pernter read item 25 (Hellmann) :—

"Strictly homogeneous series of observations, extending over long periods are essential for the study of secular changes, and at present very few such series are in existence. It is highly desirable that observations be continued with as little change of method as possible at a number of stations in each network, the number to depend on the size of the network." (Appendix X.)

18. Optical
Atmospheric
Phenomena.

24. Motions
of Cyclones
and
Anticyclones.

25. Stations
for secular
investiga-
tions.

In introducing his resolution M. Hellmann pointed out that the dearth of truly homogeneous series of records is due to two causes :—

(1.) The surroundings of the station alter in character.

(2.) Instrumental improvements have been introduced from time to time.

He demanded that "secular stations" should be established whose primary duty it would be to carry-on observations with as little change of method as possible.

M. von Bezold pointed out that stations on mountains and at monasteries are specially suitable for work of this nature. Messrs. Angot, Mohn, and Rykatcheff welcomed the proposal. M. Hann moved to add a rider that Meteorological Offices be requested to collect old series of observations and to examine them critically.

M. Hellmann thereupon amended his original motion to read as follows :—

"The Conference recommends Central Offices to continue observations with as little change of method as possible at one or more stations within their system—the numbers to depend on the size of the system—and to publish the results regularly. A request was added for the examination and publication of series of observations extending over long periods which have not yet been printed."

M. Angot moved that the morning of Wednesday (September 13th) be allotted to meetings of Commissions.

M. Rudzki requested that this point be deferred to the next meeting.

The meeting adjourned at 12.15 p.m.

J. M. PERNTER.
W. TRABERT.

Third General Meeting, Tuesday, September 12th, 1905.

The meeting commenced at 9 a.m., the President in the Chair.

M. Rykatcheff read the following cablegram from Mr. Bauer, from Washington :—

"Magnetic survey of the Pacific Ocean commenced under favourable circumstances. Severe magnetic storm and aurora during eclipse. All good wishes for the Conference.—Bauer, Washington."

Cablegram
from
Mr. Bauer.

Adverting to the discussion on the "weather diary" (*see above*, p. 26), M. Pernter stated that many observers in Austria volunteer to keep a weather diary, but have no instruments. He recommended Central Offices to encourage such observers.

7. Weather
Diary.

Item 32 (E. Rosenthal) was then discussed :—

"Would it not be useful to prepare for publication a short summary of the principal results of the meteorological observations made during the last century." (Appendix XV.)

32. Meteorological
Summary of
19th Century.

After a discussion in which Messrs. von Bezold, Rykatcheff, Hellmann, Köppen, Angot, Hergesell, Mohn, took part, the following resolution was proposed by M. Hellmann and adopted by the meeting :—

"The Conference is of opinion that the proposal made by M. E. Rosenthal is most important, and requests the Central Physical Observatory of St. Petersburg to take steps to put it into practice. It also requests M. Hellmann to assist in the preparation of this work."

33. Organisation.

The first part of item 33 has been referred to the Commission on Terrestrial Magnetism and Atmospheric Electricity.

The second part of item 33 (von Bezold) was considered :—

"At all Conferences of Directors, and also at meetings of the International Meteorological Committee, stress should be laid on the official character of the gathering. The number of meetings should be kept as small as possible."

Messrs. von Bezold, Hergesell and others took part in the discussion.

In so far as the matter affected Commissions, Mr. Shaw proposed that the Committee arrange with the International Association of Academies for joint discussions with the Commissions appointed by that body of questions connected with meteorology and terrestrial magnetism.

Messrs. Assmann and Hergesell drew attention to the special circumstances of the Aeronautical Commission. M. Hildebrandsson pointed out that hitherto each Commission has had on it at least one member of the International Meteorological Committee, who naturally became the connecting link between the Commission and the Committee. M. von Bezold reiterated the necessity for limiting the number of meetings.

Messrs. Hergesell, von Bezold, Mazelle, Assmann, Hellmann, Sresneffsky discussed the manner of issuing the invitations.

M. Angot considered that the consideration of the question should be left to the International Committee. M. Köppen thought that the general principles should be agreed on by the Conference, and that in doing so the historical development of the present organisation should be taken into consideration. He did not advocate the drawing up of definite rules of procedure.

M. Hellmann proposed the following resolution :—

"The Conference requests the International Meteorological Committee to prepare for the approval of the next Conference of Directors a general scheme for regulating international meteorological organisation. The scheme should take account of the historical development of the present organisation, and should be in agreement with the various resolutions adopted at Conferences of Directors and at meetings of the International Meteorological Committee or of Commissions."

The resolution was adopted.

Items 26, 27, 29, 30, 31, 34, 36 were referred to Commissions. The consideration of Items 28 and 35 was postponed.

Item 37 (Claxton) was then discussed :—

"The terms 'backing' and 'veering' used to describe changes in wind direction require more precise definition."

37. "Backing" and "Veering."

M. Köppen explained that the chief difficulty arose from the application of these terms in the two hemispheres.

Messrs. Shaw, Hildebrandsson, Köppen, Froc, Mohn, Silvado, Brunhes, von Bezold and others took part in the discussion.

M. Hergesell moved that the question be referred to a Sub-Commission consisting of Messrs. Köppen, Shaw, Kesslitz, Silvado Froc, Algué, Mazelle, and Fineman.

Adopted.

Items 38 and 39 are assigned respectively to the Cloud Commission and to the Codex Commission.

Item 40 (B. Brunhes), the last on the list was then discussed :—

40. Small Atmospheric Whirls.

"The Conference should direct the attention of meteorologists to the study of small atmospheric whirls (of sand, dust, dry leaves, ants, &c.) of only a few metres, or even centimetres in diameter. The investigation should be on similar lines to those made by Professor J. Brunhes (Freiburg, in Switzerland) and his pupils on whirls in flowing water. The following points should be accurately noted :— (1.) The direction of rotation, in order to ascertain whether local causes so completely determine this as to render rotation in the opposite direction impossible. (2.) The mean time of a complete rotation. (3.) Whether the whirl is carried along by an air current, and, if so, the velocity of that current."

After a discussion, in which MM. Shaw, Rykatcheff, Brunhes, Lyons and Angot took part, the following resolution was adopted :—

"The Conference has been greatly interested in M. Brunhes paper, and recommends that small atmospheric whirls be specially studied, especially in the Southern Hemisphere."

The President announced that this concluded the business set down for the day, as all other items had been referred to Commissions.

M. Hellmann begged leave to propose the following resolution :—

"The Conference cordially welcomes the presence of a representative of the Brazilian Meteorological Service. It wishes that service all prosperity, and hopes that it will be able to extend its field of operations inland and that it will adopt the international form for its publications."

Meteorological Service of Brazil.

Adopted unanimously.

M. Silvado described the gradual development of the meteorological service of Brazil and promised to do his best to further the wishes of the Conference. (Appendix XX.)

The President called upon the Reverend L. Froc, S.J.

Meteorological
Organisation
of Chinese
Imperial
Customs
Service.

M. Froc gave an account of the meteorological organisation of the Chinese Imperial Maritime Customs, and proposed the following motion (Appendix XXI.) :—

"The Conference takes the opportunity of putting on record its high appreciation of the services rendered to meteorological science and to navigation in the far East by the free transmission of telegrams undertaken for many years by the Great Northern Telegraph Company, the Eastern Extension Australasia and China Telegraph Company, the Compagnie des Télégraphes Chinois, and latterly by the Deutsche Telegraphen Gesellschaft."

Adopted unanimously.

28. Height of
Clouds.

M. Durand-Gréville demanded the discussion of Item 28 which had been postponed.

The President put the question for discussion.

"When estimating the height of clouds (or of dust), illuminated by the sun below the horizon, account should be taken of the circumstance which causes them to be in shadow during the quarter-of-an-hour which precedes astronomical sunrise or succeeds astronomical sunset."

M. Durand-Gréville gave a detailed explanation of his point of view, on which the President remarked that the question was purely theoretical and hence could not be discussed at the Conference.

The minutes of the first meeting were then distributed.

Minutes of
Previous
Meeting.

The President pointed out that there would be no further questions for a General Meeting to discuss until the Commissions had prepared their reports. As no Commissions would be able to do so by the following morning, he invited them, if possible, to conclude their work on the following day, as both morning and afternoon were available for meetings. In any case he hoped that a few Commissions would be able to complete their reports on the morrow, and he thereupon fixed the next General Meeting for Thursday, September 14th, at 9 a.m.

The meeting adjourned at 11.35 a.m.

J. M. PERENTER.
W. TRABERT.

Fourth General Meeting, Thursday, September 14th, 1905.

Minutes.

The President opened the meeting at 9.10 a.m. and announced that the minutes of the second meeting had just been distributed.

The minutes of the first meeting were confirmed.

The President requested that the re-election of the International Committee be taken first, and that the Reports of the Commissions on Squalls, on the Codex, and on Terrestrial Magnetism be then dealt with.

Before these matters were taken up, Item 35 (Rev. L. Froc, S.J.), which had been postponed at a previous meeting, was discussed :—

"Suggestion to add to the international weather symbols used in meteorological publications a special symbol for

Zodiacal light, ☾."

After a debate in which Messrs. Froc, Angot, Shaw, Mazelle, Marchand, Sresneffsky, and Rykatcheff took part, the following resolution was put from the chair and adopted :—

"The Conference recommends that observations of the

Zodiacal light be made, and that the symbol ☾ be used to denote this phenomena."

The minutes of the third meeting were distributed.

The President thereupon proceeded with the re-election of the Committee. He pointed out that the Committee receive their mandate from the Conferences of Directors. The mandate remains in force from one Conference to the next, but then expires. The present Committee therefore resign and the Conference will have to elect a new one. It is for the Conference to decide whether the number of members of Committee should stand at 17 as heretofore or be increased. It will perhaps be desirable to proceed with the election of 17 members and to consider subsequently the question of increasing the number. The President stated that it was entirely within the competence of the Conference either to re-elect the former members or to propose a new list. It was not for the President to suggest names.

Election of
International
Committee.

M. von Bezold moved the re-election of the former members :—

Chaves.	Lancaster.	Paulsen.
Davis.	Mascart.	Pernter.
Eliot.	Mohn.	Russell.
Hellmann.	Moore.	Rykatcheff.
Hepites.	Palazzo.	Shaw.
Hildebrandsson.		

The motion was carried by acclamation.

M. Pernter thanked the Conference, on behalf of himself and his colleagues, for their re-election, and pointed out that only 16 members were available for re-election in consequence of the death of M. Billwiller. He asked that another name be submitted.

On the motion of M. von Bezold, M. Nakamura (Tokio) was elected.

M. Hildebrandsson took the chair.

M. Pernter moved that the Presidents of Commissions be members of the International Meteorological Committee.

M. Angot was of opinion that it was undesirable to alter the constitution of the Committee without notice, as many countries which would be affected were not represented at the Conference,

Organisation
Presidents of
Commissions.

After a discussion, in which Messrs. Hildebrandsson, Angot, Hergesell, Rykatcheff, Hellmann, Pernter and Shaw took part the following resolution, proposed by M. Angot and amended, by M. Hellmann, was adopted :—

"Proposals involving a change in the constitution of the International Meteorological Committee should be formulated at least six months before the date fixed for a Conference of Directors. They should be made the subject of a report to the Conference, which should be printed and circulated for a reasonable time before the meeting. During the intervals between two Conferences changes of constitution may be agreed on by the Committee."

M. Pernter again took the Chair.

Report of
Squall
Commission.

The Report of the Commission on Squalls was then discussed. Reporter M. Hildebrandsson. (See Report of Commission, p. 42.)

The following resolutions were sent up by the Commission and were put to the meeting separately by the President :—

Permanent
Commission
appointed.

1. "The Conference entrusts Messrs. Durand Gréville, Hildebrandsson and Shaw with the organisation of the study of squalls."

Adopted.

Collection of
Records.

2. "Meteorological Institutes, including those devoted to Aeronautics are requested to forward to the gentleman named, for a selection of days—say about ten each year—(1) copies of such observations as may be necessary for drawing isobaric charts for intervals of one millimetre; and (2) the original traces of barographs, thermographs and anemographs (or photographic copies of them)."

Adopted.

Autographic
Instruments.
(Item 30).

3 A resolution regarding the management of autographic instruments of Richard type, with a view to increasing the usefulness of the records for the study of squalls was deferred after a short debate. It was negatived at the close of the discussion on the Report of the Commission on Squalls.

After a discussion, in which Messrs. Köppen, Angot, Hildebrandsson, Rykatcheff, Hellmann, Hergesell, Brunhes, Froc and Marchand took part, the following amendment to resolution 4 was adopted :—

Lists of
Important
Disturbances.

4. "It is desired that Observatories possessing autographic instruments of large size publish lists of the important atmospheric disturbances shown in the records, and, if possible, reproduce the traces in a manner similar to that adopted by the Observatory of Magdeburg and the Meteorological Institute of Saxony."

Tabulation of
Traces.

5. "The Commission is of opinion that the manner of tabulating the curves must depend on the object for which the results are to be used, and that it is not possible to give general directions on this subject."

Adopted.

6. "Item 31 (comparative examination of squalls) is covered by the resolutions previously approved."

Adopted.

The report of the Commission "on Codifying the Resolutions adopted by the International Meteorological Committee and by Conferences of Directors and on the Comparison of Standard Barometers" was then dealt with. Reporter M. Hellmann. (See Reports of Commissions, pp. 46 to 48.)

39. Inter-
national
Codex.

The Commission proposed the following resolution for adoption by the Conference :—

"The Conference is of opinion that the publication of the Codex prepared and submitted by Messrs. Hellmann and Hildebrandsson will prove a most valuable means for promoting international meteorological work, and hopes that the Institutes of Berlin, London and Paris will arrange for the publication of German, English and French editions of the work."

German,
English,
French
Editions.

After a lengthy discussion, in which Messrs. Rizzo, Angot, Hellmann, Teisserenc de Bort, von Bezold and Silvado took part, the resolution was adopted, with the following rider proposed by M. Teisserenc de Bort :—

"The Conference considers it desirable that the Codex be published in other languages also, and thanks the Reverend J. Algué for his offer to arrange for the publication of a Spanish edition."

Edition in
Spanish.

M. Hergesell moved a vote of thanks to Messrs. Hellmann and Hildebrandsson for having undertaken the preparation of the Codex.

Carried with applause.

In the matter of the comparison of barometers, the Commission reported "that the Directors of the Institutes of Berlin, Paris, London, St. Petersburg and Vienna have expressed themselves as prepared to recommend their respective Governments to co-operate in a comparison of the barometers of the Meteorological Institutes of Europe."

26. Com-
parison of
Barometers.

M. Hellmann, in support of the proposal, stated that most institutes do not possess "absolute" standards, and that the term "standard barometer" (*baromètre étalon*, *Haupt-barometer*) is used in many cases to describe the chief instrument at the headquarters of the meteorological system. M. Köppen pointed out that so long as the differences between the barometric standards of different systems are unknown they cannot be allowed for, and hence discontinuities arise when isobars are drawn for large areas.

M. Hergesell considered that the various institutes should provide themselves with absolute standards.

After a lengthy discussion, in which Messrs. Shaw, Hellmann, Angot, Köppen, Rykatcheff, Algué and Mohn took part, M. Köppen moved that attention be drawn to the resolution of the Vienna Conference regarding the inspection of stations within the individual systems.

M. Angot moved that the facilities afforded by shipping be utilised for carrying out comparisons with extra-European barometers.

Rev. Algué undertook to carry out such comparisons with the assistance of the Lloyd.

After some further discussion the debate was closed, and the President put the various resolutions as follows :—

Comparisons
advocated.

1. "The Conference notes with satisfaction the offer of the Directors of the institutes of Berlin, London, Paris, St. Petersburg and Vienna, and is of opinion that the proposed comparisons of barometers will prove to be of great importance to the meteorological services of the whole of Europe." Carried.

Inspections
of Station.

2. "The Conference desires to draw attention to the resolution of the Conference at Vienna regarding the inspection of stations within the individual systems." Carried.

Non-
European
Countries.

3. "As far as practicable, comparisons of the barometers of extra-European Institutes should be also taken into consideration." Carried.

4. "Messrs. Hellmann and Rykatcheff are requested to make arrangements for putting into practice resolution 1." Carried.

Magnetic
Commission.

The report of the Magnetic Commission was then dealt with. Reporter M. Rykatcheff. (See Reports of Commissions, p. 49.)

M. Messerschmitt moved that the proposals of the Commission be read and discussed separately. Not carried.

The report was thereupon read, in full, and subsequently the individual proposals were discussed separately :—

Comparison
of
Instruments.

1. "The Magnetic Commission considers it essential that the instruments used at the different magnetic observatories be regularly and frequently compared with one another. The Directors of the chief meteorological institutes are requested to arrange for making the comparisons."

Adopted, after a debate, in which Messrs. Angot, Schmidt, Hellmann, Silvado, and others joined.

Magnetic
classification
of days.

2. "From January 1st, 1906, magnetic observatories are requested to prepare statements showing the magnetic character each day on the scale 0 to 2. The question of the publication of these statements is referred to the Permanent Bureau."

Adopted, after a debate, in which Messrs. Marchand, Angot, and Schmidt joined.

Exchange of
Records.

3. "Magnetic observatories should exchange promptly copies of their traces for very disturbed days (type 2 on the Schmidt classification), and for other days of special interest. For this purpose a list of magnetic observatories should be drawn up." Adopted.

4. "The Commission requests the Conference to recommend that magnetic observatories which possess autographic instruments publish hourly mean values (in Greenwich time) deduced from their curves in place of the instantaneous values at the hour. It should be understood that monthly means (local time) be published as in the past, in addition to the monthly means determined in this way."

Hourly
Means.

M. Rykatcheff moved that this resolution be referred to the Committee. Messrs. Schmidt, Angot, and Rudzki took part in the discussion.

M. Rykatcheff's motion was ultimately adopted.

5. "The Commission are unanimously of opinion that local circumstances differ so greatly at different observatories that it is undesirable to prescribe uniform rules of procedure. It is left to the discretion of individual Directors to fix the number of absolute measurements for their observatories."

Number of
absolute
measure-
ments.

The Conference acquiesced in this view.

6. "A Permanent Bureau, consisting of from three to five members, is to be elected from among the members of the Magnetic Commission, which is about to be re-appointed by the Conference. It shall be the duty of this Bureau to carry out the resolutions of the Magnetic Commission, and to prepare the business for the meetings. The Bureau is also instructed to communicate with the Department for Terrestrial Magnetism of the Carnegie Institution, and to work out a plan for the co-operation of the larger existing institutes with the Department. This plan for co-operation shall be submitted for approval at the next Conference of Directors." Adopted.

Organisation.

7. "The completion of the network of magnetic observatories is necessary. For theoretical and practical reasons it is desirable in the first instance to aim at the establishment of a number of temporary stations near a line joining the poles of the magnetic axis and crossing Africa meridionally. These stations should be equipped with autographic variation instruments, and, if possible, they should be maintained in operation for a complete sunspot cycle." Adopted.

Network
of Observa-
tories.

8. "The Commission is of opinion that autographic thunderstorm recorders are still in the experimental stage, and it consequently cannot recommend the general adoption of these instruments at observatories." Adopted.

11. Auto-
graphic
Thunder-
storm
Recorders.

9. "The Committee is of opinion that investigations on atmospheric electricity have not progressed beyond the stage of study, and that definite methods of tabulation cannot be recommended as yet." Adopted.

27. Atmos-
pheric
Electricity.
Tabulation of
Records.

The President asked whether the Conference was prepared to receive several communications of scientific interest. The proposal was acceded to.

Miscellaneous
Communica-
tions.

Mr. Stupart read a communication from M. van Rijkevorsel on the changes of position of regions of maximum and minimum temperatures.

The Reverend J. Algué gave an account of the solar-physical observatory established at Tortosa (Spain) by the Reverend B. Cirera. (Appendix XXII.)

M. Carlheim-Gyllensköld described his investigations of globular lightning.

M. Polis stated that the establishment of a network of stations in Luxemburg was under consideration. He moved a resolution:—

“The Conference considers the establishment of a network of meteorological stations in Luxemburg highly desirable.”
Adopted.

M. Sresneffsky read a report on the determination of humidity.
The meeting adjourned at 12.45 p.m.

J. M. PERENTER.
W. TRABERT.

Fifth General Meeting, Friday, September 15th, 1905.

The President, M. Pernter, opened the meeting at 9.15 a.m. He submitted the minutes of the meetings on September 11th and 12th, which were adopted.

He announced that the reports of Commissions would be taken first, and that he would then call upon Messrs. Teisserenc de Bort, Rotch, and Hergesell to read communications of great interest. Discussion of these papers would not be in order as they were of purely scientific nature and did not deal with questions of organisation.

The report of the Solar Commission* was then considered. Sir Norman Lockyer (President) read the reports of the meetings of the Commission at Cambridge (1904) and Innsbruck (1905).

He read all the resolutions adopted by the Commission, and requested the Conference to adopt the following resolutions put forward by the Commission:—

1. “The Commission desire to have permanent meteorological stations established in the North of Siberia and America. At least two or three stations in each Continent are desirable.”

Adopted.

2. “The Commission would be glad to receive observations from the following islands. They draw attention to the importance of permanent meteorological observations in these regions:—

Atlantic Ocean.

Iceland }
Greenland } Denmark.
Faroe }
Canaries, Spain.

* The report is printed *in extenso* in the “Report made to the Solar Physics Committee by Sir Norman Lockyer, K.C.B., F.R.S., upon the work done in the Solar Physics Observatory, South Kensington, from 1st January to 31st December, 1905.”

Meteoro-
logical
Service in
Luxemburg.

Report of
Solar Com-
mission.

Permanent
Arctic
Stations.

Island
Stations.

Madeira }
Cape de Verde } Portugal.
Ascension }
Saint Helena } Great Britain.
Falkland Islands }
Staten Island, Argentina.
Fernando Noronha, Brazil.
Fernando Po, Spain.
West Indies. Various.
Bermuda, Great Britain.

North Pacific Ocean.

Sandwich Islands, United States.
Caroline Islands, Germany.
Japanese Islands, Japan.
Philippine Islands } United States.
Guam }
Christmas Island, Great Britain.

South Pacific Ocean.

Bismarck Archipelago } Germany.
Samoa }
Fiji Islands, Great Britain.
New Caledonia } France.
Tahiti }
Java, &c., Holland.
North Borneo, Great Britain.

Indian Ocean.

Seychelles } Great Britain.
Mauritius }
Reunion } France.
Madagascar }
Zanzibar }
Socotra } Great Britain.
Chagos Archipelago }
Christmas Island }

Arctic Ocean.

Karmakuli (Nova Zembla), Russia.”

3. “The Commission requests its President to approach the various Governments concerned through the International Meteorological Committee, and to urge on them the desirability of organising meteorological stations in those of the islands named in which there are at the present day no arrangements for observing, and of securing the continuity of the records in other cases.” Adopted.

Diplomatic
Action
demanded.

4. “Directors of Meteorological and Hydrographic Institutes are requested to communicate data regarding the level and flow of water in rivers and lakes in addition to the meteorological data sent to the Commission.” Adopted.

Height of
Rivers and
Lakes.

The Conference approved the remainder of the report and the remaining resolutions of the Commission, which did not call for

special support. It also approved the motion of M. Hellmann drawing the attention of the International Association of Academies to the work of the Solar Commission.

Report of
Meeting of
International
Committee.

The President announced that the newly-elected International Committee had met on the previous day, and called upon M. Hildebrandsson for a report of the proceedings.

M. Hildebrandsson read the minutes of this meeting of members of the International Meteorological Committee held on September 14th. He reported that M. Mascart had been re-elected President and M. Hildebrandsson Secretary, and that the following Commissions had been re-appointed (*see* Report of Meeting, p. 55):—

1. Commission on Terrestrial Magnetism and Atmospheric Electricity. President, M. Rykatcheff, St. Petersburg.
2. Commission on Scientific Aeronautics. President, M. Hergesell, Strassburg.
3. Solar Commission. President, Sir Norman Lockyer, London.
4. Commission on Radiation. President, M. Ångström, Upsala.

The report was adopted. The President stated that former members of these Commissions would continue to belong to them, and that the Presidents had power to nominate additional members.

Report of
Cloud Com-
mission.

The President called on M. Teisserenc de Bort to present the report of the Cloud Commission.

M. Teisserenc de Bort read the report (*see* p. 56), in which the following resolutions were recommended for adoption by the Conference:—

Definition
of Stratus.

1. "Definition of Stratus.—This should read 'A uniform layer of cloud resembling a fog but not resting on the ground,' instead of 'A horizontal sheet of lifted fog.' The complete absence of details of structure differentiates Stratus from other compact cloud forms."

"Lenticu-
laris."

2. "Certain cloud forms which are particularly frequent on days of Scirocco, Mistral or Föhn, have an oval shape and occasionally show irisation. These cloud forms are to be described by the term '*lenticularis*,' e.g., *cumulus lenticularis*, *custr. lenticularis*. A plate illustrating this cloud form will be included in the Cloud Atlas."

Typical
Cases.

3. "Observers are invited to underline the abbreviated description of a cloud form on occasions when the cloud is regarded as specially characteristic of its form; thus *à Cu*. The forms from which rain falls should also be noted."

Instructions
to Observers.

4. The Conference recommends editors of meteorological discussions or of Instructions to Observers to reproduce the definitions of cloud forms given in the International Atlas without changes or additions, in order that complete uniformity may be attained."

5. "The Commission has agreed to improve some of the plates contained in the Atlas. In cases in which several cloud forms are shown on the same plate, the name of each form will be indicated on the plate by the recognised abbreviated designations."

Revision of
Illustrations.

6. "The Commission considers the distinction, suggested by M. Pernter, between a fog which wets exposed surfaces and one in which exposed surfaces remain dry to be a useful one. The attention of the International Committee is drawn to the symbol \approx proposed for this phenomenon by M. Pernter.

19. Wet Fog.

7. "The Commission proposes to describe Nimbus by the contraction Nb. in place of N. and Stratus by St. in place of S. in order to avoid confusion with the abbreviation N. = North and S. = South."

Abbrevi-
ations.
Nimbus.
Stratus.

All these resolutions were carried without discussion.

The President invited the Conference to hear communications from Messrs. Teisserenc de Bort, Rotch and Hergesell on their investigations of the Anti-trade Wind in the Trade Wind regions. He repeated that he could not call on any member of the Conference to discuss these communications without infringing the terms of the resolution of the Conference of Munich, which limited the discussion at Conferences to questions of organisation. This principle had been reaffirmed by the present Conference at the meeting on September 12th. He then successively called upon Messrs. Teisserenc de Bort, Rotch and Hergesell.

Investigation
of Upper Air.
Anti-trade
Winds.

Messrs. Teisserenc de Bort and Rotch gave a summary of the results obtained in their recent investigations in the Trade Wind region and in the belt of calms of the North Atlantic Ocean. M. Teisserenc de Bort described the history of the expeditions. Mr. Rotch reported on the kite ascents. M. Teisserenc de Bort outlined the results of pilot balloon ascents. In all ascents a component directed towards the North was met with in the upper layers of the atmosphere.

M. Hergesell discussed the results obtained from balloon and kite ascents made in the Mediterranean Sea and North Atlantic Ocean during several cruises of the Prince of Monaco's yacht. He had found no indication of the existence of an anti-trade wind in his experiments.

The Conference received the communications of Messrs. Teisserenc de Bort, Rotch and Hergesell with applause, and hoped that they would continue their interesting investigations. M. von Bezold moved a vote of thanks to the Prince of Monaco and to Messrs. Teisserenc de Bort and Rotch, who had defrayed the expenses of these expeditions.

Votes of
Thanks.

M. Köppen stated that a German hydrographic expedition was about to be sent from Hamburg to the Bismarck Archipelago *via* the Cape of Good Hope. The expedition would be provided with kites and balloons, and would carry out ascents during the voyage.

German Ex-
pedition to
Bismarck
Archipelago.

The President thereupon proceeded to the discussion of the resolutions proposed by the Commission on Weather Telegraphy. He called on M. Mohn, the Reporter of the Commission.*

Report of
Telegraphic
Commission

* As the resolutions fully summarise the work of the Commission, the minutes of its meetings have not been printed in this Report.

M. Mohn proposed the following resolution on behalf of the Commission :—

Reduction of
Sea Level.

1. "Directors of meteorological networks are requested to have the reduction of barometric readings to mean sea level made in such a manner that the final results, however arrived at, may not differ from the results which would be obtained from the complete formula of the International Tables, by more than 0.3 mm. (0.012 inch), on the assumptions (1) that the temperature and humidity at the time of observing be entered in the formula, and (2) that the vertical temperature gradient be taken as 0.5° C. per 100 metres (1° F. per 300 ft)." (Appendix III.) Adopted.

On the motion of M. Köppen the following rider was added :—

"The Conference recommends that only very simple and convenient tables be used for the reduction of telegraphic observations in order to avoid loss of time and clerical errors. An illusory degree of accuracy is undesirable."

M. Erk moved that both resolutions come into force on January 1st, 1906. Adopted.

M. Mohn resumed his Report.

5. Extreme of
Temperature
in Daily
Reports.

2. Item 5, Introduction of uniformity of practice in the extremes of temperature published in Daily Weather Reports :—

"As this point bears also on climatology, the Commission requests that it may be referred to the International Meteorological Committee. The Commission favours the entry of the minimum temperature for the 24 hours preceding the despatch of the telegrams in the reports.

Gravity
Correction.

"The Conference requests that ambiguity as to whether the gravity correction has been applied to barometric readings published in the Daily Weather Reports of the various Offices be avoided. Information on this point should be given either in each issue of the Report or at least once a year in the explanatory preface." Adopted.

10. Wireless
Messages.

3. In connexion with item 10, "*The Daily Telegraph* now publishes reports of the approach of disturbances from the Atlantic Ocean received by wireless telegraphy" (Polis) (Appendix IV.), the following resolution was proposed :—

"The Conference is convinced that wireless messages from the Atlantic Ocean will be of great service in forecasting in the future. Before a regular service is inaugurated in connexion with Meteorological Offices it is absolutely essential to devise means for adequately checking the observations transmitted.

"The Conference requests the Meteorological Office of London to prepare a report on this subject at the earliest opportunity and to circulate it to other offices which may be specially interested in the matter."

The resolution was adopted. A vote of thanks was passed to M. Polis for the trouble he had taken in preparing the question for discussion.

4. Item 20. "The assembled Directors should arrange to include data regarding the motion of clouds in their daily meteorological telegrams" (K. Schmid); and item 21. "Can the Conference adopt a resolution requesting that the direction of motion of clouds be given in the daily weather reports of all countries?" (Rev. L. Gangòiti).

20, 21. Inclusion of Cloud.
Data in
Telegrams.

The Conference requests the Deutsche Seewarte to prepare a report on the question for consideration by the International Meteorological Committee.

5. Item 34. "Would it not be of advantage to marine meteorology (storm warning services) to recommend to all institutions engaged in this branch of work an improved system of signals for communicating to ships the information at present sent to ports and semaphore stations?" (Froc) (Appendix XVI.) The Conference agreed to refer this question to the International Committee.

34. Uniform
System of
Storm
Signals.

6. Item 37. "The terms 'backing' and 'veering' used to describe changes of wind direction require more precise definition." (T. F. Claxton) (Appendix XIX.)

37. "Back-
ing" and
"Veering."

In connexion with this subject Messrs. Algué, Brunhes, Fineman, Froc, Kesslitz, Köppen, Mazelle, Shaw, Silvado and van Everdingen proposed the following resolution :—

"Meteorologists in either hemisphere are requested to denote by the word 'backing' a change of wind direction, at the place of observation (or on board ship) in the direction W-S-E-N (counterclockwise)—irrespective of accompanying changes of weather—and to use the word 'veering' to denote a change in the opposite direction W-N-E-S (clockwise).

"Corresponding terms in other languages should be similarly used.

"The Conference also requests all authors to state definitely what meaning they attach to the expressions 'dextrorsum' or 'sinistrorsum' and other similar terms in all cases where ambiguity is to be feared."

Adopted.

The President announced that all the items of the programme had now been dealt with.

He thanked the Reporters of Commissions, Messrs. Hellmann, Hildebrandsson, Lockyer, Mohn, Rykatcheff and Teisserenc de Bort and all other members of the Conference for their work and for the manner in which they had disposed of the programme.

M. Greim asked whether the date of the next Conference could be fixed forthwith. The President pointed out that the decision of the point rested with the International Committee.

Mr. Shaw thanked the President and Officers on behalf of the Meeting.

The meeting adjourned at noon. The President declared the International Conference of Directors at Innsbruck closed.

J. M. PERNTNER.
W. TRABERT.

(B) MINUTES

OF THE

MEETINGS OF COMMISSIONS.

COMMISSION ON SQUALLS.

(Comission de l'Etude des Grains et des Orages.)

September 13th, 1905.

The Commission met at 9 a.m. M. Hildebrandsson in the chair. Present, Messrs. Assmann, Fineman, Greim, Hellmann, Hergesell, Kesslitz, Köppen, Mazelle, Mohorovičić, Nedelkovitch, Pernter, Polis, Rotch, Shaw, August Schmidt, Schultheiss, Sresneffsky, Trabert and Froc (Secretary).

Items 6, 7, 8. Items of the provisional programme :—

No. 6. "In connexion with the study of unusual atmospheric disturbances (hail, thunderstorms, &c.), observers should be exhorted not merely to take the readings of their various instruments as nearly simultaneously as possible, but also to note accurately the time of occurrence of the phenomena."

No. 7. "Cannot arrangements be made for stations situated to the westward of their respective central offices to notify the central office by telegraph of the occurrence of heavy hail-squalls in which the wind attains a velocity of 20 metres per second, so that warning of approaching danger may be sent to stations situated further to the eastward."

