

REPORT
OF
THE PROCEEDINGS
OF THE
METEOROLOGICAL CONGRESS
AT VIENNA.

PROTOCOLS AND APPENDICES.

TRANSLATED FROM THE OFFICIAL REPORT.

Published by the Authority of the Meteorological Committee.



LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
AND SOLD BY
E. STANFORD, CHARING CROSS.

1874.

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INTRODUCTION.

GENTLEMEN,

I HAVE the honour to submit to you a translation of the Report of the Proceedings of the Meteorological Congress of Vienna in September last.

The text followed differs from that of the German original in that the alterations contained in the table of errata have been introduced, and that a few additional corrections, which have been noted in their proper places, have been inserted.

There is yet a further Report to appear. It is on the subject of Weather Telegraphy and Storm Warnings, and was presented to the Congress by a Committee appointed by the Meteorological Conference at Leipzig in 1872. This Report will be printed separately.

Your obedient Servant,

ROBERT H. SCOTT.

To the Meteorological Committee of
the Royal Society.

Dec. 22, 1873.

LIST OF THE DELEGATES

TO THE

International Meteorological Congress, Vienna, 1873.

Name.	Designation.	Delegate for
Aguilar, A.	Director of Madrid Observatory	Spain.
Buys Ballot, H.	Director of the Royal Meteorological Institute of the Netherlands, Utrecht.	The Netherlands.
Bruhns, C.	Director of the Royal Observatory at Leipzig.	The German Empire.
Buchan, A.	Secretary of the Scottish Meteorological Society, Edinburgh.	Great Britain and Ireland.
Campbell, J. D.	Chief Secretary of the Inspectorate-General of Chinese Maritime Customs.	China.
Cantoni, G.	Professor at the Royal University at Pavia.	Italy.
Coumbary, A.	Director of the Central Physical Observatory at Constantinople.	Turkey.
v. Czelechowsky	Ministerial Secretary in the Imperial Royal Ministry of Commerce.	Austria.
Doergens, F.	Assistant at the Royal Prussian Meteorological Institute.	The German Empire.
Donati, G. B.	Director of the Royal Observatory at Florence.	Italy.
Ebermayer, E.	Professor at Aschaffenburg	Bavaria.
Fradesso da Silveira	Director of the Observatory at the Polytechnic School at Lisbon.	Portugal.
Gloesener, M.	Inspector of Telegraphs at Liège.	Belgium.
Hann, J.	Adjunct at the Imperial Royal Central Meteorological Institute at Vienna.	Austria.
Hoffmeyer, N.	Director of the Royal Danish Meteorological Institute at Copenhagen.	Denmark.
Jelinek, C.	Director of the Imperial Royal Central Meteorological Institute at Vienna.	Austria.
Lorenz, J.	Ministerial-rath in the Imperial Royal Ministry of Agriculture at Vienna.	Austria.
Mohn, H.	Director of the Royal Norwegian Meteorological Institute at Christiania.	Norway]
Müller, R.	Director of the Imperial Royal Hydrographic Office at Pola.	Austria-Hungary.
Myer, A. J.	Brigadier-General, Chief Signal Officer of the United States Army, Washington, D.C.	United States of North America.
Neumayer, G.	Hydrographer of the Imperial Admiralty at Berlin.	The German Empire.
Plantamour, E.	Director of Geneva Observatory	Switzerland.
Quetelet, E.	Astronomer at the Royal Observatory at Brussels.	Belgium.

Name.	Designation.	Delegate for
Rubenson, R.	Director of the Royal Swedish Meteorological Institute at Stockholm.	Sweden.
Schenzl, G.	Director of the Royal Hungarian Central Meteorological Institute at Pesth.	Hungary.
Schmidt, J.	Director of Athens Observatory	Greece.
Schoder, H.	Professor at the Polytechnic School at Stuttgart.	The German Empire.
Scott, R. H.	Director of the Meteorological Office, London.	Great Britain and Ireland.
Sohncke, C.	Professor at the Polytechnic School at Carlsruhe.	The German Empire.
Wild, H.	Director of the Imperial Russian Central Observatory at St. Petersburg.	Russia.
Winnecke, F.	Director of the Strasburg Observatory.	The German Empire.
Zamara, A.	Inspector of the Imperial Royal Marine Office at Trieste.	Austria.

PROCEEDINGS

OF THE

METEOROLOGICAL CONGRESS AT VIENNA.