No. 8. "That the Conference advise that isobars be drawn for intervals of one millimetre in the daily weather charts of of all countries."

E. DURAND-GRÉVILLE.

The President called on M. Durand-Gréville, who read a detailed memorandum developing these three points. (Appendix xxiv.)

The President suggested taking the discussion in the following order :—

1. The necessity of having numerous autographic instruments in each country.
2. The arrangements for standardising these instruments by comparison with the standards of the country.
3. The checking of the time scales.
4. The nomination of several members of the Commission to undertake investigations of interesting meteorological situations.

An interchange of views followed between Messrs. Hildebrandsson, Hellmann, Durand-Gréville, Froc, Shaw, Köppen, Fineman, Sresneffsky, Hergesell and Assmann.

M. Hellmann exhibited a map of the Prussian stations possessing autographic instruments which send their records to the Prussian Meteorological Institute. Each Director indicated approximately the number of autographic instruments in use in his country. Mr. Shaw exhibited some charts, prepared with the help of records from autographic instruments, and insisted on the difficulties met with in work of this nature which is based on the co-operation of many independent observers.

M. Hellmann pointed out that the time of occurrence of phenomena can be determined with sufficient accuracy if "time marks" are made regularly on the records two or three times a day.

M. Durand-Gréville suggested that the traces of different elements might be used to check one another. Mr. Shaw objected that the question ought not to be prejudged by assuming *a priori* that all the phenomena, increase of pressure, squalls, &c., occur simultaneously.

M. Köppen recommended autographic instruments in which several elements are registered on the same sheet. Only one clockwork need then be used. The aspiration Meteorograph fulfilled this condition.

M. Assmann and M. Hergesell described the details of instruments of this kind.

Rev. L. Froc pointed out that in many instances the barographs ordinarily in use do not give all the information that is required, and that instruments with more open time scale and of greater magnification are desirable. He suggested the Richard statescope, or the micro-barograph recently constructed in England by Mr. Shaw.

M. Hergesell remarked on the sluggishness of many thermometers in assuming the temperature of the air surrounding them and on the necessity of using very sensitive recorders, similar to the aspiration instruments used in balloons, for researches of the kind proposed.

M. Hellmann proposed :—

1. To commence the investigation with the existing instruments.
2. To advise stations of the first order to provide themselves with the more expensive instruments required for the study of the complex phenomena of squalls.

M. Hildebrandsson summarised the discussion under the following three headings :—

1. It appears that there exist at the present day a large number of barographs in all countries.
2. At important observatories, instruments recording several elements simultaneously should be used.
3. The use of highly sensitive thermographs is recommended.

Data available in each country. Accuracy of Records, &c.

Summary of Discussion.

Organisation
of Investiga-
tions.

The question of the collection and distribution of the autographic records (both those of the ordinary kind and those of more open time scale) was then considered.

M. Hellmann stated that a society founded in Berlin some time ago with the object of studying barometric changes in detail had been dissolved after making a few investigations.

M. Pernter added that in Austria there existed a very close network of stations for which the observations were being published by M. Max Margules.

Mr. Shaw summarised the discussion, and after a short discussion in which Messrs. Hildebrandsson, Shaw, Hellmann, Froc, Mazelle, Durand-Gréville, Köppen, and Sresneffsky took part, the following proposals were adopted unanimously :—

Permanent
Commission.

1. "The Conference entrusts Messrs. Durand-Gréville, Hildebrandsson, and Shaw with the organisation of the study of squalls."

Collection of
Records.

2. "Meteorological Institutes, including those devoted to Aeronautics, are requested to send to the gentlemen named for a selection of days—say about ten each year—(1) copies of such observations as may be necessary for drawing isobaric charts for intervals of one millimetre, and (2) the original traces (or photographic copies) of barographs, thermographs, and anemographs.

Item 29.

The Reverend L. Froc pointed out that the preceding discussion had dealt implicitly with the question which he had set down for discussion by the Conference.

Item 29. "Cannot observers who possess barographs of sufficiently large size be requested to report all sudden fluctuations of pressure which exceed a limiting value of magnitude to be agreed upon, either in amplitude or duration?"

Rev. L. FROC, S.J.

M. Froc explained his object in bringing forward the subject, and M. Hellmann added a few remarks. The Commission thereupon adopted the following resolution :—

Lists of
Important
Disturbances.

"It is desired that observatories possessing autographic instruments of large size publish lists of the important atmospheric disturbances shown by the records and, if possible, reproduce the traces in a manner similar to that adopted by the Observatory of Magdeburg and the Meteorological Institute of Saxony."

M. Köppen pointed out that useful information could be obtained by interviewing the guards of railway trains and finding out from them the exact places at which they had encountered severe squalls. M. Froc added that the same remark applied to steamers.

30. Auto-
graphic
Instruments.

Item 30. "Can the Conference recommend a scheme for increasing the utility of records taken with autographic instruments of Richard type, seeing that such instruments are now being used very widely?" A. WOSNESSENSKY.

After an interchange of views between the President and Messrs. Mazelle and Hergesell, the following resolution was proposed and carried :—

5. "The Commission is of opinion that the manner of tabulating the curves must depend on the object for which the results are to be used and that it is not possible to give general directions on this subject." Tabulation of
Traces.

Item 31. "Detailed investigations of rapidly moving disturbances by comparisons of autographic records from neighbouring stations are desirable." Item 31.
E. ROSENTHAL.

On the motion of the President, the Commission limited itself to remarking—

6. "That Item 31 is covered by the resolutions previously approved."

The business being disposed of the meeting adjourned at 11.5 a.m.

H. HILDEBRANDSSON,
Reporter.

LOUIS FROC,
Secretary.

REPORT OF THE COMMISSION

ON THE

INTERNATIONAL METEOROLOGICAL CODEX AND
ON THE COMPARISON OF BAROMETERS.

Meeting on September 12th, 1905.

The Commission met at 3.30 p.m., M. Hellmann in the chair. Present : Messrs. Algué, Angot, Hildebrandsson, Pernter, Rykatheff, Shaw (members of the Commission) ; also Messrs. Assmann, Greim, Hergesell, Mohn, Aug. Schmidt, Schultheiss, Sresneffsky. Secretary, M. Aug. Schmidt.

Item 39. Messrs. Hellmann and Hildebrandsson :—

“Publication of an international meteorological codex containing all final resolutions of the various international meteorological Committees and Conferences.”

M. Hellmann submitted for approval the International Meteorological Codex which he had prepared, in conjunction with M. Hildebrandsson, at the request of the International Meteorological Committee (Southport, 1903). He also submitted an index (arranged under both subjects and authors) of the scientific papers published as appendices to the Reports. In the codex the final resolutions on each subject are printed (in inverted commas) at the beginning of the sections, and remarks explaining the history of the subject follow. The text of the draft is in German, but as the object of the work is not merely to provide members of the Conference with a handy book of reference, but also to give greater publicity to international resolutions, especially in countries outside Europe, which have still to be won for co-operative work, French and English editions of the Codex are of great importance.

The Commission approved the Codex as submitted, and agreed that its publication would be extremely useful. The resolutions adopted by the present Conference should be included in it.

M. Hellmann stated that the Prussian Meteorological Institute was prepared to undertake the publication of the German edition of the Codex.

Messrs. Shaw and Angot, the representatives of the British and French Offices, stated that they were prepared to advocate the publication of English and French editions.

In view of the extended use of Spanish in Central and Southern America and also in Eastern Asia, the Commission was of opinion that a Spanish edition would prove very useful, and it thanked the Rev. J. Algué for his offer to arrange for its publication. The French edition of the resolutions should form the basis for the Spanish edition.

The Commission submitted the following resolution for adoption by the Conference :—

“The Conference is of opinion that the publication of the Codex prepared and submitted by Messrs. Hellmann and Hildebrandsson will prove a most valuable means for promoting international meteorological work, and hopes that the Institutes of Berlin, London and Paris will arrange for the publication of German, English and French editions of the work.”

Publication
of German,
English,
French
Editions.

Item 26. “Further consideration of the question of the comparison of standard barometers.”

M. HELLMANN.

26. Compari-
son of Baro-
meters.

M. Hellmann pointed out that the important question of the comparison of the barometers of the various meteorological institutes had engaged the attention of several Conferences, but had not been solved in a satisfactory manner.

If isobaric charts prepared from the observations of many stations are to give a correct representation of the distribution of pressure, it is essential that the differences between the standard instruments of different countries be known. In the majority of instances, the so-called “standards” are not absolute standards which admit of the accurate determination of pressure in absolute units, but only the standards of reference for the station barometers of the system. It is not practicable to arrange for the necessary comparison of these standards of reference out of common funds. M. Hellmann therefore proposed the subdivision of the work among the chief Institutes.

He suggested that St. Petersburg might undertake to make comparisons with Helsingfors, Stockholm, Copenhagen, Berlin, Vienna and Warsaw. The work in South-eastern Europe might be undertaken from Vienna, and perhaps this office would also undertake comparisons with Rome and Zurich. Berlin should compare with the remainder of Central Europe and with part of North-west Europe, Paris with South-west Europe, and London with North-west Europe. In this way double comparisons would be made of the barometers of the individual Central Institutes which would afford a very necessary check on the accuracy of the results.

The representatives of the Institutes of St. Petersburg and Vienna declared themselves in general agreement with the proposal. The representative of the Institute of Paris also concurred, but pointed out that a comparison with the barometer of the Institute at Madrid would be of little value as the barometers at Spanish Stations are but rarely compared with that instrument.

The representative of the Meteorological Office, London, used the term “standard barometer” in its restricted meaning only. He drew attention to the possibility of obtaining accurate verifications of barometers from central physical laboratories like Kew, Breteuil or Charlottenburg.

To this M. Hellmann replied that there are very few such laboratories, and that the practical necessity for comparing the instruments of different Institutes was not met entirely by them.

M. Schmidt emphasised the fact that a true "standard" barometer could be made for a comparatively small sum, about £40, and referred to an instrument recently constructed by Professor Koch of Stuttgart. M. Hergesell supported this point of view.

M. Hellmann agreed that the provision of such instruments at all central Institutes would be the most satisfactory solution of the point at issue, but he feared this could not be realised within measurable time, and considered that a comparison of the standards of reference now in use was essential.

A short discussion followed on the best methods of carrying through the proposed comparisons.

The Commission agreed to report in the following terms:—

"The Directors of the Institutes of Berlin, London, Paris, St. Petersburg and Vienna have expressed themselves as prepared to recommend their respective Governments to co-operate in a comparison of the barometers of the Meteorological Institutes of Europe."

G. HELLMANN
(Reporter).

AUG. SCHMIDT
(Secretary).

REPORT OF THE COMMISSION

ON

TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY.

First Meeting, September 11th, 1905.

Present: Messrs. Algué, Angot, von Bezold, Carlheim-Gyllensköld, Froc, Hellmann, Kesslitz, von Konkoly, Liznar, Lyons, Messerschmitt, Paulsen, Pockels, Rizzo, v. Rudzki, Rykatcheff, Ad. Schmidt, Aug. Schmidt, Silvado, Sresneffsky, Stupart.

M. Rykatcheff took the chair in the absence of the President, Sir Arthur Rücker. A letter was read from Sir Arthur Rücker, expressing his regret at being unable to attend the meeting, and resigning the office of President of the Commission.

Resignation
of President.

Messrs. Messerschmitt and Rudzki were elected Secretaries.

Election of
Officers.

M. Rykatcheff proposed the following arrangement of the business of the meeting:—

Arrangement
of Business.

- A. Terrestrial Magnetism.
- B. Atmospheric Electricity.
- C. Organisation.

A. TERRESTRIAL MAGNETISM.

M. Rykatcheff submitted the following items for consideration by the Commission:—

- I. Comparison of magnetic standard instruments (brought forward by M. Schmidt; also reported on by Mr. Bauer). Reporter M. Ad. Schmidt (Appendices XXV. and XXVI).

Comparison
of Instru-
ments.

After a lengthy discussion, in which Messrs. Schmidt, Liznar, Angot, Rykatcheff, Carlheim-Gyllensköld, Kesslitz and Rudzki took part, the following resolution was adopted by the Commission:—

"The Magnetic Commission consider it essential that the instruments used at the different magnetic observatories be compared with one another, regularly and as frequently as possible. The Directors of the chief Magnetic Institutes are requested to arrange for the comparisons."

- II. Establishment of additional magnetic observatories (brought forward by Messrs. Schmidt and Carlheim-Gyllensköld. Reporter Ad. Schmidt, Appendices XVII, XVIII).

Additional
Observa-
tories.

Messrs. Schmidt, von Bezold, Angot, Liznar and Carlheim-Gyllensköld joined in the debate. Messrs. Schmidt and Carlheim-Gyllensköld were requested to draft a resolution of this subject to be submitted to the next meeting. (See p. 52.)

Quiet and
Disturbed
days.
M. Snellen's
proposals.

III. Exchange of lists of quiet and disturbed days. (Messrs. Schmidt and Snellen; Reporter M. Schmidt.)

M. Schmidt read the proposals of M. Snellen, who was not present. These may be summarised as follows:—

1. The Commission invites the authorities directing magnetic observatories to prepare a list of quiet days once a quarter, and to forward it as soon as possible after the close of the quarter to an officer appointed by the Commission.

2. This officer shall compare the lists, and shall select from them five days, which shall be so distributed that their mean coincides approximately with the middle of the month.

3. The list of days so selected shall be printed and circulated, as early as possible in each quarter, to the Directors of magnetic observatories, and to other interested parties.

4. The day to run from Midnight to Midnight G.M.T.

5. A day shall be regarded as "quiet" if the irregular fluctuations of any of the magnetic elements do not exceed one-third part of the diurnal range for the day.

Magnetic
Classification
of days.
M. Schmidt.

After a thorough discussion of the subject, in which Messrs. von Bezold, Schmidt, Angot, Liznar and Rykatcheff took part, the Commission agreed on the following numerical scale of classification proposed by M. Schmidt:—

0 = quiet days.

1 = disturbed days.

2 = very disturbed days.

It was left to the discretion of individual Directors to fix limits for defining these divisions.

Magnetic Observatories are requested to prepare, from January 1st, 1906, statements showing the magnetic character of each day on the scale 0 to 2. The question of the publication of these statements is referred to the permanent Bureau.

Exchanges of
Records.

IV. Exchanges of records (Messrs. Rykatcheff and Schmidt, also Mr. Bauer). Appendix XXX; Reporter Ad. Schmidt.

Messrs. Rykatcheff, Kesslitz and Angot took part in the discussion.

The Commission resolved:—

"Magnetic Observatories should exchange promptly copies of their traces for all very disturbed days (type 2 on the Schmidt classification), and for other days of special interest. For this purpose a list of magnetic observatories should be drawn up."

A proposal by M. Rykatcheff to proceed with the discussion of the question of organisation was postponed to the next meeting at M. von Bezold's request.

The discussion of business classed under A (Terrestrial Magnetism) was continued.

Hourly
Means.

V. *Publication of Hourly Means.* (Brought forward by M. Schmidt and reported on by Mr. Bauer.) Reporter Ad. Schmidt.

Messrs. Rykatcheff, Schmidt, Kesslitz and Liznar took part in the debate. The following resolution was carried:—

"The Commission requests the conference to recommend that magnetic observatories which possess autographic instruments publish hourly mean values (in Greenwich time) deduced from their curves in place of the instantaneous values at the hour. It should be understood that monthly means (local time) be published as in the past, in addition to the monthly means determined in this way."

The meeting adjourned at 6.15 p.m.

M. v. RUDZKI.

J. B. MESSERSCHMITT.

Second Meeting, September, 12th, 1905.

Present; Messrs. Algué, Angot, von Bezold, Brunhes, Carlheim-Gyllensköld, van Everdingen, Froc, Kesslitz, Liznar, Mazelle, Marchand, Messerschmitt, Mohorovičić, Paulsen, Pockels, Rizzo, v. Rudzki, Ad. Schmidt, Aug. Schmidt, Silvado, Sresneffsky.

The Chairman M. Rykatcheff opened the meeting at 5.15 p.m. The Minutes of the last meeting were read in both French and German, and confirmed.

M. Schmidt read a proposal by Mr. Claxton, who was not present, which *inter alia* would commit all magnetic observatories to making absolute magnetic measurements at least eight times a month. (Appendix XXXI.)

No. of
Absolute
Measure-
ments per
month.

M. Schmidt pointed out that it would be difficult to carry out this proposal in practice. The Conference concurred with this view and adopted the following resolution proposed from the Chair:—

"The Commission is of opinion that local circumstances differ so greatly at different observatories that it is undesirable to prescribe uniform rules of procedure. It is left to the discretion of individual Directors to fix the number of absolute measurements for their observatories."

B. ATMOSPHERIC ELECTRICITY.

Observations on the strength of current in lightning flashes. (M. Pockels. Appendix XXXII.)

Current in
Lightning
Flash.

After a short discussion, in which Messrs. Schmidt, von Bezold, and Liznar took part, as to whether this question was in order, the Commission agreed that there was no ground for excluding it.

M. Pockels briefly explained his method and showed the apparatus. He invited the Commission to set up a number of similar instruments in suitable places and offered to assist in such experiments.

Messrs. Angot and Pockels took part in the discussion.

The Chairman thanked the author for his interesting paper, but thought that it did not come within the province of the Commission to adopt a resolution on the subject.

This was agreed to.

C. ORGANISATION.

M. Schmidt read M. von Bezold's motion :—

"A permanent Bureau consisting of from three to five members is to be elected from among the members of the Magnetic Commission which is about to be appointed by the Conference. It shall be the duty of the Bureau to carry out the resolutions of the Magnetic Commission and to prepare the business for the meetings. The Bureau is also instructed to communicate with the Department for Terrestrial Magnetism of the Carnegie Institute, and to work out a plan for the co-operation of the larger existing institutes with the Department. This plan for co-operation shall be submitted at the next Conference of Directors."

The Resolution was carried after a short discussion.

M. Schmidt read the resolution on question II. drafted at the Commission's request by Messrs. Schmidt and Carlheim-Gyllensköld :—

"The completion of the network of magnetic observatories is necessary. For theoretical and practical reasons it is desirable in the first instance to aim at the establishment of a number of temporary stations near a line joining the poles of the magnetic axis and cutting Africa meridionally.

These stations should be equipped with autographic variation instruments, and, if possible, they should be maintained in operation for a complete sunspot cycle."

The resolution was adopted and entrusted to the permanent Bureau.

M. Schmidt proposed that M. Snellen be requested to continue to collect the lists of quiet and disturbed days (See. III., First Meeting, p. 50).

Carried.

M. Rudzki asked leave to explain some points in the minutes. The meeting adjourned at 6.15 p.m.

M. v. RUDZKI.
J. B. MESSERSCHMITT.

Third Meeting, September, 13th, 1905.

Present: Messrs. Algué, Åkerblom, Angot, von Bezold, Brunhes, Carlheim-Gyllensköld, Durand-Gréville, Froc, Hellmann, Kesslitz, Liznar, Marchand, Mazelle, Mohorovičić, Paulsen, Rykatcheff, Ad. Schmidt, Aug. Schmidt, Silvano.

The Chairman, M. Rykatcheff, opened the meeting at 11 a.m. The minutes of the last meeting were read and confirmed.

The Chairman read the following cablegram from Mr. Bauer from Washington :—"Magnetic Survey of the Pacific commenced under favourable circumstances. Severe magnetic storm and aurora during eclipse. All good wishes for the Conference.—Bauer, Washington."

Permanent
Bureau.

Additional
Observa-
tories.

Collection of
Lists of
Quiet and
Disturbed
Days.

Cable from
Mr. Bauer.

It was agreed that the message be incorporated in the minutes of the proceedings.

M. Rykatcheff stated that a communication had been received from the Solar Commission asking the Magnetic Commission for information on a variety of subjects. He read the document, and added that the Magnetic Commission had already adopted several resolutions which would be of service to the Solar Commission. He instanced the resolutions regarding the selection of quiet and disturbed days, the exchange of records, and the projected list of observatories.

The resolution of the Solar Commission reads as follows :—

"It was resolved that the Magnetic Commission should be asked to assist the Solar Commission in the selection of magnetic observatories, and to advise as to the amount and extent of information which those observatories would be able to give the Solar Commission in order to assist it in the investigation of the relations of solar and terrestrial meteorology."

The item (No. 3) on the programme of the Solar Commission which led to this resolution reads as follows :—

"To draw up a list of magnetic observatories, from which it would be desirable to obtain systematic data and to determine the nature and extent of the data desired and the form in which they should be tabulated and prepared for the use of the Commission, and in connection therewith to consider certain suggestions made by Prof. Langley and the Solar Physics Committee with respect to the collection of magnetic data, and more especially the suggestion that ten-day means, as well as monthly means, should be obtained."

A discussion, in which Messrs. Rykatcheff, Angot, Hellmann and Rudzki took part, followed. The following reply to the Solar Commission was agreed on :—

1. "The Magnetic Commission has adopted several resolutions which meet the wishes of the Solar Commission. Among them may be mentioned the resolutions dealing with (1) the publication of records for disturbed days and of lists of quiet and disturbed days, (2) the description of the magnetic character of each day, and (3) the publication of a list of magnetic observatories.

2. "The Magnetic Commission will communicate all its publications to the Solar Commission.

3. "In the event of the Solar Commission requiring data additional to those enumerated, the Magnetic Commission is prepared to co-operate with the Solar Commission in obtaining them, and requests the Solar Commission to specify in greater detail what is required.

4. "The Commission is of opinion that it is not within its competence to come to a decision on the subject of ten-day means. This question should be settled by the Conference of Directors to which it will be referred.

5. "The Magnetic Commission requests the permanent bureau which is about to be established to assist the Solar Commission by all means in its power."

Relations
with Solar
Commission

Reply to
Solar
Commission

M. Rykatcheff proceeded with the next item on the programme and read a letter from M. Fényi (not present) proposing to introduce autographic lightning recorders at observatories.

After a few remarks from Messrs. Kesslitz and Hellmann the following resolution was carried :—

“The Commission is of opinion that autographic thunder-storm recorders are still in the experimental stage, and consequently it cannot recommend the general adoption of these instruments at observatories.”

Discussion of item 27 of the provisional programme of the Conference followed. M. Kesslitz read a detailed report on his proposal. He asked that a form for tabulating and publishing the records of autographic electrometers be agreed on, so that comparable data regarding the electric condition of the atmosphere at different places might be obtained.

M. Kesslitz's report gave rise to a detailed discussion, in which Messrs. von Bezold, Schmidt, Messerschmitt, Kesslitz, Hellmann, Mazelle and Rykatcheff took part. M. von Bezold gave an account of the observations of M. Lüdeling. M. Messerschmitt briefly described the form which he had adopted for working up records of this kind. M. Hellmann submitted a paper on the subject by M. Sprung.

The following resolution was adopted by the Commission :—

“The Commission is of opinion that investigations on atmospheric electricity have not progressed beyond the stage of study and that definite methods of reduction cannot be recommended as yet.”

The Commission also agreed that the report of M. Kesslitz and the paper by M. Sprung be published as appendices to the report on the proceedings of the Magnetic Commission. (*See* Appendices xi., xxxiii., xxxiv.)

The meeting adjourned at 12.15 p.m.

J. B. MESSERSCHMITT.
M. v. RUDZKI.

Fourth Meeting, September 14th, 1904.

Election of the Permanent Bureau.—Messrs. Rykatcheff (President), Schmidt (Secretary), Chree, Carlheim-Gyllensköld and Moureaux.

The Chairman announced that the Commission is entitled to add to the members elected by the general Conferences of Directors by co-option. Co-opted members to have the same status as elected members.

J. B. MESSERSCHMITT.
M. v. RUDZKI.

REPORT ON THE FIRST MEETING

OF THE

INTERNATIONAL METEOROLOGICAL COMMITTEE.

September 14th, 1905, at Innsbruck.

(Procès-verbal de la séance du Comité international le 14 Septembre, 1905, à Innsbruck.)

Present : Messrs. Hellmann, Hepites, Mohn, Paulsen, Pernter, Rykatcheff, and Hildebrandsson (Secretary).

Present by invitation, M. Angot.

M. Hildebrandsson was asked to take the Chair in the absence of M. Mascart, the former President.

1. M. Mascart was elected President ; M. Hildebrandsson, Secretary.

Election of
Officers.

2. The following Commissions were re-elected :—

Appointment
of Commis-
sions.

1. Magnetic Commission : President, M. Rykatcheff ; Messrs. Bauer, v. Bezold, Carlheim-Gyllensköld, Liznar, Mascart, Moureaux, Palazzo, Paulsen, v. Rijkevorsel, Rücker, Schmidt, Schuster, Chree, Dubinsky, Kesslitz, Messerschmitt and Stupart.

2. Aeronautical Commission : President, M. Hergesell. For names of other members, *see* Minutes of the Meetings of this Commission at St. Petersburg in 1904.

3. Solar Commission : President, Sir Norman Lockyer ; Messrs. Angot, Ångström, von Bezold, Teisserenc de Bort, Bigelow, Birkeland, Cirera, Davis, Deslandres, Sir John Eliot ; Messrs. Hale, Hann, Hepites, Janssen, v. Konkoly, Köppen, Langley, W. J. S. Lockyer, Lyons, Marchand, Mohn, Pernter, Riccò, Rizzo, Rotch, Sir Arthur Rücker ; Messrs. Rykatcheff, Scheiner, Shaw, Silvado, Steen, Stupart, Violle, Vinó, Woeikoff, Max Wolf and Wolfer.

4. Commission on Radiation : M. Violle having sent in his resignation on the ground of failing health, M. Ångström was elected President ; Messrs. Chistoni, Chwolsen, Hincks, Pernter, Hale, Violle, Marchand and Innes.

All these Commissions are entitled to add to their number by co-opting additional members.

3. It was agreed not to reappoint the Commissions on Clouds and Weather Telegraphy as these commissions had completed their work.

H. H. HILDEBRANDSSON.

REPORT OF THE COMMISSION ON CLOUDS.

President, M. L. Teisserenc de Bort.

New Edition
of Cloud
Atlas.

The first edition of the Cloud Atlas will soon be out of print. A new edition is called for by many meteorologists. To meet this request, the former Cloud Commission, consisting of Messrs. Hildebrandsson, Riggenbach and Teisserenc de Bort, issued a circular asking for subscriptions and requesting colleagues to send in any suggestions regarding the new edition which might have occurred to them.

The Classification of Clouds should be adhered to, but the descriptions and diagrams of clouds might be amended if considered desirable.

Many of our colleagues (Messrs. Berson, von Bezold, Froc, Pernter, Polis, Nesdöroff, de Quervain, Rotch, Sprung, Shaw, Wind and others) have sent in suggestions. For the most part these concern the definitions and representations of Stratus and Nimbus.

The Conference elected a new Commission to consider these proposals, consisting of Messrs. Teisserenc de Bort, Hepites, Hergesell, Hildebrandsson, Köppen, Pernter and Rotch.

The Commission has discussed all the desired improvements in the definitions, &c., and proposes the following resolutions for adoption by the Conference. (The resolutions are printed on pp. 38, 39 of the Minutes of the General Meetings.)

(C.) APPENDICES.

APPENDIX I.

INVESTIGATIONS ON SOLAR AND TERRESTRIAL RADIATION.

At the last meeting of the International Committee at Southport I had the honour to present a Report on the current state of the study of radiation, and to make several proposals which appeared to me to be essential for its progress.

These proposals may be summarised as follows :—

1. It is highly important to organise regular measurements of the total solar radiation at all meteorological observatories. These measurements should include hourly observations with direct reading instruments, as well as continuous records with autographic instruments.
2. Ångström's Compensation-Pyrheliometer should be used for the eye observation. It has been recognised as the most suitable instrument for this purpose.
3. Various arrangements may be used for autographic records. The selected actinometer may be adapted to record mechanically, electrically or photographically. When deciding on a form of instrument, accuracy and sensitiveness must be taken into account as with all good measuring instruments. It goes without saying that the instrument should be calibrated, and that it must be verified from time to time by comparing its indications with those of an absolute standard.
4. To determine the loss of energy due to absorption by the earth's atmosphere, about which our knowledge is very limited at the present day, measurements should be made at different altitudes; special importance attaches to measurements at great altitudes.
5. In addition to measurements of the total solar radiation, which are both easiest to make and of most importance, efforts should be made to assist in the fundamental researches now being made on the intensity of different parts of the spectrum. The problems of solar physics connected with variations of solar energy can only be solved in this way.

J. VIOLETTE.

APPENDIX II.

CAUSES OF HEAVY AND WIDESPREAD PRECIPITATION. PERIODICITY OF THESE OCCURRENCES.

Meteorology and hydrology are concerned with the circulation of water over the globe. The former science deals largely with the phenomena caused by the presence of aqueous vapour in the

atmosphere; the latter concerns itself with the motion of water on the surface of the earth. The two sciences thus share a great many interests, a fact which justifies the Austrian Hydrographic Department in sending a representative to attend the Conference of Directors of Meteorological Institutes.

Drainage schemes, however elaborate, cannot afford complete protection against damage by floods, and timely warning of approaching danger to threatened districts may be the means of saving many valuable lives and much property. In spite of the co-operation of telephone and telegraph services (which have in some instances been provided specially for the purpose) warnings, which are based on observations of precipitation and of the height of water in rivers, frequently reach their destinations too late. A considerable time is required both for collating the observations and for communicating the warnings to the very large number of isolated individuals who may be threatened. The smaller the catchment area of a river the greater the difficulty of giving adequate warning, but even in large areas in which there is a flood-forecast service, floods are occasionally missed. This is generally due to unexpected heavy precipitation within the area which should have been warned. For example on a recent occasion when forecasts for low water had been issued for the portion of that Moldau below Prague, which has been rendered navigable and the lock gates had accordingly been closed, the inhabitants were alarmed to find the water on the following morning but little below the well-known danger level. Serious damage was only avoided with difficulty. The rapid rise of the river was caused by a cloud burst in the valley of the Beraun, which joins the Moldau just above Prague. This example also illustrates the fact that the improvement of a waterway makes trustworthy flood warning all the more necessary, for the river would doubtless have been able to carry off the additional volume of water had it not been converted into a canal.

There can be no doubt that forecasts of the level of rivers are a matter of great importance to inland navigation, and that the issue of flood warnings would be greatly improved if they could be based not as at present exclusively on observation of precipitation and of water level, but also on meteorological forecasts of heavy precipitation.

Apart from the question of flood warnings, such forecasts would be of enormous value, in utilising the water for economic purposes. On all sides we hear demands for the storage of flood water and its subsequent use for power purposes. At the present time such demands can only be acceded to in specially favourable cases. In general flood reservoirs must be kept in readiness to receive flood water, and must consequently be emptied as rapidly as possible, which means that the water is wasted. A Report* on the utilisation of storm water in the lakes of the Traun district, recently issued by the Department, may be of interest in this

* K. k. hydrographisches Zentralbureau: Beiträge zur Hydrographie Österreichs, Vol., VII.: Das Traungebiet und die Verwertung des Retentionsvermögens der Salzkammergut-Seen zur Milderung der Hochwassergefahren. Vienna, 1904.

connexion. If trustworthy warning of heavy rains could be given sufficiently early so as to enable the reservoirs to be emptied, the stored water might be used for economic purposes and a powerful impulse would thus be given to the construction of protection works in other localities.

Forecasts giving only 24 hours' notice of heavy rainfall would be of enormous practical value. To provide an adequate basis for them much work would have to be done, but the practical gain would be commensurately large. In the first instance, the causes which lead to widespread heavy precipitation would have to be determined and the pressure distributions which lead up to them would need to be critically studied.

Before formulating a resolution I beg leave to refer to the investigations made by the Austrian Hydrographic Department which have led me to think that such forecasts are within the range of possibility. The floods of the years 1897, 1899 and 1903 have been investigated, and an attempt has been made to identify the distributions of pressure which accompany catastrophic rains. It appears that the region of heavy precipitation generally coincides with a wedge of high pressure projecting into a depression, and that the intensity of precipitation is increased by the absence of secondary depressions. This wedge, to which Billwiller† and Penck‡ have previously drawn attention, is associated with the majority of heavy rains; similar formations are often associated with heavy thunderstorms. The investigations have been based on a series of large scale maps in which isobars were drawn for intervals of two millimeters. Many additional cases have also been examined at the (Austrian) Hydrographic Office, in which wedge-shaped isobars were associated with heavy rains. The further study of the question must be left to meteorologists, and I therefore beg leave to propose the following resolution for adoption by the Conference:—

“Meteorological Institutes are recommended to carry out researches on the causes of unusually heavy and extensive precipitation occurring in the area for which they issue forecasts, and are requested to make the results of such investigations available for general use by publishing them.”

In conclusion I beg leave to bring another question before the Conference, viz., that of the periodicity of unusual weather phenomena. The matter is one of great economic and hydro-technical importance. For instance, the possibility of the occurrence of floods during the period of construction of technical undertakings must always be reckoned with. If the periodic recurrence of dangerous situations could be established, less effective protective measures might suffice over certain periods and much money might be saved in

* K. k. hydrographisches Zentralbureau, Beiträge zur Hydrographie Österreichs, Vols. II. and IV.: Die Hochwasserkatastrophen der Jahre 1897 und 1899 in Österreich, beziehungsweise im österreichischen Donaugebiete. Vienna, 1898 and 1900.

† Billwiller: Die Niederschläge in der Schweiz, September, 1881 und ihre Beziehung zur Luftdruckverteilung. Met. Zeit., Vol. XVII. (1882), p. 1.

‡ Penck: “Die Donau” Schriften des Vereins zur Verbreitung naturwissenschaftlicher Kenntnisse in Wien, Vol. XXXI., p. 48. Vienna, 1891.

consequence. I therefore beg leave to ask the Conference to adopt the following additional resolution :—

“It would be useful to collect from all available historical documents of different states information regarding abnormal weather phenomena such as floods, droughts, severe winters, &c., and to publish it.”

E. LAUDA.

APPENDIX III.

REDUCTION OF BAROMETRIC READINGS TO MEAN SEA LEVEL.

Circular letter of the Deutsche Seewarte.

SIR, Hamburg, May 25th, 1905.

ADVERTING to my letter No. 10666 III. of December 10th, 1904, I beg leave to send herewith a statement (Enclosure I.) of the methods adopted in different European countries for the reduction of barometric readings to mean sea level. A summary of the methods and of the replies which have been received to the letter I have referred to are appended to the statement.

I also enclose (II.) a short discussion of the question. A more detailed account of it is given in a pamphlet by Professor Grossmann,* entitled “Die Barometrische Höhenformel und ihre Anwendung,” which will be sent to you in due course.

On the basis of these communications I beg leave to bring forward the following proposals for general adoption in connexion with telegraphic work :—

(1.) Tables shall be prepared for each station more than 20 metres (= 60 ft.) above M.S.L., giving the increments required for reduction to sea level for all pressures and temperatures. The entries in these tables shall be under the headings “Pressure” (corrected for index error and reduced to 32° and to Lat. 45°), and “Temperature” (dry bulb reading corrected for index error).

(2.) These tables shall be sufficiently detailed to avoid interpolation.

(3.) Tables VII.† (or VIII.) A and D (*see below*) of the

* The pamphlet was published in “Annalen der Hydrographie und Maritimen Meteorologie,” Vol. XXXIII., 1905. A summary appeared in “Met. Zeitschrift,” Vol. XXIII., 1906.

† The formula on which the international tables are based may be written (adopting metric units) :—

$$H = (18429 + 67.53 \theta + 0.003 H) \frac{1}{(1 - \beta)} (1 + \gamma) \log \frac{B_0}{B}$$

H = height of station in metres.

θ = mean temperature of the air column.

B_0 and B = the barometric readings at sea level and at station level respectively at 0° C.

$1 - \beta = 1 - 0.378 \frac{E}{B}$ is the term depending on the relative humidity in which E = the mean pressure of the aqueous vapour in the air column, B = the mean pressure of the air in the column.

$1 + \gamma = 1 + 0.00259 \cos 2 \lambda$, where λ = the latitude.

Table VII., A, gives the values of 1000 M corresponding with values of H and H

θ , where $M = 10^m - 1$ and $m = \frac{H}{(18429 + 67.53 \theta + 0.003 H)}$.

Table VII., D, gives values of $(B_0 - B)$ corresponding with values of 1000 M and H.

Tables VIII., A and D, give corresponding data for English units.

International Meteorological tables shall be used as the basis for calculating the new tables.

(4.) Tables VII. (or VIII.) A and D make no allowance for (1) vertical temperature gradient, (2) humidity, (3) a small residual correction for reducing to lat. 45°.

To allow for these factors a correction shall be calculated and incorporated in the tables for each station on the basis of (1) a mean vertical temperature gradient of 0.5° C. per 100 metres, (2) the mean annual humidity.

For altitudes up to 500 metres this correction may be taken as constant. Its values are as follows :—

A. Adopting the value 18429 for the barometric constant K :—

Height (metres) ...	0-80	80-230	230-380	380-540
Correction (mms.)	— 0.0	— 0.1	— 0.2	— 0.3

B. Adopting the value 18400 for the barometric constant K :—

Height (metres) ...	0-60	60-190	190-320	320-450
Correction (mms.)	— 0.0	— 0.1	— 0.2	— 0.3

(5.) Abnormally high reduced values, which betray the influence of strong local cooling, shall be neglected when drawing isobars.

(6.) Stations below 20 metres shall apply a constant increment calculated from Tables VII. (or VIII.), A and D, on the basis of the mean annual pressure and the mean annual temperature.

I am, &c.,
HERZ.

Enclosure I.

STATEMENT OF THE METHODS ADOPTED IN DIFFERENT EUROPEAN COUNTRIES FOR THE REDUCTION OF BAROMETRIC READINGS TO MEAN SEA LEVEL.

1. **Denmark.**—The altitude of the stations is in general so small that constant increments calculated for the temperature 8° C. suffice to give sea level values correct to the nearest 0.1 mm. Only in the case of the highest station, Vestervig, can the error attain 0.2 mm.

2. **Germany.**—At stations below 20 metres included in the Daily Report of the Deutsche Seewarte a constant correction is applied. For other stations reduction tables have been calculated from Tables VII., A and D, of the International Tables, in which the entries are made under the headings “Dry bulb temperature” and “Pressure” (reduced to 0° C. and latitude 45°).

No correction is applied for humidity.

The highest stations are Munich, 528 metres, Friedrichshafen, 408 metres, and Chemnitz, 317 metres.

3. England.

The tables now in use have been recently re-calculated from Tables VIII., A and D, of the International Meteorological Tables. No correction is applied for humidity, gravity or temperature gradient, as at the small altitudes of telegraphic reporting stations the results are well within the limits fixed by the Innsbruck Conference, even if these be neglected.*

The highest stations are Malin Head, 230 ft., Oxford, 212 ft.

4. France.—The formula used is :—

$$H = 18400 (1 + a t') \log \frac{B_0'}{B'}$$

H = the height in metres.

$a = 0.00367$.

B_0' and B' are the barometer readings reduced to 0°C . and latitude 45° .

t' = a "reduced" temperature which is computed in the case of mountain stations from the dry bulb temperatures on the summit and at the corresponding base stations, and in the case of other stations from the formula—

$$t' = t + 0.0055 \frac{H}{2}$$

No correction is applied for humidity.

For mountain stations barometric readings are published for both station level and sea level.

5. Italy.—The formula used is :—

$$H = (18429.1 + 67.53 t' + 0.003 H) \log \frac{B_0}{B'}$$

in which $t' = t + \frac{H}{2} a$ when 1000 a has the following monthly values :—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
5.48	5.22	6.70	6.58	6.92	5.04	5.20	4.76	5.68	6.50	5.96	5.43

Barometer readings are reduced to 0°C . only.

No correction is applied for humidity or gravity.

* The formula used up to 1908 was a very old one :—

$$H = 60159 \left(1 + \frac{t - 32}{450} \right) (1 + 0.00268 \cos 2 \phi) \left(1 + 0.0025 + \frac{H}{R} \right) \log \frac{B_0}{B'}$$

in which—

H = height in feet.

t = dry bulb temperature in degrees Fahrenheit.

ϕ = the latitude.

R = the radius of the earth.

B and B_0 = the barometric readings (in inches) corrected for instrumental error and reduced to 32° only.

6. Netherlands.—As a general rule stations are between 3 and 5 metres above sea level and a constant increment is applied at each. The only exception is Maastricht (60 metres), where mean monthly temperatures are introduced into the formula. No correction appears to be applied for humidity.

7. Norway.—All telegraphic stations are at low levels, and a constant increment is calculated for each station from the formula—

$$B = \frac{0.0951}{1 + a t'} \frac{B'}{760} H,$$

in which—

t' = the annual mean temperature.

B' = the annual mean pressure.

$a = 0.00367$.

8. Austria.—(a.) Vienna. The formula adopted is :—

$$H = 18400.2 (1.00157 + 0.00367 t') \left(1 + 0.378 \frac{e_1 + e_2}{2} \right) (1 + 0.0026 \cos 2 \phi) \left(1 + \frac{H}{R} \right) \log \frac{B_0}{B'}$$

in which—

$R = 6378150$.

$t' = t + 0.005 \frac{H}{2}$ (t = dry bulb reading.)

B' = pressure reduced to lat. 45° at station level.

e_1 = the mean annual vapour pressure.

e_2 = the mean annual vapour pressure at sea level calculated from Hann's formula.

(b.) Trieste. ($H = 67.5$ metres.)

The formula adopted is :—

$$H = 18429 (1 + 0.004 t) (1 + 0.0026 \cos 2 \phi) (1 + \beta H) \log \frac{B_0}{B'}$$

in which the dry bulb temperature t is applied.

The observations sent in from Genoa and Laibach and also those from a few Russian stations are reduced by special tables; data from coast stations are reduced by the application of a constant correction; those from other stations are reduced by the observers.

9. Portugal.—The tables in use are calculated in accordance with the "Annuaire du Bureau des Longitudes."

10. Roumania.—Reduction cards have been prepared for the individual stations from comparison of the readings with those of Sulina (altitude 2 metres) on a number of selected occasions of uniform distribution of pressure. The selected occasions embrace different conditions of pressure and temperature. No account is taken of humidity.

11. Russia.—(a.) St. Petersburg. (1) At altitudes up to 25 metres constant corrections are applied based on an assumed decrease of pressure of 0.9 mm. per 10 metres of altitude.

(2) At all other stations the reduction is based on the International Tables; the uncorrected dry bulb readings and the mean annual humidity are entered in the formula. The tables issued to stations between 25 and 300 metres above M.S.L. give the increments to be added to the reading at station level. For higher stations, the sea level readings corresponding with the station readings are shown.

(b.) Helsingfors. All barometer readings are reduced to latitude 45° and then reduced to sea level by Table VII. A and D of the International Tables. The dry bulb temperature is adopted, and no correction is made for humidity.

The greatest altitude is 146 metres.

12. Sweden.—The formula adopted is:—

$$\log \frac{B_0}{B} = \frac{(1 - 0.00259 \cos 2\phi) (1 - 0.000000157 H) H}{18400} f(t_m),$$

$$\text{in which } f(t_m) = \frac{1 - 0.378 \frac{r_m e'}{100 B_m}}{1 + a t_m}.$$

Barometer readings are reduced to latitude 45° before they are entered in the formula; t_m is the mean temperature of the air column, e' the pressure of saturated water vapour at t_m , r_m the mean percentage humidity of the air column.

For r_m the values given below are adopted, and for B_m the value 730 mms. is taken, so that the factor $f(t_m)$ becomes a function of the mean temperature, for all stations.

For calculating t_m from t , a temperature gradient of $0.5^\circ \text{C. per } 100 \text{ metres}$ is assumed at 0°C. At other temperatures it is calculated by making the difference, $\log f(t) - \log f(t_m)$ constant for all temperatures in such a manner that—

$$\log f(t) - \log f(t_m) = 0.00164 \text{ for } t_m - t = 1^\circ \text{C.}$$

The following values of a , the co-efficient of decrease of temperature, are calculated on this assumption:—

t_m	...	-30°	-20°	-10°	0°	$+10^\circ$	$+20^\circ$	$+30^\circ$
r_m	...	70	70	70	70	60	50	40
$\log f(t_m)$	...	0.0506	0.0330	0.0159	-0.0007	-0.0169	-0.0327	-0.0482
a	...	0.004	0.005	0.005	0.005	0.006	0.006	0.006

13. Switzerland.—The method described by Hann in the *Meteorologische Zeitschrift* in 1874 is adopted. The monthly means of pressure and temperature are reduced to sea level and the differences are calculated:—

$$B_n^{(0)} - B_n = \Delta_n.$$

The differences, which include the gravity correction, are then applied to the individual readings (reduced to 0°C.) to reduce them to sea level. The corrections applied are thus constant for each month.

14. Servia.—The International Tables have been used for the preparation of the reduction tables. The dry bulb temperature, the observed vapour pressure, and the barometer reading reduced for temperature (but not for latitude) are entered in the formula.

The stations are all below 500 metres.

15. Spain.—The International Tables are used, and temperature and humidity are taken into account.

16. Hungary.—Reduction cards are prepared for each station from the International Tables. A vertical temperature gradient of $0.5^\circ \text{C. per } 100 \text{ metres}$ is assumed. Humidity is taken account of by adopting the vapour pressures which most frequently correspond at Pesth with given temperatures. These values are as follows:—

Degrees C.	...	...	-10°	0°	$+10^\circ$	$+20^\circ$
Millimetres	...	...	1.5	4.0	6.8	10.8

17. Belgium.—The barometer readings at Uccle and Cointe (Liège) are reduced by Köppen's formula:—

$$\log B_0 = \log B + \frac{H}{18460 + 72 T},$$

in which T = dry bulb temperature. At all other stations constant increments are used.

All readings are corrected for gravity.

SUMMARY OF THE METHODS USED IN DIFFERENT COUNTRIES.

(1.) Mean temperature for the air column calculated from the formula:—

$$T_m = T_o + \frac{a}{100} \frac{H}{2}$$

are adopted in the following countries:—

France: $a = 0.55$.

Italy: Monthly values of a which vary between 4.8 (August) and 6.9 (May).

Holland: Monthly values for a (Maastricht).

Austria (Vienna): $a = .5$.

Hungary: $a = .5$.

Sweden: a complicated method of procedure is followed, for the computation of a (see above).

(2.) Humidity is taken into consideration in the following countries:—

Austria, Trieste: $(1 + .004 t)$ is introduced into the formula instead of $(1 + .00367 t)$.

Austria, Vienna: A rather complicated method is followed, (see above, p. 63).

Russia: The mean annual absolute humidity is introduced at all stations above 25 metres.

Sweden: A complicated formula (see above).

Servia: The observed humidity is introduced into the formula.

Hungary: The humidity corresponding to the most usual conditions prevailing at Pesth under similar conditions of temperature is assumed for all stations.

(3.) The small correction for the variation of gravity with altitude appears to be neglected in Belgium, Germany, France, Italy and Finland.

(4.) In Switzerland the increments are calculated for each month from monthly mean values of pressure and temperature. In Roumania the increments depend on the prevailing pressure distribution, as well as on the temperature of the external air.

The replies which have been received to the proposals of the Seewarte may be summarised as follows:—

1. France, Hungary, Holland, Portugal, Italy and Roumania favour the proposals made by the Deutsche Seewarte for the introduction of a uniform method of reduction. Hungary and Italy go so far as to declare themselves prepared to adopt a change of method.

2. Denmark is opposed to the introduction of a uniform method on the ground that it would lead to the introduction of systematic errors.

3. Sweden (Prof. Ekholm) points out that values of the vapour pressure or the vertical temperature gradient different from those suggested might prove more suitable. A more important point is raised by consideration of the mean temperature most suitable for entry in the formula. At mountain stations there is no diurnal change of pressure corresponding with the diurnal variation of temperature. The assumption of a very close connexion between the temperature at the time of observation and the pressure thus appears unjustifiable. Prof. Ekholm is of opinion that it is preferable to adopt Ferrel's plan and to introduce the mean of the last three observations of temperature (2 p., 8 p. or 9 p., 7 a. or 8 a.), or of the last observed maximum and minimum temperatures. In all these matters a really rational method will not be attained until pressure observations are reduced upwards to a fixed level above the sea.

4. Switzerland (Prof. Billwiller) points out that the method adopted in Switzerland (*see above*, p. 64) has stood the test of 25 years' trial, during which time it has given very satisfactory results. The barometric gradient over Switzerland has been satisfactorily shown, but the observations from neighbouring countries (Austria and South Germany), which are reduced by other formulae, frequently show large apparent errors which would disappear if the Swiss method of reduction were universal. "For the reduction of barometric readings at stations above 100 metres, the method advocated by Prof. Hann and myself is certainly the best. It is the only correct one in view of the frequent occurrence of local reduction or elevation of temperature (Föhn.)."

5. Hungary (Hofrat v. Konkoly) points out that the International Tables are not very convenient for daily use as they involve the necessity for first finding an approximate value

of the reduced pressure to be subsequently corrected by the introduction of the term for humidity.

6. Italy (Prof. Palazzo) points out that if a universal method should be agreed on, the International Meteorological Committee would have to prepare a special edition of the new tables in a language understood by all, for example, French.

Enclosure II.

ARGUMENTS IN SUPPORT OF THE PROPOSALS PUT FORWARD BY THE DEUTSCHE SEEWARTE FOR THE ADOPTION OF A UNIFORM METHOD FOR THE REDUCTION OF BAROMETRIC READINGS TO MEAN SEA LEVEL.

(1.) Replies to Objections.

In connexion with the method of reduction applied in Switzerland, which was proposed by Professor Hann in 1874, mention should be made of a note published by Hann in the same volume of the "Meteorologische Zeitschrift" (p. 130), in reply to criticisms of the original paper from Professor Wild. "I fully recognise the importance of M. Wild's criticism of my second proposal, and *take this opportunity of recalling my recommendation of the general adoption of this method* (the italics are Professor Hann's), and limiting its application to mountain stations should it be desired to include these data in synoptic charts." On occasions of great local reduction of temperature in valleys Professor Hann's method, which introduces into the reduction formula higher temperatures and lower pressures than the observed values, must give lower pressure at sea level than the more usual methods. These values may fit in with the general distribution of pressure rather better than those which are strongly influenced by local conditions. Such marked local effects are, however, dependent on special meteorological conditions as well as on the position of the station, and it seems preferable to omit these stations when drawing isobars for sea level, rather than to adopt universally a method of reduction which is known to give only approximate results.

The proposal to reduce all barometric readings to a fixed plane above mean sea level, to which M. Ekholm once more directs attention, is a matter of great importance. Even if this plan were adopted, assumptions would have to be made regarding the distribution of temperature and water vapour in the air column, and, moreover, the guidance in the drawing of isobars which wind observations at present afford would be more or less lost. The isobaric charts published in Daily Weather Reports might also lose in general interest if such a course were adopted.

The introduction of the mean of the preceding temperature observations in place of the temperature at the time of observation, as suggested by Ferrel, is also open to serious criticism, and it seems very doubtful whether any advantage would be derived from the introduction of this rather complicated system.

(2.) Limits of accuracy of the proposed method.

(*See Professor Grossmann's paper, loc. cit.*)

The magnitude of the change in the increment for reducing barometric readings to sea level, introduced by the term relating

to humidity, is shown in the following table for altitudes up to 500 metres, and for values of the ratio, $\frac{E_0}{B_0}$ between .01 and .04.

Height in Metres.	$\frac{E_0}{B_0}$ at Sea Level.							
	.01		.02		.03		.04	
	mm.	inch.	mm.	inch.	mm.	inch.	mm.	inch.
0	0	0	0	0	0	0	0	0
100	-0.04	-.002	-0.07	-.003	-0.11	-.004	-0.14	-.006
200	-0.07	-.003	-0.14	-.006	-0.21	-.008	-0.28	-.011
300	-0.10	-.004	-0.21	-.008	-0.32	-.013	-0.42	-.017
400	-0.14	-.006	-0.28	-.011	-0.42	-.017	-0.55	-.022
500	-0.17	-.007	-0.34	-.014	-0.51	-.020	-0.67	-.027

In calculating the table, the mean temperature of the air column has been taken as 0° C.; at higher temperatures the figures are smaller on account of the smaller density of the air. In practice the ratio $\frac{E_0}{B_0}$ seldom exceeds the value .02.

The magnitude of the change in the increment introduced by taking the mean temperature of the air column as $\left(T + a \frac{H}{2}\right)$ is as follows:—

Height in Metres.	a .									
	0.004		0.005		0.006		0.007		0.008	
	mm.	inch.	mm.	inch.	mm.	inch.	mm.	inch.	mm.	inch.
100	-0.04	-.002	-0.04	-.002	-0.05	-.002	-0.06	-.004	-0.07	-.003
200	-0.07	-.003	-0.09	-.004	-0.10	-.004	-0.12	-.005	-0.14	-.006
300	-0.10	-.004	-0.13	-.005	-0.16	-.006	-0.18	-.007	-0.21	-.008
400	-0.14	-.006	-0.17	-.007	-0.21	-.008	-0.24	-.010	-0.28	-.011
500	-0.17	-.007	-0.22	-.009	-0.28	-.010	-0.30	-.012	-0.36	-.014

(3) *Reduction to sea level when all terms in the formula are taken account of.*

The simplest method of accomplishing the reduction when all terms are to be taken into account is to calculate the so called "reduced temperature." As Professor Grossmann has shown, the auxiliary tables required for this purpose need not be complicated.

(4) *Reduction to mean sea level adopting the mean annual humidity and a constant temperature gradient.*

The tables become considerably simplified if constant values be assumed for the pressure of aqueous vapour, the temperature gradient, and the atmospheric pressure in the ratio $\frac{E}{B}$. We may then proceed in one of two ways:—

1. Corrections, applicable to the individual stations, may be applied to the temperature values;
2. The effect of the additional terms on the pressure increment required to reduce to sea level may be calculated and incorporated in the tables prepared from the

International Tables VII. (or VIII.), A and D. In that case the observer would only have to perform a single operation, viz., to apply to the barometer reading (corrected for index error and reduced to 0° C.) the increment corresponding with the observed dry bulb reading.

(5) *Reduction to sea level, assuming—(a) that the ratio $\frac{E}{B} = 0.01$;*

(b) a vertical temperature gradient of 0.005 C. per metre.

Making these assumptions, the following table shows the magnitude of the corrections to be applied to the increments calculated from the International Tables VII. (or VIII.), A and D:—

Height in Metres.	Corrections on account of						Total Correction.	
	$\frac{E_0}{B_s} = 0.01.$		$\alpha = 0^{\circ}.005$		δ			
	mm.	inch.	mm.	inch.	mm.	inch.	mm.	inch.
0	0	0	0	0	0	0	0	0
100	- 0.04	- .002	- 0.04	- .002	+ 0.01	+ .0004	- 0.07	- .003
200	- 0.07	- .003	- 0.09	- .004	+ 0.03	+ .001	- 0.13	- .005
300	- 0.10	- .004	- 0.13	- .005	+ 0.04	+ .002	- 0.19	- .008
400	- 0.14	- .006	- 0.17	- .007	+ 0.06	+ .002	- 0.25	- .010
500	- 0.17	- .007	- 0.22	- .009	+ 0.07	+ .003	- 0.32	- .013

δ is a correction required for reducing to sea level readings which have been already reduced to latitude 45°, by means of tables in which the barometric constant is taken as 18429; $\delta = 0$, if tables based on the constant 18400 are used and the readings are reduced to latitude 45°.

The mean temperature of the air column is taken as 0° C.

The increments are to be applied to barometric readings corrected for index error and reduced to 0° C. and to latitude 45°.

A further small correction, depending on the latitude, ϕ , must also be applied. Its magnitude at 500 metres above sea level is as follows:—

ϕ	mm.	Inch.	ϕ	mm.	Inch.
0	-0.12	-.005	50	+0.02	+.001
10	-0.12	-.005	60	+0.06	+.002
20	-0.09	-.004	70	+0.09	+.004
30	-0.06	-.002	80	+0.12	+.005
40	-0.02	-.001	90	+0.12	+.005
50	+0.02	+.001			

The magnitude of the correction introduced by the terms $\left(1 + \frac{H}{R}\right)$ is too small to be taken into account at these altitudes.

Reduction tables may be prepared for each station by applying the corrections given in the last column of the table shown above to the increments calculated as functions of B and T from the International Tables VII. (or VIII.), A and D. With such tables the observer would merely have to look up the increment corresponding with a given dry bulb reading, and a given pressure reading (at 0° C. and latitude 45°), and add it to the latter.

The introduction of a mean temperature gradient of $0^{\circ}.5$ C. per 100 metres is in accordance with the assumption now generally made in climatological work at Hann's suggestion.

The assumption of a uniform value ($.01$) for the mean annual value of the ratio $\frac{E}{B}$ is also admissible in most cases. The use of more accurate value in exceptional cases might be optional.

A more accurate method of taking account of the influence of humidity and temperature gradient is that of finding their effect on the adopted temperatures (as described under (3), p. 68), but as the observer would in that case have to operate with two temperatures, and as we are only dealing with small corrections, the calculation of the effect of these terms on the pressure increments seems preferable. The preparation of the tables offers no difficulty, as they merely involve the application of a constant correction, which can be easily found.

ATTITUDE OF THE DEUTSCHE SEEWARTE TO M. NILS EKHOLM'S PAPER "SUR LA RÉDUCTION DU BAROMÈTRE AU NIVEAU DE LA MER À EMPLOYER POUR LES CARTES SYNOPTIQUES JOURNALIÈRES."

1. The decision to adopt a constant correction for stations at altitudes up to 20 metres is not a new one. In the particular case quoted in Ekholm's paper for Hernösand, the increments calculated (1) from the mean annual pressure and temperature, and (2) from the data of the day in question, are respectively 1.44 mm. and 1.68 mm., or in round numbers 1.4 and 1.7 mm. The day was, however, a very exceptional one as the temperature stood at -34° C.

2. For the seven other instances quoted by M. Ekholm the results of the reductions, adopting the mean annual humidity of the air, are given under C on page 8 of his paper. The method suggested by the Deutsche Seewarte of adopting a constant value, 0.01 , for the ratio $\frac{E_0}{B_0}$, is not considered. (E_0 = the vapour pressure reduced to sea-level; B_0 = the barometric pressure at sea-level). It may be pointed out that this proposal is quite as simple as that of leaving the humidity entirely out of account, as it only requires the application of a small correction which is constant for each station. (See above p. 68.) For instance, the correction for Innsbruck amounts to -0.4 mm. The method of procedure advocated by the Seewarte gives for the first three cases quoted for Innsbruck the values 777.12 , 758.72 , 759.48 at sea level, which agree with the values 777.28 , 758.50 , 759.28 obtained by using the observed humidities to within 0.2 mm. They are in each case 0.04 mm. smaller than the values obtained by Ekholm using the mean annual humidity. We see therefore that, even in these extreme cases, the simple method advocated by the Seewarte gives results which are correct to within 0.2 mm.

3. The details of the calculations for the seven cases quoted, are not given by M. Ekholm. Attention is drawn once again to the exceedingly simple method of calculating the "reduced temperature" described by Professor Grossmann in his paper, "Die barometrische Höhenformel und ihre Anwendung" (Annalen der

Hydrographic und maritimen Meteorologie, Vol. XXXIII., 1905; also Meteorologische Zeitschrift, Vol. XXIII., 1906.) The reductions, in which the small tables given in this paper can be used exclusively, take the following form, when made by this method.

	Innsbruck.	Innsbruck.	Innsbruck.	Langres.	Langres.	Dovre.	Dovre.
B	722.2	711.2	710.7	719.1	724.5	682.0	702.0
T	-6.6	29.0	21.2	-6.8	22.2	-25.6	18.0
e	2.7	15.9	15.0	2.3	16.5	0.3	12.3
H	577	577	577	466	466	644	644
ϕ	47° 16'	47° 16'	47° 16'	47° 52'	47° 52'	62° 5'	62° 5'
T	-6.6	29.0	21.2	-6.8	22.2	-25.6	18.0
$\frac{H}{\alpha \frac{1}{2}}$	1.44	1.44	1.44	1.16	1.16	1.61	1.61
ϵ	0	0	0	0	0	0	0
$\Delta \phi$	-0.06	-0.06	-0.06	-0.07	-0.07	-0.39	-0.39
Δ_h	+0.01	+0.01	+0.01	+0.01	+0.01	+0.01	+0.01
Δ_δ	-0.43	-0.43	-0.43	-0.43	-0.43	-0.43	-0.43
Δ_e	0.41	2.49	2.35	0.34	2.51	0.02	1.96
α ()	0.01	0.22	0.15	0.00	0.17	0.07	0.08
Reduced Temperature.	-5.22	32.67	24.66	-5.79	25.55	-24.71	20.84
Increment to reduce to M.S.L. (mms.)	55.05	47.33	48.61	44.01	39.60	63.07	54.49
Pressure at M.S.L. (mms.)	777.25	758.53	759.31	763.11	764.10	715.07	756.49

4. In the event that the introduction of the mean annual humidity giving rise to errors which exceed the allowable limits, the introduction of the observed humidity in the manner suggested by Professor Grossmann does not involve appreciably more labour than the other methods suggested by M. Ekholm in cases where we have to deal with a large number of readings from the same station. All the correctional terms are constant for the same station with the exception of (1) the term for humidity, and (2) the term a (....). The latter cannot influence the reduction to sea level by more than 0.05 mm., even in extreme cases.

To illustrate further Grossmann's method the reduction tables for Innsbruck are reproduced at the end of this paper. Table I. gives a correctional term which depends on the barometer reading (at 0°, corrected for index error and, if desired, also for latitude) and on the observed vapour pressure; to this must be added a constant term, 0.096, calculated on the assumption of a diminution of temperature of 0.5° C. for an increase of height of 100 metres. These two terms when applied to the observed dry bulb reading give the "reduced temperature" to be adopted in selecting the required increment from Table II. which has been calculated from Tables VII. A and D of the International Table.

If greater accuracy is insisted on, a small additional correction (a [....]) must be applied to the adopted dry bulb reading. If Δ_c be the constant portion of the correction, and Δ_a that depending on the humidity, Professor Grossmann shows that a small additional correction Δ' is required where

$$\Delta' = 0.00367 (\Delta_a + \Delta_c) T.$$

Its value is so small that it may be neglected in all save the most extreme cases; in the three examples quoted for Innsbruck it alters the final results by 0.00, - 0.07 and 0.05 mm. respectively.

5. With regard to M. Ekholm's demand that the calculation should admit of an accuracy of 0.1 mm., even in the most extreme cases, the Deutsche Seewarte is of opinion that this degree of accuracy is requisite only in cases where the vertical distributing of temperature and humidity are known, and all other possible sources of error are excluded.

The method advocated by the Seewarte is for use at telegraphic reporting stations. The reduction is intended to give comparisons between barometric readings taken at different levels so as to obtain a representation of the horizontal distribution of pressure. Such comparison is not possible unless a preliminary reduction is made.

In no case can the calculations lay claim to a high degree of precision as they involve assumption regarding the conditions of temperature and humidity in an air column which has no actual existence. If, as is unfortunately the case, the observations on which synoptic charts are based are not truly simultaneous, it seems reasonable to rest satisfied with an accuracy of the order of a half or a third of a millimetre.

6. For these reasons the Deutsche Seewarte adheres to the proposals made in the circular letter of May 25th, 1905, and recommends them for general adoption.

Should the majority of the members of the Conference favour a method which admits of greater accuracy, the Seewarte begs leave to suggest the method put forward by Professor Grossmann, which requires two tables and provides for the introduction of the observed vapour pressure into the calculations. Tables applicable to the station at Innsbruck have been calculated by this method and are appended.

HERZ.

SPECIMEN TABLES FOR REDUCING BAROMETRIC READINGS TO MEAN SEA LEVEL.

Station : Innsbruck. Height above Mean Sea Level, 577 metres.
Latitude 47° 16' N.

TABLE I.

Corrections depending on the Humidity, and to be applied to the Dry Bulb Reading to obtain the "reduced temperature."

Vapour Pressure (c) in mms.	Barometric Reading at 0° C.								Vapour Pressure (c) in mms.
	670	680	690	700	710	720	730	740	
1	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	1
2	0.33	0.32	0.32	0.32	0.31	0.31	0.30	0.30	2
3	0.49	0.49	0.48	0.47	0.47	0.46	0.45	0.45	3
4	0.66	0.65	0.64	0.63	0.62	0.61	0.61	0.60	4
5	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	5
6	0.99	0.97	0.96	0.95	0.93	0.92	0.91	0.90	6
7	1.16	1.14	1.12	1.11	1.09	1.08	1.06	1.05	7
8	1.32	1.30	1.28	1.26	1.25	1.23	1.21	1.20	8
9	1.49	1.47	1.44	1.42	1.40	1.38	1.37	1.35	9
10	1.65	1.63	1.61	1.58	1.56	1.54	1.52	1.50	10
11	1.82	1.79	1.77	1.74	1.72	1.69	1.67	1.65	11
12	1.99	1.96	1.93	1.90	1.88	1.85	1.82	1.80	12
13	2.16	2.12	2.09	2.06	2.03	2.00	1.98	1.95	13
14	2.32	2.29	2.25	2.22	2.19	2.16	2.13	2.10	14
15	2.49	2.45	2.42	2.38	2.35	2.32	2.28	2.25	15
16	2.65	2.62	2.58	2.54	2.51	2.47	2.44	2.40	16
17	2.83	2.78	2.74	2.70	2.66	2.63	2.59	2.56	17
18	2.99	2.95	2.90	2.86	2.82	2.78	2.75	2.71	18
19	3.16	3.11	3.07	3.02	2.98	2.94	2.90	2.86	19
20	3.33	3.28	3.23	3.19	3.14	3.10	3.05	3.01	20

In addition to the above, a constant Correction of + 0°.96 = + 1° C. must be applied to the Dry Bulb Reading, on account of the vertical temperature gradient, to obtain the "reduced" temperature.