Protocol of the First General Meeting of the International 1st Meeting.
Meteorological Congress at Vienna.

Vienna, September 2, 1873.

Commencement of sitting, 10.30 a.m.

PRESENT:

His Excellency the Minister of Instruction, Carl von Stremayr.

DELEGATES:

MM. Bruhns, Buchan, Buys Ballot, Campbell, Cantoni, Coumbary, Czelechowsky, Donati, Dörgens, Ebermayer, Gloesener, Hann, Hoffmeyer, Jelinek, Lorenz, Mohn, Müller, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke, Zamara.

Of the visitors invited the following were present:—

As representative of the Minister of War, Rear-Adm. G. v. Millossich.

Dr. W. Köppen, Assistant at the Central Physical Observatory, St. Petersburg.

M. St. Kostlivy, Assistant at the Central Meteorological Institute, Vienna.

Dr. Th. v. Oppolzer, Regierungsrath and Professor in the University of Vienna.

M. F. Osnaghi, Adjunct at the Central Meteorological Institute, Vienna.

Dr. Aug. Petermann, Gotha.

M. E. Sedlaczek, Lieut.-Colonel, Institute for Military Geography, Vienna.

Dr. Edm. Weiss, Professor in the University of Vienna.

M. JELINEK, in the name of the Permanent Committee elected at Leipzig in the previous year, declared the meeting opened.

Thereupon, HIS EXCELLENCY THE MINISTER OF INSTRUCTION, C. v. STREMAJR welcomed the Congress in the name of the Government in the following speech:

1st Meeting.

It is a fruitful thought to introduce in all countries, by the personal intercourse of and united action between men of science, a common system of observation, and a discussion of the meteorological phenomena which in their varying form are manifested over the entire earth. In this way not only will scientific investigation more speedily reach its goal, but also that highly practical point of view will be sooner attained, which will direct on the progress of meteorology, the eyes, not only of sailors and agriculturists, but of all educated men. My first duty, therefore, is a pleasant one, to express to all the Governments most sincere thanks for the great readiness with which they have supported this undertaking by sending their delegates.

You especially, gentlemen, do I greet most heartily in the name of the Austrian Government, and I accompany the laborious work which will be thrown upon you during the next few days, with the honest wish that the history of the exact sciences will mark the *First International Meteorological Congress in Vienna* as an important turning point in the development and importance of meteorology.

M. BUYS BALLOT, in the name of the Congress, thanked the Imperial Government, for the successful organization of the Congress, and His Excellency for the kindly words of welcome which had fallen from him. The thanks were expressed by the members by rising from their seats.

M. JELINEK briefly touched on the questions to be discussed by the Congress, and he saw a favourable omen for their satisfactory solution in the circumstance that almost all Governments which had received invitations had sent representatives. There was one serious exception, for one country which had yielded distinguished contributions to the department of exact science, was not represented at the Congress, but even in this case co-operation in the common work might confidently be expected: it was further to be regretted that by the mode of the constitution of the Congress, which only admitted delegates of Governments, it has become impossible for many eminent meteorologists, who had been present at the Leipzig Conference, to take part in the labours of the Meteorological Congress.

Finally he held it for his duty on the day of the opening of the Congress to refer to those men who for a long series of years had held the first rank in the sciences of Meteorology and Terrestrial Magnetism, and had introduced into the science a more comprehensive treatment of the various questions from a more general point of view, and, inasmuch as they had insured the general recognition of the necessity of working in common, had rendered possible, and smoothed a way for the meeting of to-day. He would only mention three most eminent names, as the men who bore them were unfortunately absent from the Congress; Geheim. Regierungsrath Dove, of Berlin, who had been prevented, owing to the delicate state of his health, from accepting the office of delegate; Director Adolphe Quetelet, of

Brussels, the President of the Maritime Conference at that place in 1853; and General Sir Edward Sabine, of London, the founder of Magnetical and Meteorological Observatories over distant points of the earth's surface. 1st Meeting.

The members showed their recognition of the services of the gentlemen named, and their regret at their absence, by rising from their seats.

M. JELINEK then submitted to the Congress some communications which had been received, the majority of which would be considered in detail in the course of the proceedings. Only one of them required special notice at this juncture, viz., the communication from the Imperial Academy of Sciences, placing its meeting-apartments at the entire disposal of the Congress.

The meeting then proceeded to the choice of the Bureau. His EXCELLENCY THE MINISTER OF INSTRUCTION was chosen Honorary President, and accepted the post with thanks.

As Vice-Presidents were nominated:—

MM. Bruhns.	MM. Scott.
Buys Ballot.	Wild.
Jelinek.	

As secretaries:—

MM. Müller.	M. Sohneke.
Neumayer.	

The proposed Byelaws and the Programme of Proceedings which were to be discussed at the next meeting were then read.

The following Agenda were adopted for the next meeting (Wednesday, September 3, 10 o'clock):—

1. Discussion on Byelaws and Programme.
2. Appointment of Sub-committees.
3. Discussion on Questions 12-17 of the Programme.

Close of the sitting at 11.30 a.m.

Verified at the meeting of September 3 by the Chairman.

BUYS BALLOT.

Protocol of the Second General Meeting, 3rd September 1873. 2nd Meeting. 10.20 a.m.

Present:—MM. Bruhns, Buchan, Buys Ballot, Campbell, Cantoni, Coumbary, Czelechowsky, Donati, Dörgens, Ebermayer, Gloesener, Hann, Hoffmeyer, Jelinek, Mohn, Müller, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohneke, Wild, Winnecke.

Chairman:—M. Buys Ballot.

After reading and confirming the protocol of the first meeting the list of the documents presented to the Congress was communicated.

Documents.

1. Mr. SCOTT handed in a communication from the British Meteorological Society, containing a report on several questions of the Leipzig programme, which had been discussed at certain meetings of that society.
2. Documents relating to the establishment of Meteorological Stations in China. (40 copies.)
3. Letter from the Astronomer Royal relative to the establishment of Meteorological Stations in China. (40 copies.)
4. Statistique de Servie. 2^{me} livraison, redigée par W. Jakschitsch. (15 copies.)
5. Rev. F. W. Stow. An Account of some Experiments on Solar Radiation made at Harpenden, Herts. (8 copies.)
6. Symons. Description of Rain Gauges used in the Experiments at Strathfield Turgiss, Winchfield, Hampshire. (50 copies.)
7. Prestel. Ergebnisse der Beobachtungen und Erfahrungen, betreffend die Sturmwarnungen und die Sturmsignale. (25 copies.)
8. Zurcher & Margollé. Discours du Commodore Maury. (6 copies.)
9. Wild. Probe einer Anordnung des Druckes der Beobachtungen für das Jahrbuch. (30 copies.)
10. Poey. Nouvelle classification des Nuages. (1 copy.)
11. Donati. Sul modo con cui si propagarono i fenomeni luminosi della grande aurora polare del Febbrajo 1872. Firenze, 1873. (30 copies.)
12. Ulysse Marchi. Le thermomètre à maxima et à minima imaginé et construit par U. M. Florence, 1872. (40 copies.)
13. Wild. Anhang zu den Annalen des physikalischen Central-Observatoriums für 1872. Meteorologische Beobachtungen nach graphischen Instrumenten und magnetische Beobachtungen in St. Petersburg. (30 copies.)
14. M. JELINEK handed in a printed circular of Professor R. Wolf, of Zürich, to the members of the Meteorological Committee of the Swiss Natural History Society and on the duties of the delegates of Switzerland at the Meteorological Congress.
15. The same. A letter to himself from Professor E. Plantamour, of Geneva, on the foundation of an International Central Establishment for Meteorology.
16. The same. A paper from Mr. G. J. Symons, of London, respecting the method adopted in England for the observation of Solar Radiation.
17. The same. A paper from Mr. G. J. Symons respecting the Rain gauges used in England.
18. Mr. SCOTT handed in a communication from Mr. G. T. Kingston, Director of the Meteorological Office in Canada, respecting the most suitable exposure of thermometers.
19. The same. A letter from Surgeon-Major Black, of Edinburgh, containing the description of a Rain gauge for use at sea.

p. 70.

p. 71.

p. 87.

p. 86.

p. 84.

20. The CHAIRMAN submitted a communication from Prof. G. Cantoni containing his reply to the questions relating to the calculation of Temperature and Humidity.

M. DONATI submitted a centigrade thermometrograph by U. Marchi of Florence for inspection.

The CHAIRMAN announced that M. Fradesso da Silveira regretted being prevented by the state of his health from taking part regularly in the proceedings of the Congress, and from having his name placed on any of the sub-committees which were to be formed.

The next business was the reading of the provisional and adoption of the definitive Bye-laws.