TABLE

Increments for Reduction of Barometric

Reduced Temperature.	670	675	680	685	690	695	700	705
°	mms.	mms.	mms.	mms.	mms.	mms.	mms.	mms.
— 30	56.5	57.0	57.4	57.8	58.2	58.6	59.1	59.5
— 28	56.1	56.5	56.9	57.3	57.8	58.2	58.6	59.0
— 26	55.6	56.0	56.4	56.8	57.3	57.7	58.1	58.5
— 24	55.1	55.5	55.9	56.4	56.8	57.2	57.6	58.0
— 22	54.6	55.1	55.5	55.9	56.3	56.7	57.1	57.5
— 20	54.2	54.6	55.0	55.4	55.8	56.2	56.6	57.0
— 18	53.8	54.2	54.6	55.0	55.4	55.8	56.2	56.6
— 16	53.3	53.7	54.1	54.5	54.9	55.3	55.7	56.1
— 14	52.9	53.3	53.7	54.1	54.5	54.9	55.3	55.7
— 12	52.5	52.8	53.2	53.6	54.0	54.4	54.8	55.2
— 10	52.1	52.4	52.8	53.2	53.6	54.0	54.4	54.8
— 8	51.6	52.0	52.4	52.8	53.1	53.5	53.9	54.3
— 6	51.2	51.6	52.0	52.4	52.7	53.1	53.5	53.9
— 4	50.8	51.2	51.6	52.0	52.3	52.7	53.1	53.5
— 2	50.5	50.9	51.2	51.6	52.0	52.4	52.7	53.1
0	50.1	50.5	50.8	51.2	51.6	52.0	52.3	52.7
+ 2	49.7	50.1	50.4	50.8	51.2	51.6	51.9	52.3
+ 4	49.3	49.7	50.0	50.4	50.8	51.2	51.5	51.9
+ 6	49.0	49.3	49.7	50.1	50.5	50.8	51.2	51.5
+ 8	48.6	48.9	49.3	49.7	50.1	50.4	50.8	51.1
+ 10	48.2	48.6	49.0	49.4	49.7	50.1	50.4	50.8
+ 12	47.9	48.3	48.6	49.0	49.3	49.7	50.0	50.4
+ 14	47.6	47.9	48.3	48.6	49.0	49.3	49.7	50.0
+ 16	47.2	47.6	47.9	48.3	48.6	49.0	49.3	49.7
+ 18	46.9	47.2	47.6	47.9	48.3	48.6	49.0	49.3
+ 20	46.5	46.9	47.2	47.6	47.9	48.3	48.6	49.0
+ 22	46.2	46.5	46.9	47.2	47.6	47.9	48.3	48.6
+ 24	45.9	46.2	46.6	46.9	47.3	47.6	48.0	48.3
+ 26	45.6	45.9	46.2	46.6	46.9	47.3	47.6	48.0
+ 28	45.3	45.6	45.9	46.3	46.6	47.0	47.3	47.7
+ 30	45.0	45.3	45.7	46.0	46.3	46.6	47.0	47.3
+ 32	44.7	45.0	45.4	45.7	46.0	46.3	46.7	47.0
+ 34	44.3	44.7	45.0	45.3	45.6	46.0	46.3	46.7

II.

Readings to Mean Sea Level.

710	715	720	725	730	735	740	Reduced Temperature.
mms.	mms.	mms.	mms.	mms.	mms.	mms.	°
59.9	60.3	60.7	61.2	61.6	62.0	62.4	— 30
59.4	59.8	60.2	60.7	61.1	61.5	61.9	— 28
58.9	59.3	59.7	60.1	60.5	60.9	61.3	— 26
58.4	58.8	59.2	59.6	60.0	60.4	60.8	— 24
57.9	58.3	58.7	59.1	59.5	59.9	60.3	— 22
57.4	57.8	58.2	58.6	59.0	59.4	59.8	— 20
57.0	57.4	57.8	58.2	58.6	59.0	59.4	— 18
56.5	56.9	57.3	57.7	58.1	58.5	58.9	— 16
56.1	56.5	56.9	57.3	57.7	58.1	58.5	— 14
55.6	56.0	56.4	56.8	57.1	57.5	57.9	— 12
55.2	55.5	55.9	56.3	56.7	57.1	57.5	— 10
54.7	55.1	55.4	55.8	56.2	56.6	57.0	— 8
54.3	54.7	55.0	55.4	55.8	56.2	56.6	— 6
53.9	54.3	54.6	55.0	55.4	55.8	56.1	— 4
53.5	53.9	54.2	54.6	55.0	55.4	55.7	— 2
53.1	53.5	53.8	54.2	54.6	55.0	55.3	0
52.7	53.1	53.4	53.8	54.2	54.6	54.9	+ 2
52.3	52.7	53.0	53.4	53.8	54.1	54.5	+ 4
51.9	52.3	52.6	53.0	53.4	53.7	54.1	+ 6
51.5	51.9	52.2	52.6	53.0	53.3	53.7	+ 8
51.1	51.5	51.8	52.2	52.6	52.9	53.3	+ 10
50.7	51.1	51.4	51.8	52.2	52.5	52.9	+ 12
50.4	50.7	51.1	51.4	51.8	52.1	52.5	+ 14
50.0	50.4	50.7	51.1	51.4	51.8	52.1	+ 16
49.7	50.0	50.4	50.7	51.1	51.4	51.8	+ 18
49.3	49.7	50.0	50.4	50.7	51.1	51.4	+ 20
49.0	49.3	49.7	50.0	50.4	50.7	51.1	+ 22
48.7	49.0	49.4	49.7	50.0	50.4	50.7	+ 24
48.3	48.7	49.0	49.3	49.6	50.0	50.3	+ 26
48.0	48.3	48.7	49.0	49.3	49.7	50.0	+ 28
47.7	48.0	48.3	48.6	49.0	49.3	49.7	+ 30
47.4	47.7	48.0	48.3	48.7	49.0	49.3	+ 32
47.0	47.3	47.6	48.0	48.3	48.6	49.0	+ 34

APPENDIX IV.

PROPOSALS FOR EXTENDING THE AREA OF DAILY REPORTS
TO INCLUDE THE EASTERN PORTION OF THE ATLANTIC
OCEAN.

The Daily Weather Reports of the present day show the distribution of pressure and temperature over Western, Southern and Central Europe. It is highly desirable to extend the area of the charts so as to include the eastern portion of the Atlantic Ocean. This could be done if the various liners crossing the ocean would communicate their observations by wireless telegraphy to the receiving stations on land. About 70 vessels leaving European ports (most of them for America) are now provided with wireless apparatus :—

Sailing from the English Channel	about 50 vessels.
" " Mediterranean	" 12 "
Belgian Mail Packets, Ostend—Dover	" 8 "
Total	" 70 "

Graphic itineraries issued by the Marconi Company show the approximate positions of these boats for each day. To prepare a chart for the eastern Atlantic Ocean with approximately the same degree of accuracy as is now attained over western Europe about 16 floating stations would be required off the coast of the Iberian Peninsula. Between latitudes 45° and 50° there are about 5 stations to each day, and for more southerly latitudes an average of 2 stations a day would be available. Data from the Azores and Iceland, which are now in telegraphic communication with the continent would complete the map. As several companies, for instance the North German Lloyd, are about to equip their boats with wireless apparatus, we may hope to have sufficient stations for the construction of isobaric charts very shortly. The observations should be coded on the international scheme and be transmitted to the receiving stations on the coasts of Ireland, Spain, or Portugal; ships in more northerly latitudes might perhaps communicate with Iceland where the Marconi Company are about to establish a station.

P. POLIS.

APPENDIX V.

OBSERVATIONS ON ELECTRIC PHENOMENA OF THE ATMOSPHERE
MADE WITH AUTOGRAPHIC THUNDERSTORM RECORDERS.

In the year 1900 Professor Boggio-Lera introduced an autographic apparatus for recording thunderstorms which promises to throw considerable light on these phenomena and therefore ought to be adopted generally. The principle involved is that of wireless telegraphy in which Herzian waves, set up by the lightning discharges, are made to affect a coherer.

I beg leave to draw attention to this apparatus, which is extremely simple and can be made by every observer at but slight cost, especially if he is prepared to dispense with a clock. This is a point of great importance when an instrument is required for universal use. All that is needed is a wire helix of about 100 turns, a coherer (made from wire), and a collecting wire; a magnetic compass placed near the helix serves as an indicator. The apparatus can be made extremely simple as lightning flashes influence the coherer very powerfully. It is not desirable to obtain records of very distant discharges, and for this reason the apparatus should not be too sensitive.

Experience, extending over several years, has shown that the apparatus will record all thunderstorms occurring in the neighbourhood, even those below the horizon.

The apparatus gives useful information as to whether there exists a tendency for the formation of thunderstorms, or whether an approaching dark cloud will give rise to a thunderstorm or not. The behaviour of the compass needle also shows various peculiarities during the course of a storm which are of interest.

No question should arise as to the satisfactory working of the coherer in view of the success which now attends the use of that instrument in wireless telegraphy. It has also given satisfaction in recording lightning flashes. The fact that the coherer does not respond to all flashes should not be brought up against it. Flashes are rarely missed, only about one in twenty is lost, and these may be accounted for by the collecting wire not being "tuned" for every flash and by interference phenomena. It is, however, essential to have the instrument tested from time to time by a competent observer. This can be easily done experimentally with an electric spark. The apparatus should not be set up in large towns in which there are always many electromotors, high potential wires, &c.

Further particulars of the instrument are contained in a pamphlet "Über Konstruktion und Funktion eines einfachen Gewitterregistrators."

Kolacsá, May, 1905.

J. FÉNYI, S.J.

APPENDIX VIa.

ARGUMENTS IN SUPPORT OF ITEMS 12, 13, 14, 15, 16, AND 19
OF THE PROVISIONAL PROGRAMME.12. *Classification of Stations.*

There is no guiding principle underlying the present international system of classifying stations into First Order, Second Order, Third Order, and Rainfall stations. I beg leave to propose that the basis of classification be the number of elements observed with the help of instruments. Other points to be considered are the number and kind of the instruments and whether they be autographic. The following elements, all of which are observed

instrumentally, should form the basis of classification: pressure, temperature, humidity, and precipitation. I assume that wind and clouds are estimated and not determined instrumentally. The fact that a station possesses a nephoscope or an anemoscope is not taken into account in classifying it.

Commencing at the bottom of the scale, stations might be equipped as follows:—

- (1) Raingauge only, *i.e.*, one element, one instrument.
- (2) Raingauge and Thermometer, *i.e.*, instruments for two elements: Precipitation, Temperature.
- (3) Raingauge, Thermometer, Hygrometer (or in place of or in addition to thermometer and hygrometer, a psychrometer), *i.e.*, instruments for three elements: precipitation, temperature, humidity.
- (4) Raingauge, Thermometer, Hygrometer (Psychrometer), Barometer: instruments for the four elements: precipitation, temperature, humidity, pressure.

In addition, stations provided with autographic instruments have to be considered. As regards these, I would suggest compliance with the two following conditions as qualification for admission to a higher order, *viz.*:—(1) possession of all the instruments enumerated under (4), and (2) possession of at least two autographic recorders.

In cases in which autographic recorders are in use for all these elements and also for wind (direction and force or velocity) and sunshine, I would suggest using the term "observatory" in place of "station of the first order." The name "observatory" would thus be restricted to stations provided with a complete outfit of autographic instruments for recording pressure, temperature, humidity, wind, sunshine and rainfall.

Observatories would have to be further classified as central observatories or as observatories of the first or second class. At central observatories additional observations are made and auxiliary apparatus is in use both for direct readings (actinometers, nephoscopes, dissipation apparatus, balloon apparatus, &c.) and for continuous recording (say of solar radiation, atmospheric electricity, or seismological phenomena). They also test the instruments used at the stations of the network. Observatories of the second class would be provided only with the outfit detailed above, but those of the first class would possess additional instruments as well.

Hitherto the want of a guiding principle has prevented the adoption of a uniform nomenclature in the classification of stations. My proposals are intended to aid in producing uniformity. (For details of the proposed classification, *see* p. 23.)

13. Amount of Cloud.

Information regarding cloud has been restricted as a rule to an estimate of the area of the cloud canopy. Formerly the form and density of the cloud were also noted. It may be considered desirable to return to the older method of entry, but I do not propose to raise this question now but will leave it for consideration by the

Committee which will be re-elected by the Conference. In the meantime I wish to see an agreement arrived at which will do away with the defect of the present system which leads us to enter cloud amount 5 both for occasions when passing bands of cirrus cover half the sky and for those when the sky is half obscured by heavy stratocumulus. Might not the form of cloud be indicated by an index 0, 1, 2, 3, &c.? I think such a scheme would work well in the case of stratus, stratocumulus and cumulus clouds; for cirrus clouds it would not be so satisfactory. For cirrus, I would suggest an estimate of the area over which the blue of the sky is actually blotted out. I therefore beg leave to request that cloud amount 5 be entered on occasions when the whole sky is covered by true cirrus cloud, and that in the cases of other cloud forms, indices 0, 1, 2, 3 be appended to the figure for cloud amount to indicate the density and thickness of the clouds and the light which penetrates them. The entries would then be made thus, 10⁰, 5³, 4², &c.

14. Limits of Accuracy required in Measurements of Temperature and Rainfall.

Meteorological publications lack uniformity in this matter. Rainfall is generally printed in whole millimetres. Occasionally temperature is given in whole degrees only. As a general rule this degree of accuracy will suffice, but in many cases it would be a distinct loss not to have the tenths of a degree stated. I therefore beg leave to propose that, when dealing with individual readings, rainfall be recorded and published to the nearest tenth of a millimetre, and temperature to the nearest tenth of a degree (centigrade).

15. Forms of Clouds.

The present definition of nimbus, the raincloud, is a tautology. We say—raincloud is every cloud from which rain is falling. That is true enough, but it is also self-evident. There is no case on record of rain or snow falling from cirrus, cirro-stratus or cirrocumulus cloud, also not from alto-cumulus. Experience teaches us that rain and snow fall from altostratus, when it has developed into a slate-grey layer covering the entire sky, from stratocumulus, so long as it is continuous, from storm cumulus and from thick fogs. We ought therefore to describe dense altostratus, and heavy stratocumulus as "rain clouds," and add a note that thick low fogs in form of stratus occasionally give rise to rain, and that thunder rains fall from cumulo nimbus clouds.

16. *Rauhreif, Raufrost and Glatteis.*

There is no uniformity in the use of these terms. My own observations have led me to draw a marked distinction between the well-known heavy deposit of rough ice which forms during the windy foggy weather on all objects, most heavily on the side exposed to the wind, and the delicate covering which forms during calm, or practically calm, foggy weather. The formation of the former has been closely studied by Assmann, and I beg leave to suggest the restriction of the term "Raufrost" to describe this

phenomenon. The latter frequently decks our gardens with a wonderfully beautiful covering of microscopic ice crystals and ice threads, and for it I suggest the name "Rauhreif" or "Duft."

As regards "Glatteis" the definition should lay stress on the universal cause of its formation, viz., the so-called "ice-rain," consisting of supercooled rain drops which congeal wherever they fall and cover all surfaces with a smooth coating of ice. I have never yet observed a case of "Glatteis" which had a different origin, and I have not come across a single well-authenticated observation of another mode of formation, but I will not deny that other modes of formation may be possible. I therefore propose the following definition:

Rauhreif (V. "Duft.") A deposit of numerous ice crystals on trees, blades of grass and other objects from a foggy atmosphere during calm weather and under conditions of considerable cold. Branches and twigs are uniformly covered with a fine coating of ice crystals and frequently silvery threads of ice stretch from branch to branch. The appearance is extremely beautiful.

Rauh frost ("Anreim") occurs during cold, windy, foggy weather. Under these circumstances the fog consists of supercooled water droplets which solidify as soon as they are driven by the wind against obstacles. In this way they coat all objects with which they come in contact (not merely trees, &c., but even houses) with a layer of ice. On mountains this layer frequently attains such dimensions that all objects present the appearance of large lumps of ice. Rauh frost occurs occasionally in valleys, but it is particularly frequent and severe on mountains.

Glatteis (∞). When rain consists of supercooled water drops (temperature of -4° or -5° C. has been observed in these "ice rains") the ground and all surface on which it falls, become coated with smooth ice. The supercooled drops freeze as they strike the ground or other object, and cover it with a smooth coating of ice even if its temperature be several degrees above the freezing point. The deposit is called "glatteis."

Very occasionally "glatteis" may be formed in other ways and it would be a good thing if observers would send in detailed and trustworthy accounts of every formation of "glatteis."

[No attempt has been made here to give the English equivalent of the German terms. The French edition of this Report uses the word "frimas," to translate "Rauhreif, Duft"; "givre" for "Rauh frost, Anreim"; "verglas" for "glatteis."] (See also p. 25).

19. Wet Fog.

Wet fog, i.e., fog which wets exposed surfaces and from which small droplets are being deposited should be specially noted. For this purpose I beg leave to propose the symbol ☼ , a combination of the fog symbol ☁ and a symbol formerly used to indicate rainfall ☉ . In the German language a wet fog is distinguished by the term "Nebelreissen." [The French edition uses the word *bruine*; many English meteorologists take the word *mist* as the equivalent of *wet fog*.]

J. M. PERNTER.

APPENDIX VIb.

NECESSITY FOR SIMPLE OR GENERALLY INTELLIGIBLE DEFINITIONS OF THE PHENOMENA KNOWN AS GELÉE BLANCHE, GIVRE, AND VERGLAS. ITEM 16.

Dew (rosée) and hoar frost (gelée blanche) differ in their manner of formation solely in the conditions of temperature under which they are produced. The definitions of these phenomena should be associated in my opinion in the following manner:—

"Dew is the name given to the drops of liquid water condensed on objects from the atmosphere. The precipitation is due to the cooling of the objects by radiation below the dew point of the atmosphere. It is for this reason that dew is most frequently observed on fine evenings or nights, on the horizontal surfaces of objects possessing small capacity and conductivity for heat (provided that they are insulated from conduction of heat from below).

"If saturation is reached under similar conditions, but at temperatures below the freezing point, hoar frost is formed, that is to say, needle-shaped crystals of white ice appear on the exposed surfaces, giving them a dull silvery appearance.

"From the conditions attending their formation both dew and hoar frost occur with a falling temperature."

In view of the fact that "givre" is formed in nature by two different processes, and that the precipitation in the two cases is essentially different in external appearance, I am of opinion that the two phenomena should be distinguished as follows:—

"There are two kinds of 'givre.'

"1. 'Givre' which condenses on the objects themselves. It has the appearance of needle-shaped crystals of ice and forms when frost gives way suddenly to warm and moist weather, on objects of which the temperature is still below the freezing point. These objects must have great capacity and small conductivity for heat. 'Givre' of this kind closely resembles hoar frost in external appearance, but it forms as a rule with an overcast sky, and always during a rise of temperature. The symbol for this phenomenon might be ∇.

"2. 'Givre' deposited from the air. This is a deposit from the air of supercooled droplets of water, which congeal as soon as they come in contact with solid objects. 'Givre' of this kind is deposited most copiously on the side of objects exposed to the wind. It forms a semi-transparent, rough covering of ice. The symbol for this phenomenon might be √.

In cases where the precipitation of very highly supercooled drops is as intense as in ordinary rain, the phenomenon might be called by the name "ice rain" (la pluie glacée), and be distinguished by the symbol ○.

If that were agreed to, the symbols ●, ✱, Δ, ▲, ☼, ∞, √, ∇, √, and ○ would include all the different forms of precipitation.

It seems to me more rational to regard glazed frost (*verglas*) not as a new phenomenon, but as an observed state which may be due to varying causes. It might be defined as follows:—

The name '*verglas*' (glazed frost) is assigned to a layer of ice coating the surface of the ground, of snow, or of other objects. It may be formed by '*givre*,' or by the freezing of water after rain or after a thaw, or by other circumstances.

The changes which I have suggested would not materially alter the definitions of these phenomena given in books of instructions to observers, and for that reason the observations entered on the old system and on the proposed system would not cease to be comparable.

V. CHIPTCHINSKY,

Assistant at the Imperial Institute of Forestry,
St. Petersburg.

APPENDIX VII.

ITEM 17. THE WEATHER DIARY.

By the term "weather diary," I mean a notebook in which the course of the weather and the appearances of the sky are described for each day in greater or less detail, according as circumstances and the inclinations of the observers dictate. The record should give a connected account of the weather of each day, and so form a very useful amplification of the schedules in which the observations at fixed hours are entered in their respective columns. The latter, even if supplemented by notes in the "remarks" column, cannot give a clear and complete account of all changes occurring during the day. We can never be certain that an important phenomenon did not occur during the interval between successive observations; thus, for instance, it is impossible to say on most occasions whether the sky cleared to any extent in the intervals between the observations at fixed hours for days on which the cloud amounts at the fixed hours are entered at 9 and 10. Similarly the occurrences of fog between the regular observing hours is frequently not recorded. Many similar questions arise, and it is precisely on points of this nature that a Central Office is frequently called upon for information by public bodies or private individuals. The required information can only be inferred very rarely from the observations at fixed hours, and it is only by keeping a detailed record of this nature (both by day and by night) at the "Central Anstalt" that we are able to give the required particulars for Vienna. We are, however, frequently called upon for information regarding meteorological conditions at a particular hour for other places in the Empire, and unless a weather diary happens to be available it is extremely difficult to do so. The records are also exceedingly useful in checking forecasts, and therefore contribute towards progress in that branch of our work. Moreover, records of this sort are often very necessary in scientific inquiries of various kinds. For all these reasons I wish to recommend the keeping of weather diaries very strongly. I quote two examples, one

from a short record which may be regarded as answering all ordinary purposes, the other from a very detailed register, such as only a few observers can be expected to keep:—

1. July 3, 1904. The early morning (6 a.m.) was cloudy with occasional sunshine; later on the clouds lifted, and by noon the sky was cloudless. Close. At 4.20 p.m. clouds appeared in S.E., travelling towards N. 4.30 p.m. sky entirely overcast, with rising wind, increasing to a gale. 4.45 p.m. first raindrops fell. Thunder and lightning not very frequent. 5 to 5.30 p.m. a regular cloud-burst occurred. Gradual clearing, distinctly cooler. 7 p.m. beautiful evening. 10 p.m. starlight night.

2. May 25, 1904. Early morning overcast with thick fog. At 6 a.m. the sun broke through for a short time, fog thickening again, especially to westward; after 7.30 a.m. the sun again broke through; patches of blue sky increasing and frequent sunshine. The air is calm and warm. The fog appears to be turning into true cumulus cloud, especially in the west. It looks as though the day would not prove really fine. Right; towards 10.30 a.m. it suddenly became so dark that it was difficult to read. A very black squall cloud covered the greater part of the sky. Immediately afterwards a gale from the westward sprang up, and rain fell in torrents. The squall cloud passed away but rain continued to fall. After 2.30 p.m. the sky cleared, and only a band of cirrus remained. The sun shone continuously till sunset, but the gale continued unabated till 6 p.m., and even then did not drop entirely. It has become cooler. After sunset clouds collected in the west, and continued to increase. At 9 p.m. the gale commenced afresh, but subsequently the wind moderated, at times to a light breeze.

J. M. PERNTER.

APPENDIX VIII.

ITEM 18. OPTICAL ATMOSPHERIC PHENOMENA.

A recommendation demanding attention for optical atmospheric phenomena might appear superfluous, for these phenomena are not only intimately connected with the weather, but also play an important part in the physics of the atmosphere. It is well known that a watery sun or moon indicates approaching rain; halos indicate that the clouds in which they occur consist of ice crystals; coronae give us information as to the size of the elements composing the cloud, or as to whether they consist of water droplets or of ice crystals; the sizes of the water particles can be deduced also from observations of rainbows, &c. Observation and measurement of all these phenomena undoubtedly form part of meteorology, and I therefore beg leave to suggest that such observations be recommended to all observers.

To promote work of this nature, I add the instructions on the subject which have been issued for the Austrian network of stations.

INSTRUCTIONS FOR OBSERVING OPTICAL ATMOSPHERIC PHENOMENA. ISSUED BY THE AUSTRIAN METEOROLOGICAL DEPARTMENT.

There are a large number of optical phenomena which not only arrest the attention of observers on account of their beauty, but also are more or less closely connected with the weather; they are of importance for both reasons, and observers are recommended to note them carefully.

Halos.

Many different kinds of halo have been observed (*see* fig. 1*). The most common is the halo of 22° —a large ring, CIBG, round the sun or moon, having a radius of very nearly 22° (of a great circle). When of no great intensity the ring appears white, but

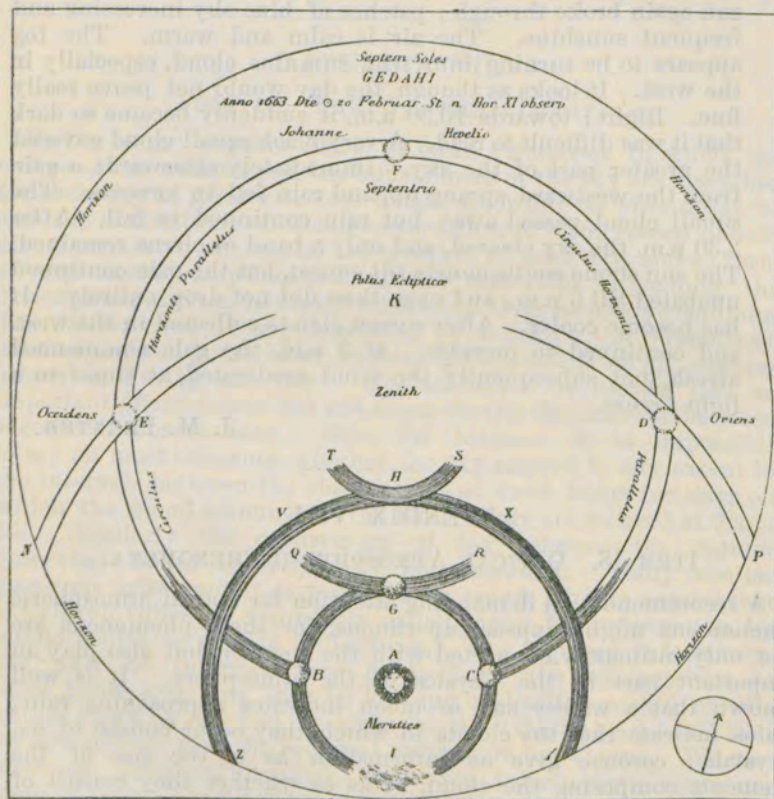


Fig. 1.

when it is more strongly developed we may easily recognise the fact that the edge nearest the sun is red—a very pure red—and

* Fig. 1 is a representation of the so-called Danzig phenomenon, as seen, drawn, and described by the well-known astronomer Hevel. The date of the observation is shown at the head of the figure. This figure is a facsimile of the original in Hevel's Publication (*see* Hellmann, Neudrucke, Meteorologische Optik, p. 57).

that orange, yellow, and, under very favourable circumstances, green, follow on, as we go outwards. The latter colour is always rather faint and whitish, and the blue is almost always so faint that it is not recognised as blue. Violet is never recognisable. The ring thus appears white on its outer edge.

A ring of about twice the radius, halo of $46''$, Fig. 1, VXYZ, is of much more rare occurrence. Its luminosity is much less than that of the halo of $22''$; the arrangement of the colours, if visible, is the same.

Occasionally a cloudless white ring, which passes through the sun parallel to the horizon, may be recognised. This is called the horizontal circle or mock sun ring. The latter name has been given to it because the mock suns described below lie on or near it. It is represented in the figure by the circle CDFE, in which the portion BC, which passes through the sun, cannot be detected. This is frequently the case, but there are many cases on record in which the portion passing through the sun was distinctly visible.

A fourth ring is exceedingly rare; it is white, and has a radius of about 90° ; it is known as the halo of 90° . In the diagram two portions of it, NE and DP, are visible; if produced they would pass through K. It is obvious that this halo can never be seen in its entirety in our latitudes, for this would require the sun to be in the zenith.

It should be mentioned that the rings are frequently incomplete in the cases of the three first-mentioned halos also; at times only small portions of them can be seen.

There are a number of other halo phenomena which, from their method of formation, can only be seen as arcs. Among these are the so-called *arcs of contact*, of which two are shown in the figure. Both of them are arcs of upper contact, RGQ belonging to the halo of 22° , LHS to that of 46° . Arcs of lower contact may occur in connexion with both these rings, but they are very rare. The arcs of upper contact appear with their convex sides turned towards the sun, as shown in the figure. Contact arcs appear occasionally at the sides of the halos of 22° and 46° , but they are as rare as the arcs of lower contact. The arcs of upper contact are very luminous at the points of contact, which have occasionally been described as "mock suns." The colour effects are often brilliant, red being turned towards the sun, *i.e.* on the convex edge of the halo. The coloration of the arc of upper contact of the halo of 46° is frequently exceedingly brilliant. The ends of the arc of upper contact of the halo of 22° are frequently bent downwards.

A large number of other rings and arcs have been observed on rare occasions, and are generally described as "irregular"; observers who are fortunate enough to see such irregular bows are requested to sketch and describe them carefully, and, if possible, to measure their angular distance from the sun.

Of all halo phenomena, mock suns (parhelia) and mock moons (paraselenae) are probably the most admired. These terms are used to describe luminous, or even brilliantly bright, images of the sun which are seen most frequently at or near the intersection of the halo of 22° with the white mock sun ring (B and C, fig. 1).

Very rarely mock suns are seen at or near the intersection of this ring with the halo of 46° . The mock suns of this halo are always very faint, and their colouring is indistinct; mock suns belonging to the halo of 22° are, on the other hand, both frequent and very luminous, and their colours are brilliant. Red is on the side nearest the sun, with yellow, green, and blue following in order. Blue is generally indistinct, and violet is usually too faint to be distinguished. As a rule a long and pointed white tail, occasionally attaining a length of 20° , extends from the mock suns along the mock sun ring (see fig. 1).

The mock suns of the ring of 90° (D and E, fig. 1) have been observed on a few occasions only since Hevel's day.

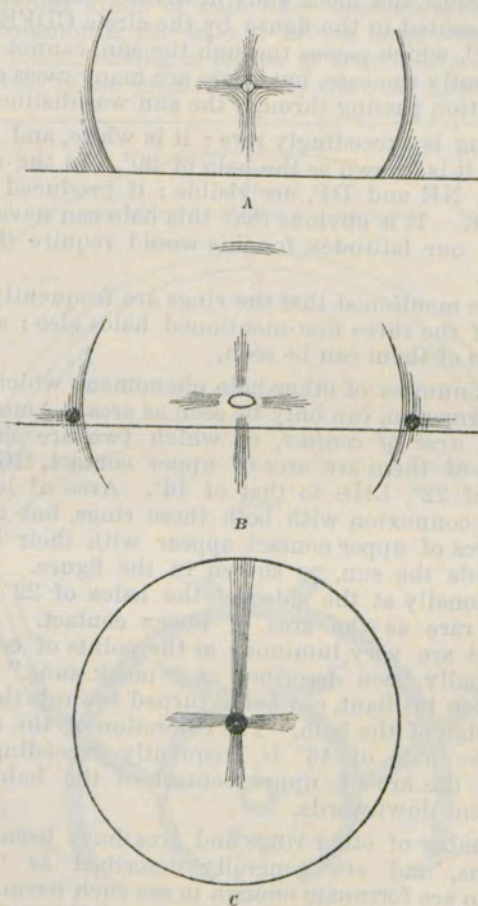


Fig. 2.

Not infrequently mock suns are seen without that any of the rings are observed.

A white brilliant image of the sun is occasionally observed immediately opposite to it, i.e., 180° away from the luminary along the mock sun ring. This is known as the counter sun.

Mock counter suns, at about 60° along the mock sun ring from the counter sun, have been repeatedly observed, and their distances from the sun have been measured.

Other mock suns, besides those which have been mentioned, are occasionally seen. Observers are requested to sketch and describe what they see carefully, should they happen to observe one of these. If possible they should determine its position by measurement.

Other very beautiful halo phenomena are afforded by *sun pillars*, which are most easily observed at sunrise or sunset. These frequently extend about 20° above the sun and generally end in a point. At sunset they may be entirely red, but as a rule they are of a blinding white and show a marked glittering. If the sun is high in the heavens, white bands may appear vertically above and below him, but these are not very brilliant and often they are very short. Occasionally these white columns appear simultaneously with a portion of the white mock sun ring, and so form another very remarkable phenomena, viz., the cross (Fig. 2).

Frequently parts only of the rings and arcs are visible, having apparently no connexion with one another, thus lending a very peculiar appearance to the sky; not infrequently these arcs intersect obliquely, which increases the strangeness of the appearance.

Many other halo phenomena are known to occur, but the space which can be devoted to the subject in a book of instructions to observers is limited, and they cannot all be described here. All halo phenomena should be carefully sketched and described.

Halos only occur in presence of cirrus clouds or of light ice fog; they are produced by refraction and reflection of the rays of the sun or moon by ice crystals. The sun has been assumed as the source of light in all the phenomena described. This has been done solely for the sake of brevity; precisely similar though rather less brilliant appearances may be produced by moonlight.

Coronae.

Coronae are seen most frequently round the moon. As their diameter is generally considerably smaller than that of the halo of 22° they are very near the luminary and can thus only be seen around the sun under favourable circumstances. No doubt they occur round the sun as frequently as round the moon; they may be observed by making use of a reflector or of a smoked glass to reduce the intensity of the light.

Coronae are very different from halos. The latter are produced by refraction, whereas the former are diffraction phenomena. The positions and orders of the colours serve to distinguish the two sets of phenomena. Coronae invariably show a brownish red inner ring, which, together with the bluish-white inner field between the ring and the luminary, forms the so-called *aureole*. Frequently, indeed very frequently, the aureole alone is visible. The brownish red ring is characteristically different from the red ring of a halo; the former is distinctly brownish, especially when

the aureole alone is visible, and of considerable width, whereas the latter is beautifully red and much narrower. If other colours are distinguishable, they follow the brownish-red of the aureole in the order from violet to red, whereas the red in a halo is followed by orange, yellow and green. The order of the colours is thus reversed.

The size of the diameter of the ring has been erroneously suggested as a criterion for distinguishing between halos and coronae, but a corona may be quite as big as a halo. Bishop's ring* has furnished a well-known example of such a corona. The criteria which the observer should apply to distinguish the two sets of phenomena are not the diameters of the rings, but the sequence of colour and the presence of the brown-red of the aureole.

As coronae are diffraction phenomena they occasionally show the sequence of colour two or three or even four times over. This can never be the case with a halo. Observers are requested to note carefully the colours which they can identify and also the order in which they follow one another from the inside to the outside of the ring.

In a foggy atmosphere (especially on mountains) an observer, standing with his back to the sun, will sometimes see a coloured ring of light round the shadow cast upon the fog by his own head. This appearance has been variously called "*glory*," "*Ulloa's ring*," "*Brocken spectre*," etc.

Green and red patches are occasionally seen in cirrus clouds, at a great distance from the sun or moon. They have no apparent connexion with coronae and may even occur when no corona is visible. Frequently a number of these patches may be seen along a line passing through the sun. This phenomena is known as "*irisation*." The most important point to note is the (angular) distance between the sun (or moon) and the patches showing irisation.

Rainbows.