In § 6 of the provisional bye-laws Mr. SCOTT proposed to insert after the first sentence, "If the votes be equal, the vote of the Vice-President in the chair shall decide."—Adopted.

In § 7. M. BUYS BALLOT proposed to substitute for the word "chosen" the word "confirmed."

M. NEUMAYER preferred to leave the paragraph in its existing form, for he wished that the Sub-Committees should be chosen by the Congress, and should be given power to add to their numbers.

M. JELINEK proposed to phrase the whole paragraph as follows: "For certain questions in the programme sub-committees will be appointed, whose members will be nominated by the Bureau and confirmed by the Congress."

§ 7 was adopted in this form.

Accordingly the Bye-laws run in the form given in the Appendix. (Appendix 1 to Protocol No. II.)

The Congress next proceeded to the discussion of the Programme of present proceedings. The Organization Committee nominated at Leipzig in 1872 had, with the assistance of MM. Buys Ballot, Neumayer, and Scott, proposed a provisional programme for the present proceedings (in connexion with the subjects discussed at the Leipzig Conference), containing five headings and 28 separate questions.

In the discussion as to the adoption of this provisional programme, or of possible changes in it,

M. PLANTAMOUR asked permission to speak. He said that among the subjects included in the programme a very important one was not mentioned, which if it were first brought forward, would render the discussion of several of the individual questions superfluous, and thus would shorten the proceedings. This is the foundation of a Central Meteorological Institute. He proposed to place this question as the first on the programme.

M. BRUHNS expressed himself against this proposal inasmuch as the question was virtually one of organization, and so could best be treated under the 5th heading (Organization) as Question 25a.

M. WILD supported this amendment.

M. HOFFMEYER was of opinion that the main object of the Congress was to establish something of an International cha-

racter. This might be brought about in the following way. Certain stations in the Organization of each country might be designated as International stations, while the remainder might remain, as heretofore, national or local.

M. BUYS BALLOT wished that the provisional Programme should be definitely adopted, and that any new proposal, like this of M. Plantamour's, should be introduced as an Appendix to the Programme.

M. JELINEK considered the question raised by M. Plantamour to be the most difficult and important of all. It therefore could not be discussed at once at a general meeting, but must be prepared by deliberation in sub-committees, and meantime there was time to proceed to the consideration of the other less important questions.

Mr. BUCHAN agreed on the whole with M. Jelinek. He considered it better to keep to the programme which was before the meeting, inasmuch as thereby a gradual approach was made to the most important questions of organization, and so many difficulties would be removed out of the way.

M. RUBENSON also wished that the programme should be maintained, but that most of the questions should be considered from two distinct points of view, the international and the national, just as M. Hoffmeyer had proposed a corresponding subdivision of the stations.

Mr. SCOTT remarked at this juncture, that though he was present as representative of his Government, that Government would not consider itself as *bound* by any of the decisions of the Congress.

A proposal from M. WILD, to refer the question of the organization of an International Institute to the sub-committee to be appointed for Weather Telegraphy and Maritime Meteorology was rejected, M. NEUMAYER having expressed himself against it, inasmuch as this sub-committee which had already more than enough to do, would be entirely unable to undertake this discussion.

M. DONATI remarked that a proposal something like that of M. Plantamour was already contained in Question 28 of the programme, viz., the proposed nomination of an International Committee to carry out the resolutions of the Congress, and that accordingly M. Plantamour's proposal might be treated as Question 29, as a sequel to Question 28.

A division was taken on the question whether the proposal for the establishment of an International Institute should be included in the programme itself or as an appendix to it, and the matter was decided in favour of the former alternative.

The CHAIRMAN remarked that the permanent committee in making arrangements for the discussion of the 28 questions of the programme had made the proposal to refer the majority of the questions to sub-committees, and to discuss at general meetings only a few which were specially mentioned.

In general accordance with this proposal the Congress decided that the questions to be considered at general meetings should be 1 (Barometer), 17 (Units of Scale), 19, 20 (Mean and Normal Values), 26 and 27 (Publications). All other questions were to be referred to several sub-committees of which the following is a list:—

- I. Questions 2-6 (Thermometer).
- II. " 7-9 (Wind).
- III. " 10, 11, 14 (Rain and Evaporation).
- IV. " 18 (Times of Observation).
- V. " 21, 22 (Weather Telegraphy, Maritime Meteorology).
- VI. " 23-25 (Organization).
- VII. " 28 and M. Plantamour's proposal (carrying out the Resolutions of the Congress,—International Institute).

On Questions 12, 13, 15, 16 (Hail, Thunderstorms, Cloud), there was a report from the Committee appointed last year at Leipzig (Ebermayer, Schoder, and Sohncke) so that no new sub-committee was required for these matters at present.

The CHAIRMAN inquired if any delegate wished to propose additions to the programme.

Mr. CAMPBELL stated that he was commissioned from the China. Inspector-General of Customs in China (Mr. Hart), who intended to organize meteorological stations in that country, which would be in connection with Japanese, Russian, Spanish, Dutch, French, and English-colonial stations, and he hoped that this subject might be admitted to form a part of the deliberations of the Congress.

M. JELINEK thought that a special sub-committee should be appointed for this question, and M. NEUMAYER supported the proposal.

The Congress decided to nominate this sub-committee. No. VIII. (for Chinese stations).

M. SOHNCKE remarked that no notice of self-recording instruments appeared in the programme and wished to see the following question included in the programme:—

Self-recording
instruments.

"What self-recording instruments have been found to be the best hitherto?"

Mr. SCOTT thought the question of too great compass and also to be unripe for decision as yet.

MM. JELINEK and NEUMAYER expressed themselves to the same effect. They thought it desirable that the directors of central institutes should publish their experiences of their self-recording instruments in greater detail than has hitherto been the practice, giving the comparisons of the data of the self-recording instruments with the original eye-observations. The result would be that a future Congress would have sufficient material for a consideration of the question.

2nd Meeting.
Self-recording
instruments.

M. BRUHNS proposed that a general meeting should be appropriated to scientific communications on the experience gained of self-recording instruments.

M. SOHNCKE assented to this proposal, withdrawing his former motion as too wide in its scope.

M. WILD supported the wish expressed by M. Jelinek. On a division the proposal of MM. Bruhns and Sohncke was not adopted.

Thereupon the Programme for the proceedings of the Congress was adopted in the form in which it appears as Appendix 2 to Protocol No. II.

M. JELINEK brought forward two more proposals as additions to the programme respecting an interchange of reports from the central offices on the condition of meteorological investigations and publications, as well as respecting the existence of long continued series of observations.

Both proposals were to be submitted in writing at the next meeting.

p. 41.
Sub-com-
mittees.

The sub-committees were then appointed. This was effected by the several delegates, who wished to take part in the deliberations on the respective questions, volunteering to act upon the sub-committees. The eight sub-committees were accordingly nominated as follows:—

Sub-Committee I.

Questions 2-6 (Thermometers).

President:—M. Wild.

Reporter:—M. Plantamour.

MM. Bruhns, Buchan, Cantoni.

Sub-Committee II.

Questions 7-9 (Wind).

President:—Mr. Scott.

Reporter:—M. Hoffmeyer.

MM. Coumbary, Mohn, Rubenson, Wild.

Sub-Committee III.

Questions 10, 11, 14 (Rain and Evaporation).

President:—M. Plantamour.

Reporter:—M. Ebermayer.

MM. Buchan, Schenzl, Schoder, Wild.

Sub-Committee IV.

Question 18 (Hours of Observation).

President:—M. Plantamour.

Reporter:—M. Hann.

MM. Coumbary, Schoder.

Sub-Committee V.

Question 21, 22 (Weather Telegraphy and Marine Meteorology).

President:—M. Buys Ballot.

Reporters:—MM. Scott and Neumayer.

MM. Bruhns, Campbell, Donati, Hoffmeyer, Mohn, Müller, Rubenson.

Sub-Committee VI.

Questions 23-25 (Organization).

President:—M. Bruhns.

Reporter:—M. Wild.

MM. Buchan, Buys Ballot, Cantoni, Ebermayer, Neumayer, Schenzl, Scott.

Sub-Committee VII.

Questions 28, 29 (carrying out Congress Resolutions).

President:—M. Plantamour.

Reporter:—M. Hoffmeyer.

MM. Buys Ballot, Mohn, Rubenson.

Sub-Committee VIII.

(China.)

President:—Mr. Buchan.

Reporter:—Mr. Scott.

MM. Buys Ballot, Campbell, v. Czelechowsky, Wild.