The erroneous assumption that all rainbows show the same sequence of colours and have the same radius has caused the careful study of this phenomenon to be much neglected. It has been shown that the colours of a rainbow as well as their extent and the position of the greatest luminosity are very variable and depend on the size of the drops producing the bow. It is very desirable that greater attention be given again to this subject. If we note (1) the sequence of colours seen in the primary bow commencing with the red, (2) the colour which shows the maximum luminosity, and (3) which colour band is the widest, we can in most cases calculate the size of the drop producing the bow. This can be done with greater certainty if the observer also gives attention to the secondary bows which frequently appear on

* In the year following the eruption of Krakatoa (1883) and again in 1903 after the eruption of Mount Pelée, a brownish red ring of over 20° diameter was frequently seen with a clear sky. It was proved to be an unusually large corona.

the inner side of the primary bow, and (1) notes the sequence of colours in them, and (2) states whether the bows are continuous with the primary bow and with one another.

Observation should also be made of the auxiliary bow which appears outside the primary bow at a distance of about 12° from it. This bow is of less importance, if the primary bow is visible.

Colouration of the Sky.

A cloudless sky appears to be blue but it may show all possible gradations between a deep blue and a whitish-bluish shade. It is desirable to note the gradations of colour according to the scheme; deep blue, light blue, and pale blue. Such observations give information regarding the purity of the air, and may also be used as indications of coming weather.

The most beautiful colours are seen at dusk. When the sky is cloudless, the colour and form of the first "*purple light*" is worth attention. It is approximately parabolic in shape and appears at a considerable elevation above the point where the sun disappeared soon after sunset.* It varies in colour between pink and violet. Observers are also invited to note the colouring of the western sky and the appearance of the "*second purple light*" which develops after the disappearance of the first. The time of disappearance of the second light is also of importance. If "*Alpenglühén*" and "*after glow*" are associated with the sunset, the phenomena should be noted.

The colouration of the clouds at sunset is often very beautiful and very striking, and is therefore frequently noted, although the phenomena observed when the sky is clear are more important.

The following international symbols have been adopted for some of the phenomena described above: Solar halo ⊕, solar corona ⊙, lunar halo ☾, lunar corona ☾, rainbow ∩.

J. M. PERENTER

APPENDIX IX.

MOTION OF CYCLONES AND ANTICYCLONES.

It is a well known fact that atmospheric depressions and high pressure systems generally move from W.S.W. to E.N.E. in our hemisphere.

The velocity of motion and its direction are two questions which have not been completely solved, which deserve, I may almost say demand, most careful attention. The daily charts issued by the various Offices do not give the necessary data for determining the depth and motion of depressions except in an approximate manner. They refer to a particular hour of the day, and the times of highest or lowest barometer coincide with the times of the maps but rarely.

For example, if the curve of variation of barometric pressure at Rome, deduced from successive values of the minima and maxima

* All these remarks apply also to sunrise but in the reverse order.

of pressure, be compared with a similar curve deduced from the information contained in the daily weather report of the Central Office, a mean difference of between 7 and 8 hours is found. For this reason it is desirable to study these meteorological questions in a more practical manner, and I beg leave to bring forward some suggestions for attaining this object. I believe that we should be in a much better position for studying these cyclonic waves on the Continent of Europe if the following scheme were inaugurated:—

1. A limited number of observatories, suitably distributed over the region to be studied, should make it their business to record these atmospheric waves on a carefully arranged plan.
2. The region might be limited on the west by the coasts of Ireland, France, the Iberian Peninsula, and Africa, and on the east by the meridian of St. Petersburg. The parallel of 30° and 65° N. might form its southern and northern boundaries.
3. The observatories should be distributed at intervals of about 5° both in latitude and in longitude. The total number of observatories would then be about 64.
4. They should be distributed in longitude as far as possible along the meridians, so that seven or eight stations would come within each of the eight or nine areas into which the total longitude could be divided.
5. Each observatory should be provided with a barograph, and should abstract from the records (a) the values of the minima shown on the curves, with their times of occurrence; (b) the values of the pressure 24 hours before and 24 hours after the time of occurrence of the minima; (c) similar data for the maxima of atmospheric pressure.
6. The abstracts should include only those maxima and minima which differ from the normal pressure value by 5 millimetres at least.
7. The same method should be adopted at all observatories for preparing the abstracts.
8. A permanent committee should be formed to organise the observations, and subsequently to study them.
9. At the end of each year the data should be sent to a central observatory, which should be the headquarters of the committee. The latter should examine the data, and by careful comparison attempt to arrive at definite conclusions from them.

A. RODRIGUEZ, O.S.A.,
Director of the Vatican Observatory.

APPENDIX X.

ITEM 25. SECULAR STATIONS.

The possibility of preparing long range forecasts has recently given increased interest to the investigation of secular meteorological changes. I therefore think it important to draw the attention of the Conference to the task of providing suitable series of observations for future investigations.

Meteorological observations, extending over many years, to which the word "homogeneous" in its strictest sense can be applied are non-existent, and probably never will be available. Fortunately we need not insist on absolute homogeneity in the investigation of secular changes. As far as our present knowledge goes, observations which are comparable within the limits of error which attach to all meteorological observations will serve our purpose. There are a vast number of records extending over a few years which satisfy this condition, but similar records of long duration are very rare, certainly much rarer than the majority of meteorologists would suppose.

The reason for this is to be sought in the fact that formerly the necessity for homogeneity—which is also of great importance in climatological investigations—was not so fully recognised as at the present day, with the result that changes were made in the exposure or in the method of observing. Moreover, it is exceedingly difficult to secure strict homogeneity even if its necessity is fully appreciated.

As contiguous stations show similar variations, we may be satisfied if, in each network, one or more stations, according to size, preserve strict continuity. For the sake of brevity I will call such stations secular stations.

Observations should be continued at these secular stations under absolutely identical external and internal conditions notwithstanding the changes and improvements which it may be desirable to introduce at the other stations of the network. That is an ideal which should be kept steadily in view.

By external conditions I mean the surroundings of the station which influence the exposure of the instruments (excluding the barometer). The demand to keep these unaltered during a long series of years is by far the most difficult to comply with, as the land round the station is, as a rule, not under the control of the station authorities. This matter should therefore be kept in the forefront when selecting secular stations. General rules cannot be laid down, as circumstances differ greatly in different countries. The rapid and extensive building operations going on in urban areas suggest rural districts as more suitable, but on the other hand the difficulty of finding a satisfactory observer has also to be reckoned with. This is, as a rule, much easier in towns than in the country unless the observatory is maintained by the State.

Internal conditions refer to such points as the arrangements for exposing and reading and the method of reducing the observations. Homogeneity may be secured in these matters with comparatively little trouble if the Central Office realises its responsibility in the matter and exercises special control over its secular stations. This need not prevent the introduction of changes and improvements at the other stations in the network. The changes may also be extended to the secular stations if observations are continued there both on the old and on the new system. The chief point to be kept in view is the continuation of the observations on an absolutely unchanged basis at the specially selected secular stations.

Secular stations should be distinguished from the others in all publications containing meteorological data.

The present generation of meteorologists will probably derive but little benefit from these efforts, but our successors will thank us for taking steps to provide them with suitable material for investigating secular changes.

ITEM 26. COMPARISON OF STANDARD BAROMETERS.

At the second International Meteorological Congress (Rome, 1879) M. Wild brought forward a proposal to have the barometers of all the European Institutes compared by an expert who was to visit all the offices in turn. The standard barometer of the Central Physical Observatory at St. Petersburg, which at that time was the only office possessing an absolute standard, was to be made the standard of reference, and the expenses were to be borne jointly by the institutes concerned. This scheme was wrecked on the last point.

This led to the adoption by the Permanent International Committee at its meeting at Berne in 1880 of a resolution advocating a comparison of the standard instruments of contiguous countries in place of a general comparison with a single standard. This resolution was repeated at the Conference of Directors held in Munich in 1891, with addition of a rider proposed by M. Mascart "that comparisons should be made as soon as possible with the barometer of the Bureau International des poids et mesures, which is then to be regarded as the standard."

Both proposals have been acted on in a few isolated instances only, and the original goal of determining the relations of the standards of different countries to one another or to the absolute standard of the international Bureau at Breteuil, has not been attained.

During the eighties of the last century several scientists, some officially (F. Waldo), others in the course of journeys undertaken for purposes of study (Chistoni, Sundell, Brounow), compared the barometers of a considerable number of European meteorological institutes and found appreciable differences. They also found that some of these instruments suffered a change of zero in a comparatively short time and did not conform to the conditions which a standard should satisfy.

The important question of a comparison of barometric standards of reference has thus not been disposed of and ought to be taken up afresh, for if observations of pressure at stations are expected to be accurate to within ± 0.1 mm., the standards of reference at the Central Offices should agree with one another to within ± 0.025 mm. at the least. This is certainly not the case at the present time.

Thus the necessity for comparing the standards of reference of the meteorological institutes (in the first instance those of Europe) still exists. The comparisons should be made during a specified short interval of time, so that the results may apply to a particular epoch.

As it seems to me to be hopeless to have such comparisons made at common expense, I beg leave to propose that the largest meteorological institutes of Europe (those of Berlin, Hamburg, London, Paris, Rome, St. Petersburg and Vienna), which are most easily able to dispose of the necessary staff and funds, should share the labour, and that each of them should undertake to carry out comparisons with the standard instruments of neighbouring networks. This would probably lead to a double comparison of some instruments which would afford a very valuable check on the results.

I need not here enter upon details of the rounds to be undertaken by each institute or upon the manner in which the comparisons should be made, as this would be a matter for discussion by representatives of the institutes in the event of their being willing to take the matter up.

The discussion of the question by a small sub-commission of the Conference at Innsbruck will probably be the simplest method of arriving at an understanding.

In conclusion, I beg leave to point out that the active participation of institutes other than those mentioned would of course be extremely welcome. I have only suggested the largest institutes as these are able to arrange most easily for a member of their staffs to make an official tour in foreign parts, which must occupy at least a fortnight to three weeks.

G. HELLMANN.

Berlin,
August, 1905.

APPENDIX XI.

ITEM 27. TABULATION OF ELECTROGRAMS AND PUBLICATION OF ATMOSPHERIC ELECTRICAL DATA.

Autographic records of atmospheric electricity are generally incomplete. Benndorf's electrometer is now in use at many observatories, and may be taken as a type of other forms of instrument. If the sensitiveness of this instrument be adjusted so that 1 mm. = 10 volts, potentials up to ± 500 volts can be recorded, from which it follows that the high potentials occurring while rain is falling or during thunderstorms cannot be recorded, so that gaps are frequent in the tabulations.

Attempts have been made to overcome the difficulties connected with the measurement of high potentials by fitting to the electrometer an appliance for automatically reducing the sensitivity as the potential rises, and so reducing the amplitude of the motion of the needle, or by providing a second recorder of smaller sensitiveness. Both these alternatives increase expenses, and the former introduces additional complications into an apparatus which even in its present form is rather liable to give trouble. For the present we shall have to dispense with the measurement of high potentials and content ourselves with recording the potential gradient on quiet days, *i.e.*, dealing only with "fine weather electricity."

When selecting data for determining the diurnal and annual variations of potential the following points arise:—

1. Should all recorded potentials be included in the published tables of data, or should values be given for quiet days only?
2. What method of procedure is to be adopted in preparing hourly means? Should all recorded values be meaned, or should we restrict ourselves to quiet days?
3. The meteorological conditions which constitute a "quiet" day should be defined; in particular, agreement should be reached as to the upper limit of the mean amount of cloud admissible on a "quiet" day.
4. Should all data regarding atmospheric electric potential be converted into volts per metre and reduced to ground level before publication, or is it desirable to confine this reduction to hourly and monthly means?

To assist in solving these questions, I beg leave to bring forward the following proposals:—

1. Periodic publications giving hourly values of electrical potential gradient should include all recorded data. On occasions when the recording pen reaches the edges of the scale the symbols $+\infty$ or $-\infty$ should be inserted.* If the sign of the electrification cannot be determined on account of the rapidity of the changes the symbol $\pm\infty$ should be used. Loss of data due to a breakdown of the instrument should be indicated by a dot.

2. Mean values should only be formed from the data for fine days, and all days which are looked upon as "quiet" should be distinguished by an asterisk.

3. Disturbed days, for which the records of electrometers are not to be taken account of in the computation of mean values, should include the following:—

- (a) All days of precipitation (rain, snow, hail, graupel or fog) or thunderstorm.

- (b) Days of slight cloudiness on which the trace of the electrograph shows sudden variations lasting for more than one hour.

- (c) Days on which the mean amount of cloud is 5 or more. Such days should be included among the "disturbed" ones even if the records show no striking irregularities.

4. In view of the fact that the batteries used with the electro-meter often show changes of potential, it is desirable to express only the hourly and monthly means in volts per metre. The formula for carrying out the reduction should be given with all tables of monthly values.

Pola,
May, 1905.

W. KESSLITZ.

* See Measurements of potential gradient at Kremsmünster, discussed by P. Bonifaz Zölss.

APPENDIX XII.

ITEM 29. TREATMENT AND PUBLICATION OF DATA FOR SUDDEN CHANGES OF PRESSURE.

Barograms very often show rapid changes of pressure of short duration in addition to the regular periodic variations and the large irregular fluctuations due to the passage of high and low pressure systems. Changes of this nature are well known to all who are familiar with autographic records.

Several authors have already attempted to study these changes, and to connect these characteristic irregularities with other phenomena, such as heavy falls of rain, tornados, local thunderstorms, the passage of line squalls, &c. Researches of this kind would be much more easy, and interesting results would be promptly arrived at, if stations which possess autographic instruments would publish a full summary of such disturbances.

It is impossible to draw up fixed rules on the subject which shall hold good in all countries. Traces from tropical stations do not exhibit the same features as those from, say, the shores of Lake Baikal. For each country the amplitude of what constitutes a noteworthy irregularity requires to be fixed. It would probably vary from month to month.* The duration of what constitutes a rapid change (say 25 or 30 minutes) would also have to be fixed. All such changes should be noted in a special table or in a special "remarks column." We would then be in a position to trace and study disturbances of this nature over a very wide area.

The work involved need not be very great. Examination of the curves for a single year has brought to light 17 cases of violent disturbances and a total of 35 cases if the definition be made more comprehensive.

Inspection of the records has shown that on some days the curves exhibit a series of undulations which bear no resemblance to the sudden increase of pressure associated with a squall. Such days might be called "disturbed days" (*jours troublés*); to pick these out would be a matter of a few moments; it would be sufficient to note about 40 days, or perhaps even less in each year. In the cases of remarkable disturbances, the hour, the amplitude, and the duration should be stated; for "disturbed" days the hours during which the undulations occurred would suffice.

LOUIS FROC, S.J.,
Director of the Observatory of Zi-ka-wei.

APPENDIX XIII.

ITEM 30. TABULATION OF AUTOGRAPHIC RECORDS.

It is desirable that the Conference give directions as to the best way of working up the records of autographic recorders of Richard pattern, which are now so commonly used.

* A definition of the word "noteworthy" might be framed analogous to that adopted by Angot for an "exceptional" month, in his study of the climate of France (*Annales du Bureau Central Météorologique de France*, 1897, *Memoires*, p. B. 101).

Tabulation of hourly values with a view to publication is difficult and takes much time, and, moreover, the information thus afforded is comparatively meagre. Would it not be desirable to work up in detail only those cases in which rapid changes of temperature, pressure, &c., occur?

What form of manipulation of the records does the Conference consider most suitable?

AR. WOSNESSENSKI.

APPENDIX XIV. (a)

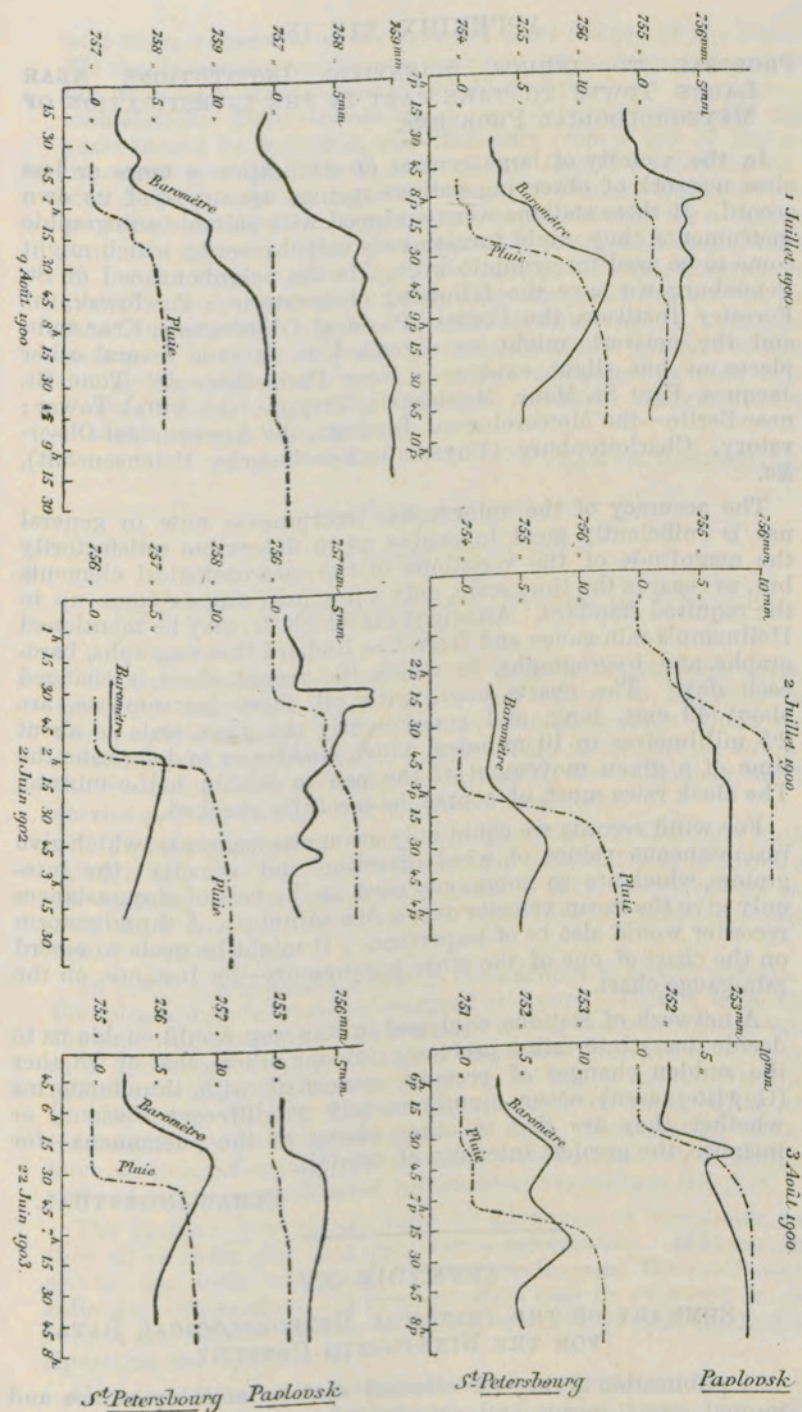
ITEM 31. INVESTIGATION OF RAPID BAROMETRIC CHANGES.

The diagrams reproduced in figure on p. 97, show particulars of a number of heavy rainstorms, and the accompanying changes of pressure at St. Petersburg and Pawlowsk. The continuous lines show the fluctuations of the barometer, the dotted lines the rainfall. The barograph for St. Petersburg is taken from a Richard instrument of the usual type, the time of revolution of the drum being 48 hours. The record has been considerably enlarged. At Pawlowsk a mercury barograph of the Sprung-Fuess type is in use. The scale of the records has been doubled. The rainfall curves are taken from two exactly similar pluviographs of the Wild-Rohrdanz type. The scale of the ordinates has been slightly reduced; that of the abscissae (time) has been nearly doubled. As the time scale has been considerably enlarged in all four cases, it may be that the traces ought to be slightly moved horizontally with regard to one another. The barograph traces show the same general feature at both stations, and only differ slightly in point of time. The rainfall traces are similar to the barometer records. The uncertainty of the time scale, referred to above, will not admit of our determining whether the time of greatest intensity of rainfall was also the time of maximum pressure. The rain records often show considerable dissimilarities at the two stations.

From this we may conclude that the changes of pressure are the essential features of the phenomena, and that the rainfall is more an accidental occurrence. We might increase our knowledge of these phenomena if records from a number of neighbouring stations could be compared in this way. At present this is not practicable at St. Petersburg, as the neighbouring stations have only got small Richard instruments, in which the drum revolves once in a week.

St. Petersburg,
August, 1905.

ELMAR ROSENTHAL.



APPENDIX XIV. (b).

PROPOSAL TO INDUCE SCIENTIFIC INSTITUTIONS NEAR
LARGE TOWNS TO TAKE PART IN THE INVESTIGATION OF
METEOROLOGICAL PROBLEMS.

In the vicinity of large centres of civilisation a more or less close network of observing stations springs up almost of its own accord. If these stations were equipped with suitable autographic instruments, they might furnish very useful records, which might come to be used for synoptic work. In the neighbourhood of St. Petersburg we have the following observatories: Pawlowsk, the Forestry Institute, the Central Physical Observatory, Kronstadt, and the network might be extended to include several other places at but slight expense. Near Paris there are Tour St. Jacques, Parc St. Maur, Moutsouris, Trappes, the Eiffel Tower; near Berlin—the Meteorological Institute, the Aeronautical Observatory, Charlottenburg (Physikalisch-technische Reichsanstalt), &c.

The accuracy of the autographic instruments now in general use is sufficiently great to enable us to determine satisfactorily the magnitude of the variations in the meteorological elements but, as regards the time scale, only a few instruments come up to the required standard. Among those which do, may be mentioned Hellmann's rain-gauge and large-size Richard thermographs, barographs, and hygrographs, in which the record sheet is changed each day. The charts used, with all these instruments, are about 40 cms. long, and consequently the time scale is about 2.5 millimetres to 10 minutes, which enables us to determine the time of a given movement of the pen to within half-a-minute. The clock rates must, of course, be carefully checked.

For wind records we could only use anemomographs, which give instantaneous values of wind direction and velocity; the integrators, which are so commonly used, in the best of circumstances only give the mean velocity over a few minutes. A thunderstorm recorder would also be of importance; it might be made to record on the chart of one of the other instruments—for instance, on the rain-gauge chart.

A network of stations equipped in this way would enable us to decide many interesting problems; among others, that of whether the sudden changes of pressure associated with thunderstorms (Gewitternasen) occur simultaneously at different stations, or whether they are tied to other phases of the phenomena—for instance, the greatest intensity of rainfall.

ELMAR ROSENTHAL.

APPENDIX XV.

SUMMARY OF THE PRINCIPAL METEOROLOGICAL DATA
FOR THE NINETEENTH CENTURY.

A publication giving for selected stations monthly values and annual sums, means and extremes for the elements, pressure, temperature, and rainfall would be most useful, and would supply,

as it were, a skeleton of the meteorological history of the century. We should require one line for each year for each station, and thus the data for a whole century would occupy about six pages for each station. Only records which have been continued for many years should be included, and then only from a few of the most important stations. About two stations should be selected for an area about the size of one of the states of Central Europe. Summaries of the kind contemplated are available only for a very few stations; moreover, they are scattered throughout a large number of publications, and we have no comprehensive survey of the available data. In course of time these scattered summaries, even if not actually lost, will be very difficult of access. A publication such as I have in view should include mainly the data collected during the nineteenth century, with a few pages devoted to the records available for the eighteenth century. A continuation should be issued after 50 years.

ELMAR ROSENTHAL.

APPENDIX XVI.

ITEM 34. AN INTERNATIONAL SYSTEM OF WEATHER
SIGNALS.

It is unnecessary to dwell on the immense advantages derived from the warnings issued by central offices to harbours and semaphore stations or on the number of human lives which have been saved by this means. I desire only to call the attention of the Conference to a proposal for increasing the efficiency of this service and for making it more useful to sailors.

I do not propose to change the character of the information which each central office collects and distributes or to introduce far reaching changes into the services. I take the warnings as I find them and hope to be able to make them of greater practical utility to navigators.

In many instances ships cannot send ashore to obtain details of the telegraphic information received at a port. This is obviously the case when passing a signal station at sea, but when in harbour, at an anchorage at some distance from the shore, it is often not practicable to send for the information at the moment of sailing. It may even be said that in the majority of cases, when the information is of the greatest use to them commanding officers have to depend entirely on signals communicated by semaphore and not on the more detailed information available at the port.

The systems now in use have the advantage of simplicity, but they all of them give only very vague information. Hitherto the service has been hampered by imperfections in the methods of collecting information, but great progress may be expected in the future, and ought we not to devise a more precise method of signalling the information?

Moreover, it is undeniable that the knowledge of the laws of storms is very different now from what it was 50 years ago among the section of the public to whom the warnings are addressed. Each

detail has been studied and manuals in all languages are in everybody's hands. One need only to have come in contact with sailors during the past 20 years to appreciate the extent to which knowledge has spread. The essential theoretical points are known; changes of the barometer or of the wind are interpreted in the light of these; many ships even possess autographic instruments. There is therefore no danger of being misunderstood if a more complete system of signalling be introduced.

The developments which have taken place in the meteorological services need not be described to an audience of meteorologists. I merely mention the creation of an observing system in the Azores by His Majesty the King of Portugal, and the immense advantages we are likely to reap from wireless telegraphy, which promises to convert all the great liners into floating observatories, so that the state of the Atlantic Ocean will be known from day to day.

The information which the present methods give the sailor may be summarised as follows:—He is informed that he is threatened by a danger situated at an *unknown distance* from the coast on which he finds himself, but he is left in ignorance of the precise position of this danger or of the time in which he may expect to meet with it, and it is almost impossible for him to tell whether he should push forward with all speed or return on his course in order to avoid it.* I am not putting a hypothetical case. I could quote instances of first class battleships or of mail boats of large tonnage, commanded by capable officers, running into danger and experiencing damage without the least mistake on the part of the storm warning staff, simply through the inadequacy of the system of signalling.

What course should we adopt to attain the greatest degree of perfection without sacrificing simplicity? I have discussed the matter with many sailors who have had experience of various systems and am in a position to form an opinion. Their suggestions may be summarised as follows:—“*Indicate the position of the centre of the disturbance as accurately as possible and the direction in which it is moving.*” Commanding officers of the present day are able to draw conclusions from this information and to act accordingly.

As a matter of fact, what the officers require to know is not the character of the weather which threatens the coast they are leaving, but the conditions which they will meet with on the voyage and on the coasts they will pass along. The solution of the difficulty is very simple. It consists in generalising the information signalled and in telegraphing the same information to all stations.

* To take an example: a ship making 15 knots is en route from a Mediterranean port to a port in the English Channel. An Atlantic cyclone is signalled at the same time some 500 miles N.W. of the Azores, approximately in 45° N., and moving towards N.E. or E.N.E. The coast of Portugal is in no danger from this storm, and, accordingly, storm signals are not hoisted at Cape St. Vincent. The ship passes this station, sees no signal, and continues on her course only to meet with the gale in the neighbourhood of Ushant. If the proposed method were adopted a signal indicating “cyclone to N.W. of Azores moving towards N.E.” would have been displayed, and every commander would have known that he ought not to proceed beyond Cape Finisterre without taking great precautions.

It may be mentioned in passing that this would be a gain also to the central offices, which would no longer have to spend time in deciding what wind threatens each individual station, and in which direction it is likely to shift. It would also mean an economy in telegraphy, for all possible cases might be codified in advance, and one or two code words would suffice to communicate the information.

I do not propose to enter into details. That will be a matter for the Directors of central offices or for the International Committee to take in hand, if the principle is approved by the Conference. A single code would suffice for Europe, and its application would be very simple. It would suffice to divide the Atlantic and the waters that surround our Continent into five or six principal sections and to sub-divide each section into districts; each district or department would receive a number, and by displaying the appropriate number at the storm warning stations all interested in the matter would be informed of the existence of a danger centre in that district. A second signal would indicate the direction of motion of the disturbance as determined from the latest information. Other numbers, but fewer of them, might be used in cases when bad weather cannot be associated with a distinct centre of disturbance or in cases of advancing cold waves, &c. In all cases the warning should be communicated to all stations, so that an officer leaving, say, London, which is in no way threatened, might know that he might expect to meet with squally weather when approaching Brest or Cherbourg. In view of the great speed of modern vessels such information would be very useful.

I beg leave to point out that the proposal is not entirely imaginary. A somewhat similar system has been worked practically and successfully for nearly 25 years. A code made up in this way was introduced at Shanghai in 1883 to meet the needs of that great port; it was subsequently extended, with certain modifications, over the area round the north of the Yang-tse-Kiang and then to other parts of the coast of China by order of the administration of the Maritime Customs of the Imperial Chinese Government. For several years the Russian and German Governments have adopted the system in the Far East. Sailors of the world's navies and mercantile marines bear witness to its efficiency, and, what is of equal importance, find no difficulty in understanding it.

Might not trial be made of a system of this kind at a few of the principal storm-warning stations on the coasts of Spain, Portugal, America, Ireland, and on the Azores? The expense would be trifling. The old signals would be continued at these stations for the benefit of fishermen and the coasting trade.


LOUIS FROC, S.J.,

Director of the Observatory of Zi-ka-wei.

APPENDIX XVII.

ITEM 35. AN INTERNATIONAL SYMBOL FOR THE ZODIACAL LIGHT.

The Zodiacal Light cannot be observed in all latitudes. Nevertheless, it would be useful to have a symbol for indicating this phenomenon in the "remarks" column, just as we have a symbol for the Aurora, which is also not visible everywhere. The visibility of this phenomenon is a proof of the purity of the atmosphere, and it has before now been the subject of interesting researches.

The type for the proposed symbol  can be easily cast. Its shape vaguely resembles the form of this beautiful light. The fact that there is a symbol for it will, probably, lead to notes being made of its form, brilliancy, &c.

LOUIS FROC, S.J.,
Director of the Observatory of Zi-ka-wei.

APPENDIX XVIII.

ITEM 36. LACK OF PRECISION IN THE DEFINITION OF NIMBUS CLOUD.

The International Cloud Atlas does not draw attention to the fact that precipitation may fall from other cloud forms, as well as from nimbus. When rain is falling, "Nimbus" is generally entered by observers and no attention is paid to the true form of the cloud, whereas it is well known that other cloud forms, for instance, Str, and Str Cu, and in rare cases AS may give rise to precipitation. If Nimbus is entered on all occasions when rain is falling, we are not, as a matter of fact, noting the form of cloud, but are merely duplicating the entry of the fact that rain is falling. On the other hand, Nimbus cloud may occur without simultaneous precipitation; it is by no means invariably connected with falling rain (or snow). From this the necessity arises of determining the cloud form, independently of the formation of precipitation, as Howard did in his original classification. If precipitation is taking place at the hour of observation, the appropriate symbol should be appended to the cloud designation, thus: ● 10 SCu., * 10 N., Δ 9SCu., &c.; further details should be given when necessary, among the remarks. The edition of the International Cloud Atlas, prepared at the Central Physical Observatory of St. Petersburg, for use at the cloud stations in the Russian network of stations, contains a paragraph which is not included in the international instructions: "If rain is falling from a cloud other than Nimbus, the symbol for rainfall should be entered among the remarks next to the symbol for the cloud form from which the rain is falling, thus: ● S., ● CuN."

It is very desirable to make this addition to the instructions, in order that the lack of precision in the determination of cloud forms at times when precipitation is taking place may be avoided.

NESDÜROFF.

APPENDIX XIX.

ITEM 37. DEFINITION OF "BACKING" AND "VEERING."

This question perhaps requires an apology, but in Mauritius at least, there appears to be uncertainty as to the meaning of the words "backing" and "veering."

Sailors apparently use the expression "veer" for the original change of direction, no matter whether direct or retrograde, and then use the expression "back" for a subsequent change in the opposite direction.

My predecessor used the expression "veering" for a retrograde motion (against the hands of a clock), and "backing" for a direct motion (with the hands of a clock).

Personally I have always interpreted the expression "veering" to mean a direct motion and backing "a retrograde motion."

T. CLAXTON.

APPENDIX XX.

THE METEOROLOGICAL SERVICE OF BRAZIL.

Mr. President and Gentlemen,

In 1888 Captain Adolpho Pinheiro was entrusted by the Brazilian Government with the creation of a national meteorological service. Up to that date only a few stations were in existence and these had worked absolutely independently of one another. M. Pinheiro was obliged to fight for his ideas up to the time of his death in 1896, without being able to do more than collect material which would prove useful in a happier future.

For some months after his death I was provisionally entrusted with the continuance of the work. The new political situation in my country has enabled me to make some advances in climatology, in forecasting, and in terrestrial magnetism. In 1896 the national meteorological service was under the direction of the Admiralty. It possessed but one station, which observed three times a day. The remaining stations were outside the service and very few in number. Each worked entirely on its own plan. They possessed instruments of different types, and were in no sort of communication with one another. No systematic work was done in terrestrial magnetism. Occasional observations of magnetic declination were made with the usual instruments.

It will be seen that instead of combining to obtain positive results, we split up our forces without having any definite goal in view.

The Minister of Marine adopted my proposals for co-ordinating the work and developing the service, and we thereupon commenced to collect data. In 1900 I was appointed Director of

Meteorology. I am happy to be able to inform you that the Brazilian Meteorological Service now has 36 stations of different orders, made up as follows:—

One Central Observatory; Rio; making hourly observations.

Two stations of the First Order: Curitiba and Luisceramobim. These use a meteorograph by Theorell, and belong to the Brazilian telegraphic network.

Eight stations of the Second Order: Belem, Fortaleza, Natal, Recife, Aracajú, Florianópolis, Rio Grande, Itaquí. These observe three times a day—at 9 a.m., noon, and 9 p.m.