The CHAIRMAN requested the sub-committees to come together immediately after the close of the sitting, and announced the Agenda for the third general meeting to be held on Friday the 5th, at 10 a.m., viz.:—

1. Official business.
2. Consideration of Questions 12, 13, 15, 16, and, if time permitted, also of 1 and 17 of the Programme.

The sitting was adjourned at 1.30 p.m.

Verified at the meeting of the 5th September by the Chairman.
ROBERT H. SCOTT.

Protocol of the Third Meeting, September 5, 10.15 a.m.

3rd Meeting.

PRESENT:

Delegates:—MM. Bruhns, Buchan, Buys Ballot, Cantoni, Coumbary, Czelechowsky, Donati, Dörgens, Ebermayer, Fradesso da Silveira, Gloesener, Hann, Hoffmeyer, Jelinek, Lorenz, Mohn, Müller, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors:—MM. Köppen, Weiss.

Chairman:—Mr. Scott.

The Protocol of the second meeting was read and confirmed.

3rd Meeting.

Hail.

The CHAIRMAN read a telegram from Geheimrath Dove at Berlin, expressing his thanks to the Congress.

In accordance with the Agenda the discussion of Question 12 of the Programme was commenced.

It runs as follows:—

Is it desirable in giving the falls of Hail to draw a distinction between "Graupel" and true Hail?

p. 42.

At the suggestion of M. BRUHNS the respective portion of the report of the sub-committee nominated at Leipzig in 1872 (Ebermayer, Schoder, Sohncke) hereto appended (Appendix 1 to this Protocol) was read.

After a long discussion on this question, in which especially MM. WILD, SCOTT, QUETELET, SOHNCKE, EBERMAYER, BRUHNS, HOFFMEYER and JELINEK took part, the following proposal made by WILD and amended by JELINEK was adopted:—

Hail is to be described as a precipitation of frozen water, in which the stones attain such a magnitude that they may be expected to do damage to agricultural products.

Thunder-storms, p. 43.

The next subject on the Agenda was Question 13 of the Programme.

a. In counting Thunderstorms, should the Storms as such or the Days of Storm be given?

b. In what way should the instances of Sheet-lightning be noticed?

The report of the above-named Leipzig Committee, in reference to a, was read, and after some remarks by MM. BRUHNS, BUCHAN, PLANTAMOUR and QUETELET, the recommendations of the sub-committee were adopted.

In order to obtain values which admit better of comparison it is recommended only to count the Days of Thunderstorms, but this is not intended to prevent individual observers from inserting in the column of "Remarks," in addition the number of the Storms, the time of their commencement, their duration, direction of motion, &c.

In reference to 13b the respective portion of the report of the sub-committee was read, and finally the proposal of the majority of the sub-committee, supported by MM. WILD and QUETELET was adopted:—

As days of storm only those are to be noted on which both Lightning and Thunder have been observed. If only Lightning without Thunder has been noticed the entry for the day must be Sheet Lightning.

At this point M. NEUMAYER communicated some experiences of his own regarding special electrical phenomena in connexion

with this question, and recommended particularly the observations of such sound-phenomena, at the time of electrical discharges, as hissing and a harsh rattle preceding the actual thunder.

3rd Meeting.
Thunder-storms.

The first portion of Question 15 was next taken up:—

Cloud, p. 44.

In what way should the proportion of Cloud in the sky be estimated and indicated?

M. SCHODER read the respective portion of the above-named report of the Leipzig Committee.

M. BUYS BALLOT explained that he had hitherto employed the method of description of the degree of cloud directly opposite to that now proposed, but yet that he was quite ready to introduce the new method if it met with general adoption.

M. QUETELET made an exactly similar communication.

Hereupon the recommendation was adopted in the following words:—

The degree of cloudiness is to be given by the figures 0—10, in which 0 is to represent a sky quite free from cloud, and 10 an entirely overcast sky.

On this the question was raised by MM. BRUHNS and WILD as to what numerical entries should be made in the cases of slight fog, films of cirrus, &c. &c. Cloud Forms.

Mr. BUCHAN thought it right to describe a Photometer constructed by Mr. Thomas Stevenson, which enables the observer to estimate the intensity of light and thus to draw approximate conclusions as to the density of the cloud-covering.

M. PLANTAMOUR pointed out the insufficiency of such an instrument and indicated (followed by M. EBERMAYER) the importance of minute particulars respecting clouds in regard of their form and other details.