Four stations of the Third Order: Bahia, Santos, Victoria, Paranaguá. These make one complete observation each day—noon.

Six rainfall stations: Maranhão, Parnahyba, Natal (a different position), Parahyba, Maceio, Ladario. These measure the rainfall once a day at noon. They do not record pressure or temperature.

Seven private stations in Brazil, which report by telegraph and by post: Manáos, Joazeiro, Oudina, Cuiabá, S. Paulo, Porto Alegre, Luiscedá.

Six stations in Argentina, which send reports by telegraph: Buenos Aires, Cordoba, Mendoza, Corrientes, Rosario, Posadas.

One station in Paraguay, which sends reports by telegraph: Ascension.

One station in Uruguay, which sends reports by telegraph: Montevideo.

We are working at the development of the service, and hope to increase the number of stations in course of time, so as to cover the whole of the inhabited part of Brazil. The annual grant assigned to the service is 90,000 francs.

A forecasting branch was started in 1902 for the issue of forecasts 24 hours in advance for Rio and its neighbourhood. Warnings are sent to the stations whenever bad weather is approaching. The hourly observations for Rio are published each day in the "Diário Officiêl," together with the magnetic results for Rio and the telegraphic reports from the remaining stations. All meteorological telegrams sent from stations in the Brazilian network or from the stations in Argentina or Uruguay are transmitted by means of a word-code devised by myself, which has given satisfactory results. All the Brazilian stations observe at noon, G.M.T., for telegraphic purposes. I have only mentioned the stations which collaborate with the service under my direction. There are some additional stations in Brazil which observe principally for their own purposes or for the institutions to which they are attached.

In terrestrial magnetism the Brazilian service has made some progress. Before 1896 the only work done in Brazil in this connexion consisted of observations of magnetic declination made from time to time with ordinary instruments. Since that date monthly values have been determined of the magnetic declination, inclination, and horizontal force. The instruments in use consist of a unifilar, Kew-pattern declinometer, and a Dover inclinometer. I am glad to say that for the last five years, or rather

more, the magnetic declination has been observed at Rio each day, and that observations of the declination and the horizontal force have been made twice a week.

The development of the service has been such that I have been able to arrange for a magnetic committee to survey for the first time the whole of Brazil. In the course of 11 months I succeeded in determining the value of the three magnetic elements at 30 stations, which necessitated a journey of 14,000 miles. I caused 21 pillars to be erected on the exact spots where the observations were made, with tablets on them giving the magnetic results, the geographical position, and the date when the observations were completed. The lines of equal intensity have been drawn for each element for the epoch January 1st, 1904. I submit herewith the original diagrams. I am aware that the number of stations is too small for so large an area as that covered by Brazil, but all things must have a beginning. If the magnetic committee is re-appointed every five years, as I hope it will be, we shall be able to increase the number of stations, so as to be able to trace all the variations in the magnetic curves.

There is in Brazil at the present day a place very near Cuyabá, near the centre of South America, at which the magnetic declination and inclination are both nearly zero. The line of no declination runs very near the four towns—Mandos, Cuyabá, Porto Alegre, Rio Grande—approximately in a direction from north-west to south-east. The full Report of the Committee will be published on my return, and copies of it will be sent to all foreign institutes, as is done with our other publications. I have given you, gentlemen, a brief summary of the work done in Brazil since 1896. The service will be steadily developed in the future.

I thank you, gentlemen, for your kind attention.

AMÉRICO SILVADO, Captain,
Director of Meteorology.

Innsbruck,
September 12, 1905.

APPENDIX XXI.

METEOROLOGICAL ORGANISATION OF THE CHINESE IMPERIAL MARITIME CUSTOMS.

In China, the Customs Service undertakes much more extended work than the bodies similarly named in Europe. The Imperial Maritime Customs were established after the expedition of 1860, for the administration of the treaty ports. They were given a very effective organisation by their founder, Sir Robert Hart, who still holds the post of Inspector General. Their work includes such functions as the management of harbours, the control of lighthouses, the sounding and buoying of rivers, &c.

Sir Robert Hart appreciated the desirability of establishing a meteorological service along the coasts of China, and recognised that the large staff attached to his administration could render great services to meteorological science. In 1869, about five years after his appointment as Inspector General, he addressed a circular on

the matter to all his officers. No doubt he had even then the idea of connecting all these observing stations with a central institution which would co-ordinate the efforts of individuals.

The first part of the scheme was soon carried out, and at the present day it may be said that there is not a Customs station or even a lighthouse in China to which a meteorological station is not attached.

Circumstances did not favour the establishment of a Central Observatory, but to make up for this, the Inspector General put all his records at the disposal of those who could use them. In this way the Observatory at Zi-ka-wei received copies of the meteorological data from other stations. The first records were received in 1879 and others soon followed as it was found impossible to work satisfactorily and to organise a system of warnings without full information. The Observatory at Manila took part in the work, as also did those at Hong-Kong and Tokio.

A telegraphic service was subsequently inaugurated. The messages are made up of groups of figures very similar to those given in the meteorological telegrams of Europe. Information is sent twice each day to the observatories interested in the matter. In this connection great praise is due to the various Telegraph Companies, Danish, German, and Chinese, for their public spirit in transmitting the messages and storm warnings without charge, and also for sending them as "urgent." Some branches of the service have been in existence for more than a quarter of a century.

The information issued by the Observatory at Zi-ka-wei is communicated to ships from eight semaphore stations established by the Customs for signalling the approach of gales and typhoons.

I hope that we shall soon establish two or three additional stations at points where much shipping passes.

In 1903 a new departure was made. The service was put under the Inspector of Coasts, and the holder of this Office, Mr. W. F. Tyler, F.R. Met. Soc., took great interest in all that concerned the efficiency of this part of his service.

There is now being prepared at Shanghai a book of instructions for observers, and we hope shortly to be able to publish the principal data in a monthly report.

I append a list of the stations. Their positions are shown on a chart which I will place in the meeting room of the Conference, together with specimens of the records and of the telegrams sent twice each day.

The Meteorological system of China extends along two great lines, the one along the Yang-tse-Kiang, the other following the coast line. Observations are taken at 18 customs offices, of which eight are on the coast and 10 inland. The lighthouses at which observations are taken also number 18. We hope that the introduction of railways will enable us to extend the network.

The instruments are carefully tested by the Inspector of Coasts, or at Zi-ka-wei, and are of uniform pattern. They consist of a mercury barometer, dry and wet bulb thermometers, maximum

and minimum thermometers, and a rain gauge. Barographs of Richard type have recently been supplied to a few of the most important stations.

It should be mentioned that the warnings issued to the semaphore stations of the Imperial Customs are based on observations taken at the stations of the Chinese network and on telegrams, received twice or three times a day, from 32 foreign stations. These reports are kindly sent by the Directors of the neighbouring Observatories by permission of their various Governments. Some others are sent by volunteer observers.

LOUIS FROC, S.J.

Note.

LIST OF METEOROLOGICAL STATIONS OF THE CHINESE IMPERIAL CUSTOMS SERVICE.

1. Observing Stations :

Nieou-tchoang, Tien-tsin, Tche-fou, Tchong-king, Itchang, Hankow, Kiu-kiang, Ou-hou, Tching-kiang, Shanghai, Ning-po, Wenchow, Foo-choo, Amoy, Swatow, Ou-tchow, San-chui, Pakhoi, Kiong-choo, Long-choo.

Light Houses :

Hon-ki, Cape N.E. of Shantung, Cape S.E. of Shantung, Sha-wei-shan, Gutzlaff, N. Saddle, Steep Isle, Pei-yu-shan, Tung-yung, Middle Dog, Turnabout, Ockseu, Dodd Isle, Tsing-tseu, Chapel Isle, Lamocks, Sugar Loaf, Cape of Good Hope, Breaker Point.

2. Stations which telegraph to Zi-ka-wei :

Nieou-tchoang, Tien-tsin (Mr. Bellingham), Tche-fou, Tchong-king, Gutzlaff, Hankow, Itchang, Ning-po, Tchong-king, Kiu-kiang, Wen-choo, Foo-choo (Sharp Peak, Telegraph Company), Amoy, Swatow.

3. Storm warning stations :

Nieou-tchoang, Tien-tsin, Ta-kou, Tche-fou, Tchong-king, Ou-song, Gutzlaff, Shanghai (C.F.), Foo-choo, Amoy, Swatow.

Many other stations record observations on tides, rainfall, fog, &c. I have only enumerated those stations which are, to my knowledge, provided with a complete set of meteorological instruments.

APPENDIX XXII.

THE OBSERVATORY AT TORTOSA.

SIR,

WORK connected with the solar eclipse has prevented me from being present at the Conference. I beg leave to send a short summary of the equipment of our Observatory, to make

it known to the members of the Conference. I also send photographs. The Observatory consists of—

1. The astro-physical building, in which are housed the following instruments :—

(a.) A double equatorial telescope, object glasses 162 mms. in diameter.

(b.) A spectro-heliograph with double slit (Evershed model) for the study of faculae and protuberances.

(c.) A spectro-goniometer by Pellin, with four large prisms which can be replaced by a Rowland's grating with camera attached. With this apparatus the rays of the spectrum and their displacement on account of their radial velocity can be examined.

(d.) A transit instrument and two clocks, one showing siderial time, the other local mean time.

2. Two magnetic buildings.

(a.) One of these is intended for absolute measurements to be made with a unifilar Kew pattern magnetometer by Dover, and an earth inductor (Potsdam model).

(b.) The other is intended for the study of magnetic changes. In the basement there are two rooms; in one of these a set of instruments for direct readings devised by Mascart is placed; the other contains a similar apparatus adapted for continuous photographic recording. The time scale is 22 mms. to the hour.

3. The building devoted to atmospheric electricity and meteorology. This will contain :—

(a.) Two Despretz d'Arsonval galvanometers for the study of earth currents, and two Thomson-Mascart electrometers for recording electric potential gradient. These four instruments record on the same sensitised paper.

(b.) Elster and Geitel's apparatus for determining the ionisation of the air, and also Gerdien's apparatus for the same purpose.

(c.) A thunderstorm recorder with a tripod by Branly, constructed under his direction.

(d.) A set of meteorological recorders, some by Richard, others by Tonnelot.

4. For meteorological work we have also—

(a.) A kiosk to be used as a refracting nephoscope;

(b.) A Besson comb nephoscope;

(c.) A Cornu photo-polarimeter;

(d.) An actinometer, Montsouri's model;

(e.) Two screens with double louvres to contain the thermometers, hygrometers, and evaporimeters.

5. The seismological building, containing—

(a.) A Vicentini universal microseismograph;

(b.) Two horizontal or conical pendulums by Grablovitz.

All the instruments are in regular use, and my principal work at the present time is to prepare a scheme for publishing the results in a monthly bulletin, which will, I hope, commence in January, 1906. For that reason I await with great interest the resolutions and opinions of the Conference, which I will carefully adhere to.

As far as I am able to do so, I give my vote to Rev Algué, the Director of the Observatory of Manila, who has just visited the Observatory.

B. CIRERA, S. J.

APPENDIX XXIII.

ON GLOBULAR LIGHTNING.

(Des fourdes en boule.)

By V. Carlheim-Gyllensköld.

Les phénomènes curieux présentés par les foudres globulaires s'expliquent facilement, si l'on admet que ces corps sont des tubes tourbillonnaires de révolution consistant en une masse d'air fortement ionisé. Évidemment ce n'est là qu'une hypothèse que je ne mets en avant que timidement. Peut-être pourra-t-elle rendre quelque service, pour dresser un formulaire pour l'observation de ce phénomène.

Permettez-moi d'entrer dans quelques détails.

D'abord, toutes les fois qu'on a vu la formation d'une boule de feu en plein air, c'était toujours dans l'extrémité inférieure d'une traînée de foudre ordinaire.

La condition nécessaire pour la formation d'un tube de tourbillon fermé dans un fluide est qu'on applique, pendant un temps très court, une forte pression sur une surface limitée du fluide. Dans le cas des foudres globulaires, la pression hydrostatique est due à la pression de l'air ionisé. En effet, la foudre peut être considérée comme une décharge en aigrette, le tube de décharge étant parcouru par les ions produits par la différence de potentiel. En admettant avec Rutherford 3.2 cm. par seconde pour la somme des vitesses des ions positifs et négatifs dans l'air pour une chute de potentiel de 1 volt par centimètre, on voit qu'avec une chute de potentiel de 32,000 volts par centimètre, la vitesse acquise sera de 1,000 m. par seconde et pourra bien expliquer la formation d'un tourbillon énergétique.

Si le jet de fluide est intermittent, il se forme dans les expériences de laboratoire, une suite d'anneaux de plus en plus éloignés de l'orifice; quelque chose d'analogue paraît avoir lieu à la formation des éclairs en chapelet.

J'avoue qu'il y a ici une difficulté. Ce n'est que rarement qu'on a observé une foudre en anneau très mince, qui est le seul cas qui a occupé Helmholtz. Or Lord Kelvin a montré qu'il est probable qu'il y a une foule d'autres formes de mouvement permanent également possibles; si l'impulsion divisée par la circulation est

très petite par rapport à la puissance 2-3 du volume du corps tourbillonnaire, l'anneau mince se transforme en un ovoïde très allongé et perforé au milieu.

Je citerai cependant l'exemple suivant, pour lequel je suis redevable à M. Luigi Palazzo. Une dame sérieuse et digne de foi vit du haut d'une tourelle de sa maison à Rome, le 29 juin 1902, au soir, un corps de forme plutôt aplatie, semblable à une amande ou à un cœur, rouge sombre au milieu, plus clair à la circonférence, long de 32 cm. environ, large de 22 cm. au plus, et d'une épaisseur un peu supérieure à 1 cm., lequel vagabondait lentement dans l'air dans le voisinage de sa tête, émettant de la lumière et laissant entendre un léger sifflement, comme celui produit par un grand coléoptère. Après s'être approché des fils téléphoniques, il les suivit pour se jeter ensuite sur le tramway électrique, dont il fondit le fil de cuivre de 8.25 mm. de diamètre.

Je passe au mouvement des tourbillons.

Dans la théorie de Helmholtz on explique le mouvement de translation d'un tourbillon aérien par l'action de forces hydrodynamiques.

Dans le cas de l'air ionisé, le tube tourbillonnaire se meut sous l'influence d'un double système de forces, savoir des forces hydrodynamiques et des forces électrostatiques. Comme les projectiles d'air des canons dans le tir contre la grêle, il est attiré par les parties saillantes des maisons et rebondit en touchant le sol.

Étudions le mouvement d'un projectile de masse m , de charge e , soumis à l'influence d'un conducteur sphérique de rayon R mis en communication avec le sol; la charge produite par l'influence sera $e' = -e \frac{R}{r}$, r désignant la distance au centre du conducteur fixe, que nous prendrons pour origine.

Si l'on néglige la friction, les équations de mouvement seront

$$m \frac{d^2 x}{dt^2} = -f e^2 R \frac{x}{r^4}, \text{ etc.}$$

(f = constante de Gauss.) On en déduit les intégrales des aires et celle de forces vives

$$(A) \quad x \frac{dy}{dt} - y \frac{dx}{dt} = C, \text{ etc.}$$

$$(B) \quad \left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2 = f \frac{e^2 R}{m} \left(\frac{1}{r^2} - \frac{1}{a}\right).$$

L'orbite est plane et son plan passe par le conducteur électrisé. Prenons ce plan pour plan des xOy . Introduisons au lieu de x et y les coordonnées polaires r et ϑ , il vient, si l'on élimine dt ,

$$cd \frac{1}{r} = \int \frac{1}{(f\mu - c^2) \frac{1}{r^2} - \frac{f\mu}{a}}; \quad \mu = \frac{e^2 R}{m}.$$

Trois cas sont à distinguer :

1° $f\mu - c^2 > 0$. On aura en intégrant et désignant par ω une constante arbitraire

$$\frac{1}{r} + \sqrt{\frac{1}{r^2} - \frac{1}{q}} = e^{\sqrt{\frac{f\mu}{c^2} - 1} (\vartheta - \omega)},$$

$$\frac{f\mu}{(f\mu - c^2) a} = \frac{1}{q}.$$

C'est l'équation de la trajectoire; la courbe définie par cette équation est comprise entre deux spirales logarithmiques.

2° $f\mu - c^2 = 0$. On doit avoir $a < 0$. En intégrant il vient

$$r (\vartheta - \omega) = \frac{c}{\sqrt{-\frac{f\mu}{a}}}.$$

La courbe s'est transformée en une spirale hyperbolique.

3° $f\mu - c^2 < 0$. On aura encore $a < 0$, et l'équation de la trajectoire devient, en désignant par λ la fraction

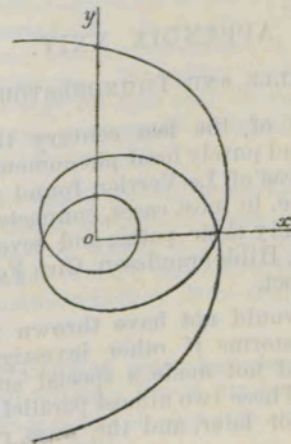
$$\sqrt{1 - \frac{f\mu}{c^2}} \quad (0 < \lambda < 1),$$

$$\lambda (\vartheta - \omega) = \arccos \frac{p}{2r}, \text{ ou } r = \frac{p}{2 \cos \lambda (\vartheta - \omega)},$$

p étant le paramètre de la trajectoire

$$\frac{p}{2} = \sqrt{\frac{(c^2 - f\mu) a}{f\mu}}.$$

C'est une espèce de parabole: le globe de feu s'approche d'abord du conducteur en décrivant des lacets dont le nombre dépend de λ , pour s'en éloigner ensuite jusqu'à l'infini. La figure ci-jointe montre la forme de la courbe pour $\lambda = \frac{1}{6}$. (On a posé $\omega = 0$.)



La disparition des globes de feu s'explique par l'action des mêmes forces hydrodynamiques et électrostatiques.

Si le mouvement du tube tourbillonnaire devient instable, le globe de feu peut se partager en une foule de petites flammes.

Il est clair que le tourbillon ne saurait perdre sa charge électrique que par la diffusion des ions; car, dans le tube tourbillonnaire les ions sont animés d'une vitesse très grande qui se conserverait indéfiniment s'il n'y avait pas de frottement. Les boules de feu conserveront donc leur charge et en rencontrant des objets élevés ils y produiront tous les effets attribués généralement à la foudre ordinaire.

Essayons d'estimer l'ordre de grandeur de la charge.

Si l'air supposé complètement ionisé ne contient que des ions de même signe, l'anneau elliptique dont il a été question plus haut contiendrait dans chaque centimètre cube de sa masse une quantité d'électricité de 4 coul. (en se reportant aux chiffres de M. Townsend dans les *Proceedings of the Royal Society*, vol. LXV). En prenant pour demi-grands axes de l'ellipse $15\frac{1}{2}$ et $10\frac{1}{2}$ cm. et pour rayon du tore $\frac{1}{2}$ cm., son volume comportera 65 cm³, et sa charge totale devient de 260 coul., ce qui suffit pour expliquer les dégâts occasionnés par l'explosion du météore.

Je finirai ces quelques remarques par un conseil aux personnes désireuses d'étudier de plus près les foudres en boule. Si en effet une boule de feu est formée par des ions cheminant dans des circuits fermés autour de l'axe du tube tourbillonnaire, le corps tourbillonnaire constituera un véritable solénoïde fermé. En dehors il n'y aura pas de force magnétique, or en dedans du tourbillon la force magnétique est parallèle à l'axe du tourbillon. Pour soumettre mon hypothèse à un *experimentum crucis*, on pourra jeter de la limaille de fer très fine sur le globe de feu. On verra alors la limaille de fer disposée en une circonférence perpendiculairement à la direction de translation de l'anneau, chaque grain de limaille étant attaché aux suivants qui forment une chaîne fermée.

APPENDIX XXIV.

SQUALLS AND THUNDERSTORMS.

Up to the middle of the last century thunderstorms were regarded as isolated and purely local phenomena. Marié-Davy and Frou, applying the ideas of Le Verrier, found about the year 1860 that thunderstorms are, in most cases, connected with depressions. They proceeded to study their paths, and several other scientists—in particular Mohn, Hildebrandsson, Ciro Ferrari, von Bezold—also took up the subject.

These researches would not have thrown much light on the question of thunderstorms if other investigators—Abercromby, Cl. Ley, Köppen—had not made a special study of squalls (Fr. *grains*, Ger. *Böen*). These two almost parallel currents of research had to meet sooner or later, and the most recent investigations

seem to have established the fact that a thunderstorm is only a particular case of a squall; in other words, that a thunderstorm is a squall accompanied by disruptive electrical discharges.

Our knowledge of squalls, whether accompanied by thunderstorms or not, is at the present day sufficiently extensive to enable us to make great use of it in forecasting. We know now that dangerous gales are not confined to the regions near the calm area at the centre of depressions; nay, the most violent of them often occur near the extreme edge of a depression along the whole length of a "ruban de grain," or "line squall," which stretches from the centre of the depression to places where the barometer stands at 760 mms., or even higher.

Telegraphic Reports of Squalls.—As the passage of a line squall is marked along its whole front by a sudden change of wind direction, and a sudden, often very great, increase of wind force, nothing would be easier than for each reporting station to inform its central office by telegraph of the passage of a squall. This would enable the central office to determine in an hour or two the orientation and velocity of propagation of the line squall, and thus it would be able to give notice, to within about a quarter of an hour, of the time of occurrence of the squalls at stations not yet affected by the phenomenon. Such warnings would be much less vague than those now sent; they might also give notice of the probable occurrence of thunderstorms, tornadoes, &c., at specified hours, when conditions seem to favour the development of such phenomena.

Isobaric Charts for millimetre intervals.—Charts constructed for intervals of five millimetres are all based on the false assumption that the shapes of the isobars are approximately circular, and that their precise shape is not of importance. In reality depressions are furrowed by crests of high pressure, forming the "rubans de grains," preceded by troughs of low pressure. These crests and troughs, which are at times several millimetres deep, are conspicuously shown on charts on which the isobars are drawn for intervals of one millimetre. They are not even entirely obliterated if the errors of observation approach one millimetre in magnitude. It is not so much the minute details of the crests and troughs which are of importance, as the fact that they are in existence. Whenever we can identify a small trough on the map, we may be sure that the region further to the east is threatened by the passage of a squall, possibly by one accompanied by a thunderstorm.

Charts drawn for intervals of five millimetres have, among other things, helped to give rise to erroneous ideas regarding thunderstorm "sacks," at the base of which thunderstorms are supposed to be formed. As a matter of fact, these irregularities are shown by all the isobars, no matter whether their designations are multiples of five or not.

Hail.—In the vast majority of cases hail begins to fall at the moment when the squall bursts. Every theory of the hail formation which does not take account of this fact must be incomplete, and therefore, in a measure, false.

Dust Rain.—There is reason to believe that dust-rains, whether accompanied by rain or not, are brought down to the surface by squall winds. The point requires further investigation.

Unusual Wind phenomena.—I have found that certain unusual wind phenomena, *e.g.*, the brickfielders of Australia, and gales accompanied by snow or dust-storms are, in reality, line squalls. The connection between other forms of unusual winds, such as the simoom or sirocco, khamsin, bora, föhn, pampero, norther, &c., and line squalls, should be examined.

Proposed Investigation of Squalls.—In spite of the courtesy of the authorities in charge of observatories, there are some investigations which are very difficult for isolated investigators, as they require a vast number of records.

Some of these problems can only be studied on the spot. The question whether the pampero is a phenomenon connected with a line squall or several line squalls must be investigated at one of the observatories of Central America; similarly the sirocco of Algiers, and the northers and tornadoes of the United States, must be studied locally.

In Europe there is scope for a great deal of individual effort, but I think that co-operative research would assist still more in increasing our knowledge of the laws of squalls.

Suppose we select for study a squall which is remarkable for its great length, for the unusual extent of country traversed, and for the violence of the hail, thunder, or rain storms which accompany it. The squall might extend—the case often occurs—from England or Scotland to the Sahara; its course might run from the Atlantic to the Russo-Siberian frontier. Obviously it would be important to study such a phenomenon in detail, but equally obviously it would take an isolated student years merely to collect the facts required for the investigation. It is in this connection that collective action is of importance. Each Director of a meteorological service should collect all records relating to events which occur within the region dealt with by his service. The documents thus collected for each area should be sorted and put at the disposal of a meteorologist for examination. Three or four members of the Commission should verify and discuss the results obtained.

The experiment should be repeated in other cases, but even the first research of this kind would probably yield valuable results. It would give us more precise information regarding the laws of squalls, and thus would assist us in forecasting the occurrence of squalls and thunderstorms.

Nature of the Records required.—We may assume that all meteorological phenomena which occur during the passage of a line squall are more or less connected with it. Every line squall forms an integral part of a large depression. In order to study it we must know the general meteorological situation over the whole of Europe and the surrounding seas. We therefore require all the observations contained in the Daily Reports of the different Offices as well as all additional observations of the same kind which can be procured.

Autographic records are equally important. We should collect the traces for the days on which the squalls occurred and also those for the preceding and succeeding days for the following elements:—Barometric pressure, Wind velocity, Wind direction, Temperature, Humidity, and Precipitation.

It is most important that the time scales of the autographic records should be correct or, if not, that their errors should be known, by comparing them with a good chronograph. As to direct reading observations, the observers should aim at reading all their instruments as nearly simultaneously as possible. As absolute coincidence is not possible they should note (to the nearest second) the exact time of observing each instrument.

I add one other point. The meteorologist called upon to discuss this mass of documents should be relieved, as far as possible, of unnecessary labour. For example, barometric readings should be corrected for temperature and reduced to mean sea level and to standard gravity before they are forwarded to him, but at the same time he should have access to all the documents to verify these reductions if he requires to do so.

Such are the arrangements which seem to me to be required for advancing this vast and complex study. I hope that the Commission on Squalls and Thunderstorms will approve my suggestions and send them up for consideration at a general meeting of the Conference.

E. DURAND-GRÉVILLE.

APPENDIX XXV.

TERRESTRIAL MAGNETISM.

PROPOSALS BY PROFESSOR AD. SCHMIDT SUBMITTED TO THE CONFERENCE OF DIRECTORS AT INNSBRUCK.

The permanent International Commission on Terrestrial Magnetism and Atmospheric Electricity appointed by the International Meteorological Conference at Paris in 1896 has met twice, in Bristol in 1898 and in Paris in 1900. After an interval of five years it is about to meet again in September of this year in connection with a Conference of Meteorologists to be held at Innsbruck. The Commission appointed by the International Association of Academies at its meeting last year in London to study certain questions connected with terrestrial magnetism and atmospheric electricity will meet simultaneously.

Let us hope that this coincidence will offer a welcome opportunity for solving various questions of organisation which the meetings at Bristol and Paris showed were urgently in need of settlement. On the one hand the relations of the Commission to the official Meteorological Conference require to be more fully defined as it is only in this way that the Commission's resolutions can attain practical importance. On the other hand the Commission stands in need of greater freedom of action within prescribed limits, to which end it is above all important to appoint

a small executive bureau. The question will also have to be considered whether co-operative action can be arranged between the Commission and the Commissions appointed by the International Association of Academies and the Department of Terrestrial Magnetism of the Carnegie Institute. This may be the more easily arranged for, as the same individuals in many instances are members of the bodies I have referred to, including the scientific Council of the Department.

Co-operation with the latter body is of special practical importance, as the Department is entitled to first place among all institutions engaged in magnetic researches, thanks to its large resources and to its far-sighted administration.

I will not go further into these questions of organisation, but I must mention them, for unless they are satisfactorily arranged the practical proposals which I am about to submit will lead only to academic discussion without actual results.

My proposals deal mainly with questions which were discussed at previous meetings, but the resolutions adopted in connection with them have only been acted on to a very small extent. I therefore lay great stress on the point that all proposals must be so framed that they can be carried into practice without difficulty. It will be necessary in many instances to forego "better" and be content with "good." By so limiting ourselves we may realise what is practicable at the present day, which is better than striving after the unattainable. Let us hope that things will gradually develop and that in the end we may reach the desired goal without serious difficulty.

My proposals deal with—

- (1) Systematic comparisons of the standard instruments of the various observatories.
- (2) The establishment of a number of new observatories for, at least, the length of a sunspot period.
- (3) The publication of hourly mean values (by G.M.T.) for every day in place of the hourly instantaneous values hitherto given.
- (4) A change in the agreement respecting the preparation of lists of "quiet" days, and the publication of the lists by a central office.
- (5) An agreement for an exchange of copies of disturbed curves.

1. I need not bring forward detailed arguments in favour of the first point. The acknowledged differences between the values obtained with different instruments (especially in the cases of horizontal force and inclination) exceed greatly the limit of accuracy of the individual instruments if their indications be regarded as relative ones only. Until we are able to refer these differences to their true causes, and consequently to determine the appropriate correction for each individual instrument, we have no option but to reduce the records empirically by direct comparison, and so make them comparable with an adopted standard (possibly the mean of all observed values). As experience has shown that the

observed differences change in course of time, the comparison will have to be repeated from time to time. We ought to regard the ordinary observations made with the instruments in regular use at the observatories only as relative measurements; absolute determination, in the true sense of the word, should be made from time to time by different methods. Each of these determinations should form an independent physical research of great accuracy, in which the elimination of all possible errors should be the first consideration, and not ease and rapidity of manipulation, as is the case with observations, which are regularly repeated. The latter points might be kept more prominently in view in the regular work than is the case at present.

The justice of the demand which I have put forward has been admitted long ago. The following resolution, proposed by M. Mascart, was carried unanimously at the Meteorological Conference in Paris in 1896:

"Comparison of the magnetic results of different countries has shown that it is necessary that the instruments which are employed in the different magnetic surveys shall be compared with one another repeatedly."

Such comparisons were made in a number of cases, even, before 1896. The results obtained by Rijckevorsel, Solander, and Bauer afforded strong proof of the necessity for further investigations of this nature, and above all for systematic comparisons. Hitherto the most important instrumental comparisons have been made by private workers, but in future they will have to form a regular part of observatory work. We cannot leave such important work to the chance of finding some one willing to undertake it. The demands made on each individual observatory would not be great. It would suffice if the standard instruments of each observatory were compared with those of the others every second year, especially as we now have a trustworthy instrument of precision for determining the inclination, in the rotatory inductor, as devised by Wild and modified by Eschenhagen. Even if only the chief observatories of six States take part in these comparisons, each one would have to take its turn only once in twelve years. The scheme would allow of some of the smaller observatories being visited from time to time, and these might co-operate by occasionally making comparisons between their instruments and those of the nearest central observatory.

In this way comparable results would be obtained from all institutes taking part in the scheme at comparatively little expense. At the present time it is especially important to keep the possibility of carrying it out steadily in view. The magnetic survey along a parallel of latitude encircling the earth, proposed by the Academy of Sciences of Berlin, which will give a definite answer to the question of the existence of a potential of the mean magnetic force of the earth, requires very accurate and regular comparison of the instruments used in different countries.

Definite arrangements cannot be made by the Conference for carrying out the proposed work, because the representatives of the individual observatories will hardly be in a position to undertake binding obligations. It would be enough if the plan I have

described (modified if necessary) was approved in principle. It should also be intimated that all such enterprises should be arranged for by mutual understanding, for unless this is done there would be danger of having a large number of comparisons carried out within a brief period, and then having to wait for many years for the work to be resumed.

I therefore beg leave to put my proposal in the following form:—

"It is absolutely essential that the standard instruments of the various observatories be compared with one another from time to time. To attain this end, it is desirable that once in every two years one of the chief observatories of the largest States should undertake to compare its instruments with those of a number of other observatories. The comparisons should be carried out with portable instruments of first-rate quality. The order of making the comparisons should be arranged by mutual understanding between the observatories."

2. The necessity of establishing a large number of new observatories in parts of the world in which at the present day there are none, has also been recognised for a long time. The question was raised at the Paris Conference by Messrs. von Bezold and Eschenhagen and was referred to the Magnetic Commission by a resolution regarding the establishment of temporary stations proposed by M. Rykatcheff. A detailed report on the subject was submitted to the Bristol meeting by Messrs. von Bezold and Rykatcheff. After an exhaustive discussion, the following resolution was there adopted:—

"It is desired that temporary magnetic observatories be established at the following places:—Tashkent, Pekin, Lick Observatory, Quito, Pará, Colombo, Cape of Good Hope, St. Paul or New Amsterdam, Honolulu, Point Barrow or Sitka or some other station in the Arctic part of North America. These observatories should be equipped if possible with absolute and autographic variation instruments, and they should be kept in operation for at least seven, and if possible for 11 or 12 years, *i.e.*, throughout a complete sunspot period."

A number of new observatories have been established since, several of them at places mentioned in the list. Taken as a whole, the network of magnetic stations still shows a large number of gaps, which there is little prospect of filling in the near future. The number of stations which would be required to cover the surface of the earth approximately uniformly though by no means closely is so very large. Even if we assign only one station to each ten-degrees square (an area $2\frac{1}{2}$ times that of the German Empire) we should require 400 stations.

In view of these facts it is desirable that we should agree as to what are the most important questions which the observatories have to solve and then select places for establishing new stations in such a way that the minimum number of stations will provide the maximum amount of information bearing on these questions. In the same way we should reduce the demands made on the new observatories as far as possible in order not to make their inauguration impossible by asking too much.

These remarks do not apply to the principal observatories—we might call them observatories of the first order—which are bound to investigate all the phenomena of terrestrial magnetism without limits. These institutions, of which each country should have at least one, should not be mere observing stations, but should act as laboratories and centres of research—a point recently insisted on strongly by A. Schuster.

These homes of research require to be supplemented by a number of stations of the second or even of the third order, whose function it should be to collect data, on a pre-arranged plan, to be worked up at the central institution. These data should be such as to enable us to investigate the dependence of magnetic phenomena on the geographical position of the observing station. We should then learn to look upon local phenomena as part of the general distribution of magnetic phenomena over the surface of the earth.