M. HOFFMEYER remarked that in Denmark the observers noted not only the amount of cloud, but also the general colour of the sky, and

M. BRUHNS stated that he considered a discussion of cloud-forms at a general meeting as premature.

The meeting then decided to refer the points which had just been raised in reference to cloud-form to a sub-committee.

M. LORENZ wished that it should be decided by the same sub-committee, whether or not it would not be possible to indicate a uniform thin coating of cloud, otherwise than by lowering the figure for the degree of cloud, for by the usual method of procedure the amount of superficial extension of the cloud was confounded with the thickness of the cloud strata.

M. PLANTAMOUR recommended to the consideration of the same sub-committee "Höhenrauch," and Mr. BUCHAN the question of whether in case of "blue sky" the horizon is or is not free from haze or mist.

3rd Meeting.
Cloud.

At the suggestion of the CHAIRMAN, supported by M. NEUMAYER, the subject was referred again to the Leipzig Committee, with the request that they would co-opt members as requisite, and present a report as soon as possible, together with the second part of the report of Question 15, which could not be discussed at the present meeting.

Atmospheric
Electricity.

In accordance with the Agenda, Question 16 was next discussed:—

Should other Meteorological Elements than those already enumerated, *e.g.*, Atmospheric Electricity, Ozone, &c., be included in the scope of normal observations, and what are the best instruments for observing them?

p. 45.

M. SOHNCKE reported for the Leipzig Committee on Atmospheric Electricity, and recommended that observations of it should only be made at Central Observatories, and, as the best form of apparatus, Sir W. Thomson's electrometer, with water (or smoke) as collector.

M. CANTONI remarked that he had obtained very good results with Palmieri's electrometer, and he accordingly recommended it. On the other hand M. QUETELET recommended Peltier's electrometer, which had been used at Brussels for 30 years with good results.

M. BUYS-BALLOT confirmed this statement from 20 years' personal experience.

It was resolved in accordance with the proposal of the sub-committee that the institution of observations on Atmospheric Electricity be recommended only for Head Observatories, and that the decision as to the choice of the best methods of observation and of the most suitable instruments, must be left to them.

Ozone, p. 47.

M. EBERMAYER reported on Ozone, and recommended that observations should only be taken at Central Observatories, and on the decimal scale, but with a different scale of colours than that given by Schönbein. Despite the imperfection of existing ozonometers, observations should be conducted for the future inasmuch as they undoubtedly yield useful *relative* values.

M. WILD said that according to Dohrandt's investigations the methods which had been as yet introduced were insufficient, inasmuch as they gave contradictory results, so that the only recommendation possible was that better modes of observation should be devised.

Mr. SCOTT mentioned the wish of the Army Medical Department to learn the views of the Congress on Ozone observations, and expressed himself at the same time against the modes of observation hitherto employed as not ensuring sufficient certainty.

M. NEUMAYER spoke from his own five years' experience in Australia, that all the Ozone papers now in use were insufficient for observations. Observations conducted by him at sea, and in all climates, in rigid adherence to the rules, proved that the evaporation of the iodide of potassium on the strip of paper materially affected the results.

M. EBERMAYER stated that he had obtained in a six years' course of observation good results, which allowed him to recognise an indubitable connection with atmospheric humidity, and with the amount of electricity in the air.

M. CANTONI admitted the existence of such a connection, on the ground of seven years' observations, but considered the influence of Light, Temperature, and specially of the motion of the air as predominant. He supported M. Wild's proposal for renewed experiments.

M. NEUMAYER further remarked that he had not been able to obtain any trustworthy results in spite of three-hourly observations, and recommended eudiometrical observations.

M. WILD communicated his experience that exposed ozone papers had become dark in six hours, but that after the lapse of six more hours the colour had been discharged.

Mr. BUCHAN said that observations had been made in Scotland for 18 years at many stations, and that the results had been decidedly unsatisfactory. Four years ago a Committee had been nominated for the special purpose of enquiring into the state of Ozone observations. The Committee, after numerous observations with various kinds of paper, experiments and enquiries, came to the conclusion that accurate qualitative and quantitative methods for the determination of the ozone present in the air are still wanting. The uncertainty of ozone observations had induced the President of the Scottish Meteorological Society (the Marquis of Tweeddale), to devote 100*l.* for ozone investigations, and the Committee had placed themselves in communication with Professors Andrews, Belfast; Tait and Crum Brown, Edinburgh.

The Congress hereupon expressed its recognition of the munificent liberality of the Marquis of Tweeddale in fostering scientific investigation.