What are the problems in which we must regard the earth as a whole, which consequently require data from a very large number of stations for their solution?

They are on the one hand the determination of the average magnetic state of the earth, above all of its secular change, and on the other hand the investigation of changes of short period, particularly the diurnal and lunar variations, and of non-periodic changes or disturbances.

A magnetic survey of the whole surface of the earth is so vast an undertaking that, even in the most favourable circumstances and with the assistance of the Carnegie Institute, it can only be completed in the course of many years. If we desire to determine the secular variation from a comparison of two complete surveys we should have to wait many decades before arriving at any conclusion, even though we could obtain an approximation to it by comparing the first survey with the data which already exist. But even so, the results obtained would only be average values for a long period. On the other hand, each of the two surveys, which would each of them require a considerable number of years for completion, would require some preliminary knowledge of the secular variation, as the data would have to be reduced to a definite epoch.

We must, therefore, endeavour to determine the secular variation for the whole earth by independent observations. This method would have the advantage that it gives us values for each year and not merely average values. It could be easily applied if we had a sufficiently close and uniform network of stations. These need not all be observatories of the first order of the kind described above, but they would have to take continuous observations and also occasional absolute measurements for their reduction, so that they would, in the main, do work similar to that now carried on at the observatories. Particular importance would attach to the standardising of their absolute instruments or, at any rate, to determining that these suffer no appreciable change through lapse of time. As regards the number and distribution of these stations, it is obvious that the total number would have to be sufficiently great to enable us to determine the potential of the

earth's magnetism from their absolute values. The potential determined in this way need not agree exactly with the potential determined for the same epoch from more comprehensive data; the difference should be of the order of magnitude of the local disturbances, and should be practically constant for a considerable time.

Though it is undoubtedly desirable, from this point of view, to increase the present network of stations by founding institutions of the kind I have described, it will certainly be long before the number of stations is largely increased. In view of the comparatively small demands in the way of accuracy that need be made in a preliminary magnetic survey of the whole surface of the globe, a number of stations, at which accurate measurements of all the elements are made, say every five years during the time the survey is in progress, would form a very good substitute for a close network of permanent stations.

I abstain therefore from putting forward definite proposals regarding observatories which are to serve these purposes, though it might be a good thing to nominate a special sub-commission to work out proposals to be submitted at a subsequent meeting of the Commission. No special consideration is required to point out a large number of places in which observatories are desirable. Every place which fills a gap, or reduces the lack of uniformity in the present network, may be so described.

The second of the two problems referred to above remains to be considered, viz., the investigation of short period and non-periodic fluctuations. We are now concerned with the determination of magnetic changes. Absolute measurements, which were of great importance in the researches previously considered, are of little use in this work, and may even be dispensed with entirely. Thereby the work of the observatory is much reduced, and expenses are greatly diminished, especially if we are willing to forego great sensitiveness in the variation instruments. The saving is so great that it will, in general, be easier to maintain several such "observatories of the third order" than one of the second order. Further reductions of expense may generally be effected by combining the station with an astronomical or meteorological observatory. A very simple structure will serve to house the instruments. It need only provide sufficient protection against change of temperature to insure that the instruments are not subjected to violent diurnal changes. Provision need not be made to counteract the annual or the slow non-periodic changes of temperature. The instruments may be made so simple that a scientifically trained observer can set them up and look after them with little trouble or loss of time, even though he have no previous experience of magnetic work. Further simplification and reduction of cost may be obtained by adopting a contracted time scale. A very open scale is not essential. Investigations of this kind are as yet still in their infancy, and it will probably be a long time before we are in a position to deal exhaustively with small variations, except in very special cases. Very open time scales may be left to the central observatories. To make full use of an open time scale we require to increase the sensitiveness of the apparatus, and

this is unnecessary in work of the kind I have in view. It is even undesirable, as it easily leads to an interruption of the record.

If the practical considerations which I have referred to make it desirable, a time scale of 10 mm. to the hour and sensitiveness of the order of 10γ to 1 mm. could be used without hesitation. The customary scale of abscissae is 15 mm. to the hour, and in the interest of uniformity it may be considered desirable to adhere to this, and also to the scale of sensitiveness, 5γ to 1 mm., which has been recommended several times by International meetings. In one particular a change from the usual practice would need to be made. The scale of sensitiveness is to be adopted, not only for the horizontal and vertical components, but also for measuring the deflecting force in the case of the declination. The usually adopted scale of $1'$ to 1 mm. is too great for polar regions and too small in equatorial regions. My proposal would substitute a scale of $1' \div \left(\frac{H}{5 \times 10^{-5}} \frac{\pi}{180 \times 60} \right)$ or $0.172/H$ to 1 mm., where H is the mean value of the local horizontal force in C.G.S. units.

Great sensitiveness is not required, but it is highly important that the sensitiveness of the different variometers should be accurately determined at frequent intervals. This can be most simply done by making use of the deflecting force of a weak electric current passing through coils connected in series and permanently attached to the three variometers. Provision for registering changes of temperature and for determining the temperature coefficients of the instruments is also essential. It is desirable to attach the apparatus necessary for this, permanently to the magnetic recorders. It may be remarked that, if the instruments are working well, the changes shown are so slow and uniform that the temperature coefficients can be determined from the regular observations by examining the effects of large but slow changes of temperature. In places at which these are small in comparison with the diurnal change of temperature, this method could not be applied.

The limitations which I have proposed would simplify the work of a station so considerably that we may hope to see the needful extension of stations accomplished without undue difficulty. The selection of places at which to start new stations should be guided by the requirements of the most important problem to be solved. This is, undoubtedly, the investigation of the diurnal variation.

We know that the diurnal change of the magnetic elements in extra-polar regions is primarily a function of the latitude, and that it may be regarded as approximately constant along a parallel of latitude. This circumstance forms the basis of a good deal of the work done by Sabine, Schuster, von Bezold, and Fritsche, and it alone enables us to form an approximate idea of the general character of the variation, as a whole.

Seeing that the character of the diurnal change depends principally on the latitude, it follows that it is of primary importance to secure a uniform distribution of observatories in latitude, and that an increase in the number of stations along a given parallel of latitude is of comparatively small importance. The vast majority of the existing observatories are situated between 35° N.

and 60° N.; from this it follows that new observatories should, if possible, be established in southern latitudes, or in high or low northern latitudes. There is no great need for them in middle northern latitudes. If the diurnal change were entirely independent of the longitude, the point on a parallel of latitude selected for a new station would be a matter of complete indifference. As a matter of fact, the diurnal variation is dependent on the longitude, but only to a small extent. As this longitude effect is not to be investigated in the first instance, it should be as far as possible eliminated; in other words, all the stations should be approximately in the same longitude. This would give us a solution of the problem for a particular meridian, which might be regarded as typical for all meridians. To approximate more closely to a general solution, the observatories should be extended ultimately to another meridian, or to several meridians, preferably to such as are equidistant from one another.

The distribution of land and sea over the surface of the globe admits of the establishment of a series of land stations distributed along the same meridian over both hemispheres in three regions:—(1) North and South America, (2) Europe and Africa, (3) East Asia and Australia. The most favourable conditions would be found on the second line, for only a comparatively small number of new stations would be required to give a double row of stations along it. I am assuming that the proposals put forward by Mr. Beattie for establishing a number of stations in South Africa, and, if possible, one in St. Helena, will be carried out. The realisation of these proposals is highly desirable, apart from the suggestions I have made, for it would help to fill one of the most conspicuous gaps in the present network of observatories. In connexion with my scheme it is absolutely essential. Assuming it to be carried out, the gap between the European and South African networks could be bridged over by establishing a comparatively small number of stations, which might, if necessary, be merely stations of the third order. The following places suggest themselves:—Timbuktu, Cameroon, Loanda, Walfisch Bay in the West, and Cairo, Khartoum, Dar es Salaam, Quilimani in the East. In addition a permanent station of this kind in the extreme north of Scandinavia would be necessary. Obviously my proposals include only the minimum of what is needed to solve the problem, and the positions selected for new stations are only suggestions.

Any opportunity for establishing permanent observatories in other regions should, of course, be seized. Extension of my proposals is specially desirable in two directions. On the one hand the changes in variation along a parallel of latitude require to be examined, and on the other hand the changes in polar regions, which require totally different treatment, must be investigated. The resolution which I beg leave to propose does not take these two points into account. This should not be assumed to mean that I regard such work as unimportant. My object is to point out the direction in which practical and theoretical demands require the first step to be taken.

"The completion of the network of magnetic observatories is necessary. In addition to the establishment of stations in

the conspicuous gaps now shown in the network, it is desirable to inaugurate a number of temporary stations approximately along a meridian. These stations should be equipped with autographic variometers and should be maintained for a period of at least seven years and if possible for eleven or twelve years."

Assuming that the International Committee adopts this or a similar resolution, it would be advisable to appoint a Commission to work out the details of the plan and to make arrangements for putting it into action.

3. The publication of hourly instantaneous values, *i.e.*, of more or less accidental values which may have but little meaning when disturbances are prevalent, could be justified as long as eye observations only were available on the ground that hourly eye observations were sufficiently tedious without otherwise increasing the work. Even in the early days the disadvantages of the method were recognised. At the present day the question of how to treat the "disturbed days" when evaluating the "normal diurnal variation" has not been satisfactorily solved. Now that autographic recording has been introduced there is no reason for restricting ourselves to 24 instantaneous values on each curve except the one that it is undesirable to increase the number of figures printed. The simplest method of showing more minutely the general character of the curve without increasing the number of figures printed consists in determining and publishing hourly mean values. In these all short and irregular fluctuations are so much smoothed that they are of little consequence. As I propose to return to this question in another connexion, I will content myself for the present with a few remarks regarding its practical application. There might appear to be some difficulty about this as the determination of hourly means might require much time and labour. The experience gained at Potsdam since the beginning of this year dispels this fear. We use a specially constructed scale and find that we can read off the mean values with sufficient accuracy, almost as easily as the instantaneous values. Even when the curves are very disturbed the estimates are surprisingly trustworthy, and, moreover, by adopting small intervals of time the diminution of accuracy may be counteracted. The mean ordinates may also be determined with a planimeter, for which purpose we have a specially constructed instrument at Potsdam.

Another important point remains to be mentioned. The proposed new method is radically different in principle from the old one, but in actual practice the two are so closely alike that the new one may be adopted by some observatories even if others do not decide to make any change. The comparability of the results will not be diminished; on the contrary, it will be increased, for with the present method it is more apparent than real. The value of the results may be still further increased if they are made truly synoptic, *i.e.*, if they are referred to hourly intervals (from midnight to 1 a.m., 1 a.m. to 2 a.m., &c.) by Greenwich Mean Time. If this be done it is desirable to deduce and publish the monthly means of the instantaneous hourly values by local time, as these

afford the simplest comparable representation of the mean diurnal change. This is a straightforward piece of interpolation which is much simplified by the smoothness of the curve of monthly mean hourly values.

I summarise what I have said in the following resolution :—

“It is desirable to publish hourly *mean* values by Greenwich Mean Time of the magnetic elements in place of *instantaneous* hourly values. The monthly mean diurnal variation should also be given in the form of mean instantaneous values deduced from the hourly means.”

4. The Conference at Bristol agreed that all days should be included in the computation of monthly mean values of diurnal variation. A resolution was also adopted asking that mean values deduced exclusively from quiet days should also be computed. It was agreed that the days selected as “quiet” ones by the various observatories should be notified to the President (for whom M. Hildebrandsson and, since the middle of 1903, M. Snellen acted), who would communicate them by circular to all observatories. This has been regularly done, nine observatories taking part in the scheme. Experience has confirmed what was anticipated at the outset. General principles to govern the selection of quiet days cannot be laid down with sufficient clearness, with the result that the selections from different observatories differ greatly. Even in the case of a single observatory it is difficult to secure uniformity of method over a long period. Moreover, the results hitherto attained have been small compared with the work involved in securing them, and apparently but little use has been made of the information which has been published. If the method of procedure recommended above (in section 3) were adopted the object aimed at in the selection of quiet days would be attained and the continued publication of lists of such days would be unnecessary.

We would thus be justified in bringing the experiment to a close. We may, however, ask ourselves whether the organisation which has been called into being to carry on the work might not be used for some other purpose. The query may be answered in the affirmative. It would certainly be desirable to be regularly and promptly informed of the general magnetic state of the earth—in particular, of the occurrence of disturbances. The most useful thing would be to prepare a numerical statement, somewhat on the lines proposed by Eschenhagen, which would describe the general magnetic state of the earth. It is undesirable to make definite proposals in this connexion at the present time, as the matter could be profitably discussed only in the light of experiments and after careful examination of the results. It would be well to appoint a special sub-commission to study the question, and to work out a plan for approval by the next Conference.

For the present, notification of the violently disturbed days would suffice. Even this would leave room for a good deal of caprice, but the drawbacks would be much smaller than is the case in selecting quiet days; above all, the attainment of satisfactory results would be much less influenced if the former course were adopted. In order to be able to set down a day as “quiet,” it

ought to be so described by all observatories; if it is missing from the list of a single observatory, its character is, to say the least, doubtful. On the other hand, a day is undoubtedly “disturbed” if it has been so classed at only a very few places. The number of observatories which have classed a particular day as “disturbed” may be taken as an index of intensity of disturbance.

A few criteria for assisting in the selection can be given even in the present state of our knowledge. Stress may be laid on the fact that the absolute amount of divergence from the normal curve can only be looked upon as of minor importance. Moreover the limiting value of the divergence would have to be selected separately for each station. The irregularity of the curve is an important matter to be considered; sudden and frequent changes in the character of the oscillations, and the fact that the normal is daily change is much deformed or entirely obliterated for a considerable length of time, are important features of “disturbed” days. It hardly need be mentioned that the lists should give not merely “disturbed days,” but the hours by G.M.T. during which the curve was disturbed. This is already done by the Observatory of Pawlowsk in its lists of “quiet” days.

These considerations lead me to propose a resolution which is in conformity with a resolution adopted at the Southport (1903) meeting of the International Committee, on a discussion provoked by J. de Moidrey :—

“From January of next year (1906) lists of the times of violent disturbances shall be prepared and published in place of the present lists of so-called “quiet” days.

“A sub-commission is to be appointed to work out proposals for utilising these lists and to fix the principles guiding the classification of records.”

5. The question of the interchange of copies of curves of special interest has been raised frequently, but until recently little has been done in this direction. Since the beginning of last year the Observatory of Potsdam has prepared lithographed copies of some of its curves, and has distributed these to other observatories. An increasing number of institutions is following this lead, so that the proposed exchange is now being carried out to some extent. A sympathetic resolution on the part of the Conference would lead to the practice becoming more general, and would secure its continuation. I therefore beg leave to move :—

“That it is desirable that copies of all violently disturbed curves be exchanged regularly between the observatories with as little delay as possible.”

In this resolution I have refrained from suggesting a uniform scale for the reproductions, as the difficulty of introducing this at all observatories might prove considerable, and so wreck the whole scheme. Agreement in the matter is very important, and it is desirable to fix a definite scale for general adoption, so that observatories which are willing and able to redraw their curves may have a standard to work to. Even if this is done in the first instance by a few institutions only, it is to be hoped that the

others will conform to the general practice as occasion offers. As the basis of such an agreement, I beg to propose a time scale of 15 mms. to 1 hour, and an ordinate scale of 1 mm. to 5 γ . This gives diagrams on a convenient size, and corresponds approximately with the mean of the scales generally used at the individual observatories.

AD. SCHMIDT.

APPENDIX XXVI.

LETTER TO THE COMMITTEE ON TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY OF THE INTERNATIONAL METEOROLOGICAL CONFERENCE MEETING AT INNSBRUCK, AUSTRIA, SEPTEMBER, 1905, BY DR. L. A. BAUER.

Professor Schmidt has kindly let me see the communication which he expects to submit to the present Meeting of the International Committee on Terrestrial Magnetism and Atmospheric Electricity. It had been my intention to be present at this meeting, but duties in connexion with the magnetic survey of the North Pacific Ocean and the eclipse observations have made it imperative to relinquish this purpose. Instead of laying before the meeting separate proposals, I beg to submit a few thoughts which have occurred to me in the perusal of Professor Schmidt's important communication.

In his introductory remarks, he refers briefly to the desirability of a closer union between existing organisations concerned with international researches in terrestrial magnetism and atmospheric electricity, regarding which, I am sure, we are all agreed. I am strongly tempted to make a few remarks on this matter, but do not think the time will be ripe for arriving at a true and satisfactory solution until the status and scope of international organisations have been more clearly defined, and the precise advantages of associating magnetic and electric work with meteorological work or other work have become more patent than they are now. I believe that, in the ultimate solution, full cognizance will be taken of the fact that the subjects of terrestrial magnetism and atmospheric electricity are worthy of consideration by themselves apart from meteorology, and that their most successful development demands, indeed, an independent treatment. It must certainly be a source of gratification that this fact has been recognised by the Carnegie Institution of Washington in the founding of its Department of Terrestrial Magnetism where magnetic researches can be undertaken purely by themselves, irrespective of considerations imposed by supposedly related sciences. This Department having for its sole object the advancement of the subject of terrestrial magnetism, is ready to render assistance in any effort having this object in view.

Passing now to Professor Schmidt's proposals, I shall take them up in order.

Number 1.—There can be no question as to the desirability and need of systematic intercomparisons of the standard magnetic instruments of each country. Possibly, however, before the plan

proposed is definitely put into execution, certain necessary preliminary investigations require first to be undertaken with the view of ascertaining precisely the cause of the corrections found, how constant the corrections are, and, if they vary, what causes them to vary; and, furthermore, the laws require determination regarding which the constants may vary with change in magnetic latitude. Some studies of this kind have become imperative in connexion with the work of the Department of Terrestrial Magnetism in progress and in contemplation (*see* statement in journal "Terrestrial Magnetism and Atmospheric Electricity," June issue). I fear, furthermore, that the practical execution of the plan, as suggested by Professor Schmidt, may meet with difficulties, since it requires that the country whose turn it is to undertake the international comparison will have to secure from some source the necessary funds, the obtaining of which will always be attendant with more or less uncertainty. Owing to the peculiar status of this Committee, none of its members, I believe, are authorised to pledge their respective countries or academies.

In this connexion, it cannot be too strongly emphasized that countries in which magnetic instruments are manufactured should have some institution which can readily undertake the testing of instruments before they are utilized for magnetic work. The absolute necessity of this matter has been forcibly impressed upon me in the purchase of a large number of instruments for the United States Coast and Geodetic Survey and the Department of Terrestrial Magnetism from various European countries during the past six years. Only England at present is prepared to readily undertake such necessary tests. The amount of good done in this respect by the Kew Observatory has not yet been sufficiently appreciated. It would be fortunate for our science could the facilities of the Kew Observatory for this important work be amplified.

I may say that, as far as the United States of North America are concerned, the funds appropriated for its official magnetic work would not permit undertaking international comparisons, or any work in fact in foreign countries. However, there would be no difficulty in the case of the Department of Terrestrial Magnetism. It can at any time carry out such work, in any manner, that may be necessary for the accomplishment of the task. In fact, the successful execution of its published plans must necessarily embrace the inter-comparisons of standard instruments of the various countries.

Number 2.—Respecting the erecting of additional magnetic observatories, I may say that, in all probability, a magnetic observatory will be established on Mount Wilson, California, or vicinity, under the combined auspices of the Solar Observatory and the Department of Terrestrial Magnetism of the Carnegie Institution, both for the purpose of assisting in the magnetic survey of the North Pacific Ocean and to investigate specially the correlation between magnetic disturbances and solar phenomena. To assist in the latter purpose, as announced in the June issue of the Journal "Terrestrial Magnetism," direct recording variometers giving a visible record, like that of a thermograph are being installed. Besides giving the desired notice regarding magnetic

storms, it is hoped that the record will be one utilizable for such broad investigation as Schmidt outlines. Should the device prove satisfactory, it is the intention to multiply copies of the instruments and to distribute them to existing favourably situated institutions ready and able to co-operate in an effectual manner. The Department may thus possibly perform a useful function in the realization of the propositions advanced.

Regarding the number and the geographical distribution of institutions contributing data for the successful study of the diurnal variation, I would be inclined to advise referring this question to a sub-committee for special investigation. I had hoped to have been able to complete my paper on "The Diurnal Motion of a free Magnetic Needle" in time to lay it before this distinguished Committee, but owing to my manifold duties I have been unable to do so. I may say, however, that as far as this paper has progressed, there is sufficient evidence, apparently, to indicate that for stations along the same parallel, the curve of diurnal motion combining both changes in declination and inclination, as in my secular variation investigations, may vary considerably. It would seem that as far as the diurnal variation of the inclination is concerned, the question of dependence upon longitude of station, as well as latitude, must certainly be taken into account. If this be true the proper distribution of stations is one meriting most careful consideration.

As to the general magnetic survey of the globe and the general investigation of the secular variation of its magnetism, these are two problems which, in accordance with the plans already published, are to receive the chief consideration of the Department of Terrestrial Magnetism. The Carnegie Institution of Washington has entered seriously upon the completion of these two great tasks. Ample assurance has been given me that the requisite funds will be provided for the systematic magnetic survey of the oceanic areas and of the uncivilized or unexplored countries. It merely remains that my colleagues will see to it that magnetic surveys are energetically prosecuted in the countries and colonies which they represent, and that they will extend to the said institution their heartiest co-operation. The magnetic survey of the North Pacific Ocean, as already announced, was begun this summer, and observers have been sent out to the various groups of islands in the Pacific and Atlantic Ocean and in the bordering countries, so that from now on there will be a steady and a systematic accumulation of magnetic data.

A careful consideration of these two great problems has convinced me that the successful execution within a period of twenty years is not such an extraordinarily difficult task as might appear. I hope even to be able to arrange the work in such a way that the mathematical analysis of the earth's magnetic field as dependent upon freshly accumulated data can be made for two epochs sufficiently apart to detect, for example, whether the earth's magnetic moment is really shrinking as indicated in my researches based upon the data at present at hand. My plans relating to these two problems are to be laid more fully before the coming annual committee of the Board of Trustees of the Carnegie Institution.

Number 3.—I fully endorse Schmidt's proposition and accompanying remarks. The question of a full and complete utilization of the photographic curves by publishing the mean ordinate for an hourly interval, instead of simply an ordinate corresponding to the full hour, is one that I had submitted to the acting secretary for discussion when it was believed that there would be a meeting of this Committee last year. Since then I had partially put the plan in operation respecting the observatory observations of the Coast and Geodetic Survey, but owing to other duties was obliged to lay the completion aside. I was, therefore, gratified in no small degree when, during my visit at the Potsdam Observatory during February of this year, I found that not only had Schmidt formulated similar ideas to mine but had actually put the plan in successful operation as far as the Potsdam observations are concerned. I am ready to adopt the plan from any date that the Committee may decide upon.

Number 4.—I also endorse Schmidt's suggestion made in connection with the proposition set forth under this number. The principal magnetic disturbances recorded at the Cheltenham Observatory are already being regularly reported in the *Journal of Terrestrial Magnetism*.

Number 5.—Instead of each observatory being asked to pledge itself to distribute regularly and promptly copies of its disturbed curves to every other observatory, which would, doubtless, necessitate more work than can be devoted to the matter by many observatories, I would recommend for adoption "that each magnetic observatory regularly and promptly send a copy of its disturbed curves to the Potsdam Magnetic Observatory for discussion under Schmidt's direction." As is well known, a general discussion of magnetic storms has been undertaken by him under the auspices of the "Department of Terrestrial Magnetism." If the plan of co-operation proves successful, the "Department" is prepared to continue its aid if it be necessary.

In conclusion, as I am about to retire from the editorship of the *International Journal of Terrestrial Magnetism and Atmospheric Electricity* at the expiration of the tenth year of its existence, I may be permitted to emphasize the need of a more effective control being exercised in the accuracy of published figures and results by those in charge of computations or by those submitting papers for publication. I have been repeatedly chagrined at the lack of care shown in this respect in magnetic publications, and have been frequently obliged, by the necessity of checking figures, to spend time which I could have devoted to better purpose. It would certainly be highly advantageous if those who are to take charge of observational work and its reduction, which, in my humble opinion, should always go hand in hand, could previously secure training in some computing institute. It apparently happens too frequently now that time is wasted because of observers or those in charge not having secured practical training in computation.

Though the editing of a journal of this character has not been a light matter, I have nevertheless got a great deal of pleasure out

of it, especially owing to the very pleasant relations I have enjoyed with the eminent investigators over the entire globe. I wish to thank all of you, not only for your cordial support and warm sympathy, but also for your generous indulgence in overlooking any faults in my management of the Journal.

July 14th, 1905.

L. A. BAUER.

APPENDIX XXVII.

ON THE LATITUDES WHICH SHOULD BE SELECTED FOR MAGNETIC OBSERVATORIES.

(Sur les latitudes qu'il convient de choisir pour les
observatoires magnétiques.)

By V. Carlheim-Gyllensköld.

Si l'on se figure le potentiel magnétique développé en série, chaque terme a un maximum pour une certaine latitude, et ces latitudes diffèrent pour les trois composantes de la force. Ces latitudes où les composantes acquièrent leur maxima sont évidemment les plus avantageuses pour une détermination exacte des coefficients.

Les calculs déjà faits permettent de juger de l'importance des divers termes. Pour les variations diurnes régulières je me suis tenu aux calculs faits par M. Schuster et par M. Fritsche; pour les variations séculaires, pour la variation semi-diurne lunaire, et pour la variation diurne du champ des perturbations, à mes propres recherches

Écrivons

$$Y_n^{(i)} = (1 - \mu^*)^{\frac{n}{2}} \frac{d^n X_i}{d\mu^n} a_n^{(i)} \cos n(\psi + \beta_n^{(i)}),$$

où $\mu = \cos \theta$, et ψ désigne la longitude; $a_n^{(i)}$ et $\beta_n^{(i)}$ sont deux constantes arbitraires, dont la première mesure l'importance du terme.

D'après M. Schuster les termes les plus importants de la variation diurne sont $Y_1^{(1)}$ et $Y_2^{(2)}$; d'après M. Fritsche les termes $Y_1^{(3)}$, $Y_1^{(4)}$, $Y_2^{(3)}$, $Y_3^{(4)}$, joueraient encore un rôle appréciable.

La variation semi-diurne lunaire dépend presque exclusivement d'un terme $Y_2^{(3)}$.

Dans le mouvement séculaire tous les termes des quatre premiers ordres sont d'une importance capitale (exception faites des termes $Y_0^{(i)}$ qui sont invariables), et de plus deux termes d'ordre supérieur, $Y_2^{(3)}$ et $Y_3^{(4)}$.

Pour plus de détails je renvoie au tableau qui accompagne cette note. (Annexe I.)

J'ai dressé ensuite un petit tableau qui donne pour chaque fonction $Y_n^{(i)}$ les valeurs de θ , à un degré entier près, où les composantes de la force magnétique présentent un maximum ou un minimum. (Annexe II.)

Si l'on tient compte de tous les termes qui constituent la variation séculaire, les latitudes où les composantes acquièrent leurs maxima se groupent autour de certaines valeurs fixes :

Complément de la latitude.					Nombre.
	θ				
	0°	7
Voisin de	20°	4
"	30°	5
"	45°	9
"	60°	9
"	70°	5
"	90°	18

Si l'on se borne aux six termes qui jouent le rôle prépondérant dans les variations solaires et lunaires, les résultats sont essentiellement les mêmes.

Il est donc à recommander, pour l'étude des variations régulières, que des observations magnétiques soient instituées aux latitudes suivantes dans les deux hémisphères :

$\phi = 60^\circ, 45^\circ, 30^\circ, 20^\circ$, et surtout à l'équateur.

Nous avons exclu les hautes latitudes où les variations sont troublées par les perturbations. Si l'on s'en tient au méridien proposé par M. Schmidt dans sa "Begründung," il fallait ajouter encore aux points proposés par lui les îles du Prince Édouard (ou île Crozet, ou île Kerguelen) et une station à 60° de latitude Sud malheureusement difficile à trouver.

Annexe I.

Coefficients des termes de la variation diurne solaire du magnétisme terrestre. (Unités du 5^e ordre, Système C. G. S.)

D'après M. Schuster* (Phil. Trans., t. CLXXX., p. 480).				D'après M. Fritsche (Tägliche Variation, p. 12).	
				Forces extér.	Forces intér.
$Y_1^{(1)}$	...	...	...	5.37	1.71
$Y_1^{(2)}$	...	...	...	8.89	13.31
$Y_1^{(3)}$	...	...	...	1.02	1.86
$Y_1^{(4)}$	...	...	...	0.80	11.04
$Y_2^{(2)}$	...	...	...	1.11	0.24
$Y_2^{(3)}$	...	...	...	0.92	6.31
$Y_2^{(4)}$	...	...	...	0.07	0.23
$Y_3^{(3)}$	...	...	...	—	0.35
$Y_3^{(4)}$	...	...	...	0.06	3.19
$Y_4^{(4)}$	...	...	...	—	0.13

* Nous n'avons conservé que les termes des 4 premiers ordres.

Le terme semi-diurne lunaire est, d'après les recherches de l'auteur en 1891 (Unités C. G. S.).

$$\frac{V}{R} = 0.826. \quad P_2^{(3)} \cos(71^\circ.6 + 2\psi + 2t),$$

désignant le temps du premier méridien adopté (mér. de Greenwich).

Coefficients et variations séculaires de l'argument du magnétisme terrestre. (D'après les calculs de l'auteur en 1902 fondés sur l'ensemble des données accessibles.)

—					Coeff. $\alpha_n^{(i)}$	Mouvement annuel de $n \beta_n^{(i)}$
$Y_1^{(1)}$	...	...	...	...	0.063306	+ 0.11780
$Y_1^{(2)}$	...	...	...	...	0.045175	+ 0.19827
$Y_1^{(3)}$	...	...	...	...	0.034104	+ 0.16138
$Y_1^{(4)}$	...	...	...	...	0.043181	- 0.20855
$Y_2^{(2) \dagger}$	...	...	...	...	0.019329	+ 0.69743
$Y_2^{(3)}$	...	...	...	...	0.026467	+ 0.02971
$Y_2^{(4)}$	...	...	...	...	0.022653	- 0.21085
$Y_2^{(6)}$	...	...	...	...	0.012172	+ 0.30866
$Y_3^{(3) \dagger}$	...	...	...	...	0.003993	+ 0.50178
$Y_3^{(4)}$	...	...	...	...	0.007211	+ 0.26437
$Y_3^{(5) \dagger}$	...	...	...	...	0.003150	+ 1.11653
$Y_4^{(4)}$	...	...	...	...	0.001358	- 0.20731

† Le coefficient de cette fonction contient un terme périodique.

Annexe II.

Voici les valeurs de θ pour lesquelles les composantes X , Y , Z acquièrent un maximum ou un minimum :

—					Pour X .	Pour Y .	Pour Z .
$Y_1^{(1)}$	...	...	...	...	0°	0°	90°
$Y_1^{(2)}$	...	...	...	...	0°, 90°	0°	45°
$Y_1^{(3)}$	...	...	...	...	0°, 60°	0°, 90°	31°, 90°
$Y_1^{(4)}$	...	...	...	...	0°, 46°, 90°	0°, 68°	24°, 69°
$Y_2^{(2)}$	...	...	...	...	45°	90°	90°
$Y_2^{(3)}$	...	...	...	...	28°, 90°	45°	55°
$Y_2^{(4)}$	...	...	...	...	21°, 66°	32°, 90°	41°, 90°
$Y_2^{(6)}$	...	...	...	...	14°, 44°, 75°	21°, 59°, 90°	28°, 60°, 90°
$Y_3^{(3)}$	...	...	...	...	55°	90°	90°
$Y_3^{(4)}$	...	...	...	...	38°, 90°	55°	60°
$Y_3^{(5)}$	...	...	...	...	30°, 69°	42°, 90°	47°, 90°
$Y_4^{(4)}$	...	...	...	...	60°	90°	90°

APPENDIX XXVIII.

ON THE ORGANISATION OF TEMPORARY MAGNETIC OBSERVATORIES IN ARCTIC AND ANTARCTIC REGIONS.

(Sur l'organisation d'observations magnétiques temporaires dans les régions arctiques et antarctiques.)

By V. Carlheim-Gyllensköld.

M. Schmidt a proposé d'instituer des observations magnétiques en plusieurs stations tropicales désignées dans le but principal d'étudier la variation diurne solaire régulière. Pour ce qui est des variations aux stations polaires, M. Schmidt dit qu'il faut les traiter d'une toute autre manière; je suppose qu'il pense alors à la belle découverte faite il y a quelques années par lui de petits courants circulaires se propageant dans l'atmosphère avec une vitesse de l'ordre de 1 km par seconde.

Or, il existe un état moyen du champ diurne des perturbations qui mérite aussi notre attention, et je vais montrer que ce champ moyen est susceptible d'être traité d'une manière tout à fait analogue à celle dont on a envisagé la variation solaire régulière.

* * * * *

La difficulté principale qu'on rencontre dans l'étude du champ périodique de la terre aimantée consiste en ce que le champ variable est une fonction non seulement du temps mais aussi de la position géographique du lieu.

Dans les études qu'on a fait jusqu'ici dans cette matière, on a supposé que le système des forces est fonction seulement du temps et de la latitude, ce qui simplifie beaucoup le problème.

Cette hypothèse, approximativement vérifiée pour ce qui est des variations diurnes régulières, l'est beaucoup moins pour le champ des perturbations. Ce cas semble beaucoup plus compliqué.

Dans un projet, qui a été communiquée aux membres de la commission, j'ai exposé une méthode fort simple qui permet de lever la difficulté dans ce cas, sans trop de peine.

Je rappellerai brièvement les principes de la méthode.

Supposons une sphère aimantée arbitrairement, avec des masses extérieures et intérieures, et présentant des courants traversant la surface. J'admets que la force magnétique en chaque point de la surface est une fonction périodique du temps :

$$(1) \quad X = X_0 + X_1 \cos t + X_1' \sin t + X_2 \cos 2t + \dots;$$

X désignant l'une quelconque des composantes X , Y , Z . On suppose ici que t désigne le temps du premier méridien adopté, et non pas le temps du lieu d'observation dont on se sert habituellement.

Supposons d'abord qu'il existe un potentiel

$$X = \frac{\partial V}{\partial x} \dots$$

En différentiant deux fois la première des équations (1) par rapport à x , la seconde par rapport à y , la troisième par rapport à z , et en les ajoutant, il vient, puisque la différentiation ne porte que sur les coefficients de la série de Fourier,

$$\Delta V = \Delta V_0 + \Delta V_1 \cos t + \Delta V_1 \sin t + \Delta V_2 \cos 2t + \dots,$$

en désignant par ΔV_i , $\Delta V'_i$, la somme des dérivées secondes de X_i , Y_i , Z_i ; X'_i , Y'_i , Z'_i ; par rapport à x , y , z .

S'il existe une fonction des forces V , la fonction V satisfait à l'équation de Laplace

$$\Delta V = 0.$$

Il s'ensuit, d'après un théorème connu, les égalités

$$\Delta V_0 = 0, \Delta V_1 = 0, \Delta V'_1 = 0, \dots$$

Chaque système de forces X_i , Y_i , Z_i , peut donc être considéré comme dérivant d'un potentiel. Le potentiel total résulte de la superposition des diverses ondes.

S'il n'existe pas de potentiel, le courant traversant la surface dépend de la somme

$$\frac{dX}{d\psi} + \frac{dY \sin \theta}{d\psi} \quad (\psi = \text{la longitude}).$$

Si X et Y sont des fonctions périodiques du temps, l'intensité du courant le sera aussi, et chaque couple de valeurs de X_i , Y_i , dans le développement des X , Y , détermine une onde correspondante dans le courant. On pourra encore appliquer à chaque système de valeurs de X_i , Y_i , Z_i , les méthodes connues usitées ordinairement pour séparer le champ externe du champ interne, et calculer les courants traversant la surface.

* * * * *

Je vais donner un court aperçu des résultats que j'ai obtenus en appliquant cette méthode aux observations recueillies pendant l'année polaire.

Les données sur lesquelles est basée cette investigation sont les valeurs de la force perturbatrice à chaque heure de la journée à un certain nombre de stations disséminées principalement dans l'hémisphère nord. Les composantes de la force perturbatrice ont été déduites par M. Lüdeling et M. van Bemmelen pour l'été de 1883, en se repérant sur les jours calmes. M. Fritsche, de son côté, en traitant de la variation diurne régulière, donne les écarts entre sa théorie et les observations. Ces écarts peuvent être considérés comme dûs aux perturbations; et je me suis assuré que, pour les stations polaires, il y a concordance entre les écarts de M. Fritsche et les forces perturbatrices déduites par MM. Lüdeling et van Bemmelen.

Je ne m'arrêterai pas à la manière de conduire les calculs, bien qu'ils offrent plusieurs points intéressants. Je passerai tout de suite à exposer les résultats.

Ici intervient le rôle du système de coordonnées choisi.

Comme on savait déjà depuis longtemps que les perturbations partent de la zone des aurores boréales, il était naturel de rapporter les coordonnées sphériques à l'axe magnétique principal de la

terre, qui coïncide à peu près avec le centre de la zone des aurores boréales. J'appelle σ le complément de la latitude dans ce système de coordonnées, ω la longitude comptée vers l'est depuis le nœud ascendant de l'équateur magnétique sur l'équateur géographique.

Cela posé, chaque système de forces perturbatrices, X_i , Y_i , Z_i , ont été développées en séries de Fourier en fonction du temps.

Occupons-nous d'abord des termes en $\cos t$ et $\sin t$. En les dessinant sur une carte en projection polaire, on remarque tout de suite que la distribution des forces est très régulière et qu'il y a symétrie par rapport à un plan méridien passant par le pôle magnétique. La composante horizontale perpendiculaire au méridien Y acquiert ses valeurs maxima et minima en des points qui diffèrent de 90° de X ; la composante verticale est semblable à X , mais de signe contraire, comme cela devait être s'il existe un potentiel, et que les forces agissantes soient extérieures.

Le potentiel contient en facteur $\cos(\omega + \alpha)$, en désignant par α une constante. Il doit donc comprendre une somme de termes : $Y_1^{(1)} + Y_1^{(2)} + Y_1^{(3)} + \dots$

Il y a plus; le potentiel qui multiplie $\cos t$, et celui qui multiplie $\sin t$, sont à peu près de la même grandeur, et les angles α diffèrent à peu près de 90° ; on a donc

$$\frac{V}{R} = \Sigma Y_1^{(1)} \cos(\omega + \alpha) \cos t + \Sigma Y_1^{(2)} \cos(\omega + \alpha + \frac{\pi}{2}) \sin t;$$

on peut donc réunir ces deux termes en un terme unique et écrire :

$$\frac{V}{R} = \Sigma Y_1^{(1)} \cos(\omega + \alpha + t).$$

Cela veut dire que cette partie du potentiel conserve une forme invariable en cheminant autour de l'axe magnétique de la terre.

L'argument qui figure sous le signe \cos n'est plus le temps local, $t + \psi$, mais le temps réduit, $t + \omega$, la longitude ω mesurée sur l'équateur magnétique étant substituée à la longitude géographique ψ . Le temps réduit ne diffère pas sensiblement du temps local vrai pour les faibles latitudes, mais s'en écarte de plus en plus quand on s'approche de l'axe magnétique: pour citer un exemple, au cap Thorsden, les deux arguments diffèrent l'un de l'autre de $3^h 8^m$.

C'est là la partie principale du phénomène. Mais il y a aussi des courants traversant la surface en deux régions diamétralement opposées et très voisines du pôle ($\sigma = 5^\circ$ ou 10°). Ces courants dont l'un entre dans la terre et l'autre en sort, sont pourtant d'une intensité insignifiante. Il sont de l'ordre de ceux que M. Bauer a tiré des excellentes cartes de M. Schmidt pour le champ constant de la terre; ils comportent quelques centièmes d'ampère par kilomètre carré. Ils tournent en 24 heures autour du pôle de l'axe magnétique.

En dehors de 30° de distance polaire il n'y a plus de courants verticaux.

Les courants horizontaux extérieurs sont figurés (fig. 1); les lignes d'égale intensité du courant vertical sont figurées (fig. 2); ces représentations sont valables pour midi, temps réduit du premier méridien adopté.

Champ diurne des perturbations magnétiques.

(Pour midi temps réduit du premier méridien, $t + \omega = 0$.)

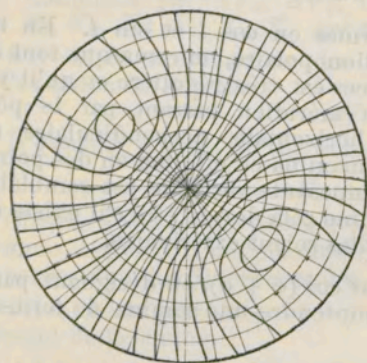


Fig. 1.

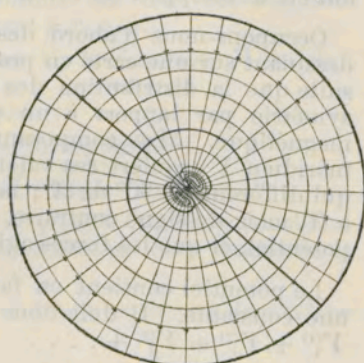


Fig. 2.

Direction des courants extérieurs.

Courants verticaux.

(Du 25 en 25 millièmes d'ampère par km^2 .)

Je ferai remarquer en passant que les courants tourbillonnaires de M. Schmidt suivent des trajectoires parallèles à la direction du courant général.

Cette circulation électrique concorde avec les lignes de courants que M. Birkeland a déduit de considérations fort différentes, et qu'il a dessinées dans l'Expédition norvégienne de 1899-1900 pour l'étude des aurores boréales.

Il est donc prouvé que les perturbations sont dues en première ligne de compte à un système invariable de courants horizontaux qui tourne autour de l'axe magnétique de la terre.

Ce fait est d'une importance capitale, car il permet de se limiter à un méridien magnétique unique, comme il est déjà d'usage de le faire dans le cas de la variation diurne régulière.

* * * * *

Dans cet aperçu rapide nous n'avons pas tenu compte du terme en $\cos 2t$ et $\sin 2t$, qui a encore une influence très appréciable. Ce terme est de la forme $\Sigma Y_2^0 \cos(2\omega + 2\alpha + 2t)$; son effet est que les lignes de courant changent périodiquement de forme en décrivant une circonférence entière autour de la terre.

On voit donc comment on pourra, dans tous les cas, prendre en considération l'influence de la longitude sur le champ variable. Dans une première approximation on pourra se contenter d'étudier les variations sur un méridien de référence convenablement choisi.

Pardonnez-moi encore quelques mots sur les stations à choisir sur ce méridien de référence. Pour s'en tenir au méridien

proposé par M. Schmidt, les stations qui peuvent entrer en ligne de compte sont :

Dans le Nord :

Van Rensselaer harbour, ou Port Foulke ;
Upnivik, ou île de Sabine ;
Godthaab, ou Scoresby sound, ou Jan Mayen ;
Reykjavik ;
Feroer, ou Iles Shetland.

Dans l'hémisphère sud :

Terre d'Enderby, ou Terre de Kemp.

Voilà les stations entre lesquelles il faudra choisir, et dont on trouvera ci-dessous les coordonnées dans le système magnétique.

On y a ajouté celles des stations tropicales africaines proposées par M. Schmidt.

Je finirai par une remarque relative aux latitudes les plus avantageuses à choisir. D'après mes calculs les termes les plus importantes du potentiel perturbateur semblent être : $P_1^{(4)}$, $P_1^{(6)}$, $P_1^{(8)}$, et peut être aussi $P_1^{(10)}$, $P_1^{(12)}$, qui ont leurs maxima pour $\sigma = 24^\circ$, 16° , 12° , 10° , 9° .

* * * * *

En revoyant aux considérations qui précèdent, je propose à la Commission internationale du magnétisme terrestre d'arrêter les conclusions suivantes :

1°. Il est désirable d'ajouter aux stations tropicales désignées par M. Schmidt un certain nombre de stations polaires voisines d'un même méridien magnétique ; les observations doivent être faites au moins pendant une année maximum et une année minimum de l'activité solaire ;

2°. Une sous commission doit être nommée chargée de préparer la question.

	σ	ω
	$0^\circ 40'$	$173^\circ 27'$
Van Rensselaer harbour...	0 46	- 165 0
Port Foulke ...	7 37	- 55 53
Upnivik ...	11 40	6 49
Ile de Sabine ...	13 26	- 13 56
Ile de Danemark ...	15 13	- 61 19
Godthaab ...	16 28	5 40
Jan Mayen...	19 43	- 20 4
Reykjavik ...	24 17	- 7 8
Thorshavn (Faeroer) ...	27 54	- 2 0
Lerwick (Iles Shetland) ...	62 31	15 52
Le Caire ...	68 10	- 20 19
Timbuctou ...	76 54	13 56
Khartoum ...	83 30	- 11 16
Cameroun ...	96 57	- 9 47
St. Paul de Loanda ...	100 10	14 32
Dar-es-Salaam ...	110 42	11 34
Quelimane ...	111 6	- 11 34
Walvisch bay ...	122 35	- 10 29
Cap de Bonne Espérance ...	138 48	3 58
Iles Marion ...	141 5	18 15
Iles Crozet ...	146 30	28 42
Ile Kerguelen ...	159 9	- 6 22
Terre d'Enderby ...		

APPENDIX XXIX.

TERRESTRIAL MAGNETISM.

THE SELECTION OF "QUIET" AND "DISTURBED" DAYS.

At its meeting in Paris in 1900 the International Meteorological Committee adopted a resolution inviting Directors of Magnetic Observatories to send in lists of the days regarded as "quiet," from the magnetic point of view.

I have been entrusted, from the end of 1903, with the duty of collecting and distributing these lists. I have applied to the observers participating in the scheme to ascertain their opinions on the value of this publication.

The majority take no interest in the matter, they send the lists solely to conform with the request of the Committee. A small minority, on the other hand, would greatly regret the discontinuance of the publication. All, however, agree that the manner in which the decision of the Committee is carried out is very imperfect.

The chief objection raised is that there is no trace of a convention regarding the meaning of the words "day" and "quiet." Some observers count their days from midnight to midnight, others from noon to noon; some adopt local time, others standard time, such as that of Greenwich. There are even some who interpret the word day very freely, and include in it any specified epoch, of which they give the beginning and the end.

Similarly the word "quiet" is very differently interpreted by different observers, so that even at stations in the same region we sometimes find one observer enumerating 20 days in a given month as quiet, while another counts only three.

Finally, there is no agreement as to whether it is necessary to distinguish between the different components of the earth's magnetic force; in other words, whether it is necessary to give the number of quiet days for each element separately, or whether the term should be applied only to days on which all three elements show only the regular features.

From this it follows that if the scheme of the Committee is to be continued, it is essential to give more precise definitions of the meanings of the words "day" and "quiet," and to agree as to whether the three elements should be separated or not.

However, the chief objection is directed against the publication as such. Why do we require to know which are the quiet days?

It is obvious that we cannot determine the magnitude of "perturbations" if we have no curve of diurnal variation which may be looked upon as a standard. If we are able to distinguish effectively between quiet and disturbed days, a standard variation curve deduced exclusively from the results for quiet days would have advantages over a curve deduced from all available records. We might even go further, and select a limited number of the most quiet days. This is what is done in England

for practical purposes. The Astronomer Royal selects five quiet days for each month. Several observatories which are not in a position to tabulate and discuss all their photographic records use the hourly value for these days to determine the mean diurnal variation for each month. They then determine the ratios to this mean value for any particular day in the month and so are able to compare the variation with that determined in a similar manner at other observatories.

The advantages which this method offers for comparing the data from different stations at different moments are obvious. On the other hand, the principal objection to the publication of lists of quiet days—namely, that the distinction between quiet and disturbed days is necessarily arbitrary—may be brought forward in a special degree against the English plan. Nevertheless, it does not matter much what standard is adopted provided that it is generally accepted, and that it can be easily expressed in numbers for each station. This would be the case with a standard deduced from a limited number of quiet days.

The arbitrary character of the choice of these days might be reduced by appointing someone to select the five quiet days not exclusively from his own records, but also by taking account of the lists of quiet days sent in by other observatories. This individual would collect the lists sent in by the participating observatories, as I am doing at present. He would select from them five days for each month similar to those of the Astronomer Royal, and would communicate the selected dates to the various magnetic observatories once every three months.

To summarise what I have put forward, I beg leave to submit the following proposals to the meeting of the International Commission on Terrestrial Magnetism and Atmospheric Electricity, which is to be convened this year at Innsbruck:—

1. "The Commission appeals to the directors of magnetic observatories distributed as uniformly as possible over the surface of the earth, and requests them to send in lists of the quiet days experienced during each quarter to an officer appointed by the Commission to receive and discuss the lists. The lists should be despatched as early as possible in the quarter next following that under discussion."
2. "This officer shall compare the dates sent in to him and shall select from them five days in each month which shall be so distributed that their mean coincides approximately with the middle of the month."
3. "The lists of selected dates shall be printed and circulated as early as possible to the directors of magnetic observatories and to all others who may be interested in them."
4. "The day should be reckoned from midnight to midnight, G.M.T."

It remains to distinguish between quiet and disturbed days. The first and perhaps the only scientist who has attempted to give a scientific definition of the word "perturbation" was Buys

Ballot, in his mémoire "Sur les 'Perturbations' de l'aiguille aimantée,"* but the method which he proposed for distinguishing between quiet and disturbed days is too cumbersome to be generally adopted.

In the absence of a satisfactory definition we must make choice between different imperfect definitions. We cannot suppose that one component of the earth's magnetic force can be disturbed without that the others show the effect of this disturbance in their diurnal variation. We must therefore use the word "quiet" in a generalised sense, so that a day should not be thus designated if any of the elements show irregularities in their diurnal changes.

As to the degree of irregularity which may be permitted before a day forfeits its "quiet" character we must remember that the perturbations differ greatly in magnitude from place to place, but that in general they bear a more or less fixed ratio to the diurnal range. The amount of disturbance which may be allowed on a quiet day therefore depends on the magnitude of the normal diurnal variation.

We should also not be too exclusive in our definition of a quiet day, for the officer whose business it will be to compare the different lists must have a sufficiently large number to select from to enable him to pick out five days which will fulfil the required condition all over the globe.

I therefore propose:—

5. "A day shall be regarded as 'quiet' if the irregular fluctuations of any of the magnetic elements do not exceed one-third part of the diurnal range for the day."

M. SNELLEN.

APPENDIX XXX.

TERRESTRIAL MAGNETISM.

EXCHANGE OF COPIES OF MAGNETOGRAMS.

The study of magnetic disturbances would be greatly facilitated if all persons and institutions interested in the question could receive copies of the records for disturbed days from as many stations as possible distributed over the entire surface of the earth. The observatories have been frequently circularised by individual investigators asking for copies of the records for specified disturbed days. As a rule these occasions are days of unusually violent magnetic storms, for which the records usually show large gaps. Proceeding on the assumption that the study of less violent disturbances is more likely to lead to important results, Professor Ad. Schmidt, of Potsdam, has distributed lithographed copies of his records for a number of disturbed days to various observatories, and has asked for copies of the records taken at these to be sent in exchange.

* Aanteekening van het Verhandelde in de Sectie-vergaderingen van het Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen, 1862, p. 6. An abstract is contained in the *Archives Néerlandaises*, Vol. XIX.

In response to the suggestion the Magnetic Meteorological Observatory at Pawlowsk proposes to prepare lithographic copies of its records for disturbed days and to distribute them to persons and institutions which may be interested in them. Up to the present copies have been prepared of the records for three occasions. I join Professor Schmidt in approaching the International Commission on Terrestrial Magnetism and Atmospheric Electricity with a proposal for an organised exchange between the different magnetic observatories of lithographic or photographic copies of the records for disturbed days. As a precise definition of the term "disturbed day" has not as yet been formulated, the choice of days might be left to the Observatories.

In addition to this, it would be well if all observatories which are equipped with autographic magnetic instruments would publish lists of the days which they regard as "disturbed," say once every quarter, precisely as they have hitherto done for "quiet" days. Such a publication would enable an observatory to prepare copies of its records for days which appear to be of special interest. The lists might be published and circulated with the lists of "quiet" days.

M. RYKATCHEFF.

APPENDIX XXXI.

THE DETERMINATION OF THE CONSTANTS OF MAGNETOMETERS.

The reasons which have induced me to bring these questions before the Committee are as follows:—

At most observatories the photographic records of the meteorological elements are standardised by eye observations three or four times daily, whereas those of the magnetic elements are seldom standardised more than four times a month; notwithstanding that the probable error of the standardisation of the latter is unduly large relatively to the variations in the element from month to month, while in the former it is exceedingly small; moreover, the changes in the zero of the magnetic records are very much larger than in the meteorological records, and so require more frequent standardisation.

The results from observatories which publish monthly values of the magnetic elements derived from hourly measures of the photographs standardised by absolute determinations show that the variations from month to month are very little greater than the probable error of observation, and I consider that an effort should be made to obtain at least eight absolute determinations of H , F , and Dip in each month (two observations a day on four separate days), and that the constant collimation, torsion, and circle reading at for astronomical meridian of the declinometer be determined at least four times a month; or, in the case of the Kew declinometer, eight complete determinations of declination a month, as in the case of H , F , and Dip.

From the results so obtained the director of the observatory would be able to judge how much of the observed change in the value of the zero, or base line, was real, and how much due to error of observation, smoothing the observations accordingly.

T. F. CLAXTON.

APPENDIX XXXII.

ON THE MEASUREMENT OF CURRENT STRENGTH IN LIGHTNING FLASHES.

To increase our knowledge of the nature of lightning discharges, more particularly of the strength of the electric currents involved in them, it is desirable to collect information on the subject systematically at the central offices. I beg leave to direct attention to a method for doing this, on which I have recently been experimenting.* It consists in placing small rods of a magnetic but non-conducting material—for instance, basalt—in suitable positions near a lightning conductor. If the discharge passes down the conductor, the residual magnetic moment of the rod gives a measure of the maximum current strength of the discharge. If the magnetic moment after a flash had struck were found to be zero, it would indicate that the discharge was oscillatory.

Observatories in exposed places which are provided with lightning conductors fitted with a single earth connection would be very suitable places for trying experiments of this kind.

I should be glad to supply central institutes which are prepared to distribute "lightning current meters" of this kind to the observatories under their direction with suitable rods of basalt; and, if desired, to send instructions for fixing and testing them.

F. POCKELS.

APPENDIX XXXIII.

AN AUTOMATIC ARRANGEMENT FOR RE-FILLING THE RESERVOIR OF A WATER-DROPPING ELECTRIC COLLECTOR.

By A. Sprung, Potsdam.

In cases in which electric dissipation and electric potential gradient are determined simultaneously, radium collectors cannot be used, though they are often recommended.† This applies also

* See *Meteorologische Zeitschrift*, 1898, p. 41; *Physikalische Zeitschrift*, Vol. 2, p. 306; Vol. 3, p. 22.

† For example, in the Report of the Meeting of the International Meteorological Committee at Southport, 1903. Appendix VIII. by Adam Paulsen, and Appendix IX. by T. Moureaux.

to the case of the Solar Eclipse Expeditions of August 1905, in which observations with Elster and Geitel's dissipation apparatus will play an important part.*

The water collector will therefore remain one of the most important appliances for determining the potential gradient in the atmosphere for some time to come, so that it is worth while attempting to improve it.

The water reservoir must be refilled at regular intervals. In Potsdam this was done only twice a day, as it would have been very troublesome to arrange to refill it during the night. A rather large reservoir was thus required.

The large size of the reservoir means large electric capacity, which in turn means that an appreciable time is required to acquire the potential of the air. Moreover, the capability of the apparatus to follow rapid changes of potential is considerably reduced. A large reservoir is also somewhat cumbersome, especially when it is desired to move the reservoir horizontally, so as to alter the sensitiveness.

For these and other reasons I contemplated arranging for automatic refilling when the record was commenced early in 1904. At first I thought to imitate the process of filling by hand by arranging for a definite volume of water to be added at regular intervals.

Some danger would, however, have attached to this course, as you cannot reckon on a uniform rate of consumption of water, as the orifice may become more or less clogged.

The following arrangement then suggested itself: a float follows the variations in level of the water and regulates the rate of addition of water by a set of electric contacts. This is much easier said than done, because—(1) the float may not interfere with the electric charge of the reservoir; and (2) the ordinary forms of taps require a considerable amount of work to be done in setting them in action. The second difficulty is the more important.

At first I tried a form of push tap, but the preliminary experiments were not successful, and I abandoned the idea.

Finally I adopted what may be called a "squeeze-tap." The word "squeeze-tap" will give the reader a general idea of the arrangement adopted. A fairly thick-walled indiarubber tube is kept compressed by a small metal plate on which a spring or a weight exerts pressure. A moderately powerful electro-magnet is arranged to release the pressure of the spring or weight which allows water to flow through the indiarubber tube. The electro-magnet is brought into action as soon as the float mentioned above reaches its lowest point, and thereby closes an electric circuit. If the simplest form of contact were used, the slightest rise of the float would break the current and so stop the flow of water, which is not wanted. We must arrange to keep the tap open until

* *Territorial Magnetism*, Vol. X., No. 1, p. 20. In connexion with the instruments to be used on this occasion we read: "1. A Benndorf autographic electrometer with water collector, which, according to our own and Dr. Linke's experiments, has the shortest time of charging. Radium preparations should in no circumstances be used as collectors."

the reservoir is full. For this purpose a system of levers* was devised, which maintains the electric contact for the required length of time.

Another important point remains to be mentioned. The electric contact, which has just been described, also acts on a pen which is recording on a rapidly-revolving chronometer drum. This pen is kept depressed during the whole time that refilling is in progress, so that the time of commencement and end of the process can be accurately determined. This affords a very welcome check on the rate of the electrometer clock, as the whole system is earthed while refilling is going on.

We thus have as many zero lines on the electrogram as refills are shown on the chronograph. We propose to arrange for about four refills each day, and to make the time required for the operation about six minutes.

The fact that we are able to determine the time required to empty the reservoir is of considerable importance, as in this way we get a good idea of the uniformity or otherwise of the flow from the jet.†

After preliminary trials extending over a period of three months, the refilling apparatus which I have described was adopted definitely at Potsdam on July 4th, 1905, and since that date it has worked without hitch up to the present time (beginning of September, 1905).‡

Potsdam.

A. SPRUNG.

APPENDIX XXXIV.

EXPERIMENTS ON THE AUTOMATICAL DECREASE OF THE SENSITIVENESS OF ELECTROGRAPHS.

I have described an arrangement for automatically increasing the range of an electrograph in the "Physikalische Zeitschrift," Vol. V., p. 326.

The principle has been applied at Potsdam to a mechanically recording Benndorf electrograph. In this instrument, as is well

* A very trustworthy but rather complicated arrangement of levers was devised and made by Mr. Kleinert, the mechanic to the Observatory.

† The auxiliary chronograph seems hardly necessary for this, as the time of refill can be deduced from the distance between the zero lines on the record. This assumes that we can, in all cases, be sure of recognising the zero lines, which is not always the case. Under these circumstances a chronograph would be desirable.

‡ At this time the apparatus was cleaned unintentionally. From thence onward until June, 1906, *i.e.*, for nearly 10 months, the contents of the reservoir and the orifice were not touched, except that the discharge pipe was occasionally tapped with a small wooden hammer. Under this treatment the distance between the two zero lines gradually increased from the original rather small value, 18 cms. to 19 cms. in February, 22 cms. in March, 26 cms. in May and July, 1906. At the present time, tapping the discharge pipe no longer does much good, and a thorough cleaning of the reservoir has become necessary. The distance between the zero lines remains practically constant for one or more days. These satisfactory results are due to the facts—(1) that the bottom of the reservoir is of special construction, and (2) that the water is added to the top of the reservoir in a narrow jet, so that its contents are not stirred up.

known, a metal pointer is attached to the electrometer needle. The end of this needle is depressed every two minutes or every half-minute by a falling stirrup, and this makes a mark on the record paper by pressing a narrow typewriter ribbon against it.

This form of recording is utilised in the arrangement about to be described for making a sharp electrical contact whenever the pen reaches either of its extreme positions. The effect of this contact is to re-arrange the leads which connect the quadrants with the storage cells in such a manner as to decrease the number of cells connected to the apparatus from, say, 100 to 33 or 34. This diminishes the sensitiveness of the electrometer to about one-third of its former value, and the recording pen, in consequence, draws back from the edge of the paper and can now record over a much wider range of potential.

In this way it is possible to record satisfactorily at certain times of the year, not merely the so-called "fine weather electricity," but also a considerable number of disturbances. To obtain records of violent disturbances, such as occur during summer thunderstorms near the observatory, the observer was instructed to move the reservoir on a sledge-like track so as to bring the discharge orifice to a distance of 20 cms. instead of the usual 100 cms. from the window through which the discharge pipe passes, whenever thunderstorms occurred. (Other distances might, of course, be prescribed according to circumstances.)

To facilitate the work of the observatory, it occurred to me to devise an automatic arrangement for carrying out this manoeuvre and to utilise our thunderstorm recorder for the purpose. The sensibility of this apparatus to all manner of disturbances made it impossible to carry out this idea. Moreover, thunderstorms form a special class of meteorological phenomena and it seemed preferable to use the increase of atmospheric potential for decreasing the sensitiveness rather than to rely on the occurrence of a thunderstorm for doing so.

The possibility of doing this with the arrangement which has been described was obvious. If the potential continues to increase, the pen arm will again approach the edge of the paper, and when it gets there contact will again be established. This contact will, however, remain without effect, for the electro-magnet has already done its work. We have, therefore, to provide for a second opportunity for the magnet to do work. The old form of needle telegraph suggested itself to me. In this apparatus a toothed wheel is made to revolve through the distance of one tooth by each contact. It is obvious that each position of the wheel may be utilised to bring about a different motion.

At Potsdam we have contented ourselves with the simple case of utilising two successive contacts and extending the arrangement already described.* In this a mercury commutator, which acts by gravity, is prevented from falling by a small hook which is withdrawn when the electro-magnet is brought into action. After the first fall of the commutator has occurred, a second arrangement comes into action in such a way that the pull of the

* Further details will be published shortly in a separate paper.

electro-magnet brings about the closing of an independent circuit which can be used in any way that is desirable—for instance, in inaugurating the transport of the water reservoir in the manner suggested above.*

The possibility of using the arrangement to do work of this nature cannot be doubted, especially if the reservoir is not too large, which is desirable for other reasons also (*see above*, Appendix XXXIII).

For the present the automatic transport of the water reservoir will not be adopted at Potsdam, as a simpler method of attaining the desired result is available. This consists in using Chauveau's cascade-condensor which has been described by Professor Lüdeling in the *Meteorologische Zeitschrift* (Vol. 20, 1903, p. 44). He first drew my attention to the method.

With regard to this apparatus I may say—if only to assist in understanding it—that it is identical in principle with the cardboard strip introduced by Elster and Geitel for observing thunderstorm electricity. The only difference appears to be that in the cardboard strip we are dealing with a continuous fall of potential along the strip, while in the cascade-condensor we have a cascade-like gradation of potential. Chauveau's application of the principle appears more scientific.

With Elster and Geitel's cardboard strip, the humidity of the air may increase the conductivity of the strip to such an extent that an appreciable loss of electricity occurs—for one end of the strip is always earthed—and this produces a damaging decrease in the potential difference to be measured.†

At Potsdam, Professor Lüdeling has attempted to construct Chauveau's pile in a very simple manner. The apparatus consists of six brass plates 50 mms. in diameter and 3 mms. thick, placed one on the other and insulated from one another by carefully prepared layers of insulating varnish. The latter will not be affected by the moisture in the air as only their edges are exposed.

The first plate is connected to the collector; the last is earthed, and the last but one is connected to the electrometer. This arrangement corresponds—*mutatis mutandis*—with that of Elster and Geitel, only that in the latter the point from which contact is made to the electrometer can be shifted throughout the whole range of potential, while Chauveau naturally recommends the position which produces the greatest diminution of sensitiveness.

This arrangement can be easily tried; should the results prove unsatisfactory the method of shifting the water reservoir will be resorted to.

A subsidiary advantage of Chauveau's method should be mentioned. It enables us to determine the strength of the electric

* See also *Meteorologische Zeitschrift*, Vol. 21 (1904), p. 307.

† At any rate this appears to be the opinion of the authors, who state that observations on different days are not comparable, so that only relative measurements are possible. See Elster and Geitel "Ueber einige Ziele und Methoden luftelektrischer Untersuchungen" (Wolfenbüttel, 1891).

field directly with the help of a suitable form of electroscope, whereas indirect methods would have to be employed if the distance of the orifice from the window were altered; for instance, we might have to determine the law of horizontal distribution of potential in front of the window.

Whatever method may be finally adopted, a few details of construction may be looked upon as settled. The question seems justified whether, in the event of a two-fold change of sensitiveness being provided for, we shall always be in a position to determine without hesitation which of the three scales we are working with.

To this I may remark that with the single change of sensitiveness which has already been adopted we have in general been able to distinguish easily between the two scales. If the observer at any of the fixed hours, 7 a.m., 2 p.m., 9 p.m., found that the automatic mercury commutator had reversed, he promptly restored the instrument to its original sensitiveness and noted the fact. On examining the record the exact spot or time at which the change occurred was easily identified and also noted.

We may expect that the introduction of a second commutating arrangement will not complicate matters unduly, for it will only be required in rare cases. The frequency of its use will depend on the limits which are set to each sensitiveness. For instance, in the original form of Benndorf apparatus we are forced to call the second or "thunderstorm" commutator into play when a potential of 1,800 volts is reached, for with 2,100 volts the probability of an unsymmetrical attraction of the needle by the quadrants is very great. This must be avoided at all costs. (See *Meteorologische Zeitschrift*, 1904, p. 306.)

The latest pattern of the instrument, which is on order for the Potsdam Observatory, will be much more satisfactory in this respect. In it the distance between the top and bottom of the quadrants will be only 1 instead of 2 cms.

In spite of this, independent registrations of the times of commutation will be advisable if two commutators are employed. This will prove specially useful at Potsdam where a second item, viz., the times of automatic filling of the water reservoir, have also to be noted (*see above*, Appendix XXXIII, p. 142). For this reason I propose to use a Fuess drum chronograph fitted with two recording pens. The price of this instrument is but little greater than that of an apparatus with only one pen.

SUMMARY.

1. If "fine weather" electricity is to be recorded satisfactorily the apparatus must be made very sensitive, for during fine weather the changes of potential are generally small.

2. When the apparatus is arranged as required under (1) the pen arm frequently reaches the edge of the paper even under fine weather conditions. To avoid loss of record automatic readjustment of the sensitiveness to one-half or one-third of its original value is very desirable. It can be provided for in practice without

risk of deranging the apparatus. Traces obtained with diminished sensitiveness still show many interesting details, especially if slight or distant thunderstorms occur.

3. It is also in a measure practicable to record violent disturbances if a second or "thunderstorm" change of sensitiveness be provided for. It will always be a matter of interest to determine the general course of changes of potential gradient even if details such as the kicks of the needle caused by violent lightning discharges are lost.

Potsdam.

A. SPRUNG.

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