After another reply from M. EBERMAYER, the following proposal made by M. WILD was adopted:

The existing methods of determining the amount of Ozone in the atmosphere are insufficient, and the Congress therefore recommends investigations for the discovery of better methods.

In continuation of Question 16, M. EBERMAYER recommended that measurements of water in the soil, and of the amount of water draining through the soil, as well as of the amount of carbonic acid in the air contained in the soil, &c., although in themselves important, yet, as not belonging to Meteorology, should

3rd Meeting.
Ozone.

3rd Meeting. be excluded from the present discussions, and the meeting adopted this proposal.

Vertical
currents of air.

In connection with Question 16, M. DONATI stated that he had recently erected a wind vane for the determination of the direction in the ordinary sense, and of its deviation from the horizontal plane, and had already made some observations therewith.

Hereupon, in consideration of the lateness of the hour, the business standing on the Agenda paper was adjourned, and before the close of the sitting the two proposals announced by M. Jelinek at the previous meeting, and two new proposals from M. Buys Ballot were read. The scope of the latter is, on the one hand, the foundation of observing stations on islands and in distant localities, and on the other the organization of establishments to facilitate the exchange of publications.

pp. 47, 48.

All the proposals were appended to the Protocol as Appendices 2, 3, and 4.

The CHAIRMAN fixed the next meeting for Monday, September 8, 10 a.m., and announced the following Agenda:—

1. Official communications.
2. Discussion of Question 15 (Part 2), then 1, 17, 19, 20, 26, 27.
3. Reports of Sub-committees, if any.

The sitting was adjourned at 1.20 p.m.

Verified at the meeting of the 8th September, by the Chairman.

C. BRUHNS.

4th Meeting.

Protocol of the Fourth Meeting, September 8, 10.20 a.m.

PRESENT:

Delegates:—MM. Bruhns, Buchan, Buys Ballot, Campbell, Cantoni, Coubary, Czelechowsky, Donati, Dörgens, Ebermayer, Fradesso da Silveira, Hann, Hoffmeyer, Jelinek, Lorenz, Mohn, Müller, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors:—MM. Köppen, Nordenskiöld.

Chairman:—M. Bruhns.

The meeting was opened, and the Protocol of the third meeting was read and confirmed, and MM. BUYS BALLOT, QUETELET, and FRADESSO, at the suggestion of the first-named gentleman, and with reference to the first portion of Question 15 of the programme (*vide* Protocol of third sitting [p. 15]), expressed their readiness to commence the new notation of the amount of cloud at their observatories on the 1st January 1874, if by that epoch it had been generally adopted.

The following official communications were made:—

1. M. BUYS BALLOT has withdrawn the second of the two proposals made by him at the third meeting (Central Establishment for the exchange of publications), inasmuch

as its real subject would be considered at the general 4th Meeting, meeting in connexion with Question 27.

2. The CHAIRMAN presented as a visitor Prof. Nordenskiöld, who had received instructions from the Society of Science of Finland to attend the meetings of the Congress.

3. The CHAIRMAN stated that M. Schmidt (Athens) had stated by letter that he was unable to be present at Vienna in time.

4. Communications received:—

A letter (from Grenoble) from M. Harold Tarry, Inspector of Finances, Paris, to the Congress, on the questions to be discussed at the present meeting.

Communi-
cations
received.

From M. Fradesso da Silveira:

The Annals of the Observatory of the Infante Don Luiz at Lisbon, years 1863–71.

Photographs of the Central Physical Observatory, and of the instruments employed at it.

Graphical representations of the daily and yearly march of the meteorological and magnetic elements.

Specimens of the curves yielded by the photographically registering instruments, and photographs of the sun and of the larger groups of spots.

From M. Nordenskiöld:—

Observations made at the Magnetic and Meteorological Observatory of Helsingfors, Vol. V., Helsingfors, 1873 (containing Air Temperature observed every 20 minutes from 1 May 1848 to 31 December 1856).

Climatological reports in Finland, Part I., 1846–55; II. Meteorologiska Anteckningar, made by Adolf Moberg, Helsingfors, 1871.

From Dr. P. Schreiber, on the trustworthiness of the Aneroid. Munich. 1873.

The Congress proceeded to the next entry on the Agenda, the Clouds, discussion on Part II. of Question 15.

Is it desirable to introduce for Clouds, Hydrometeors, and for other extraordinary phenomena, symbols which shall be independent of the language of particular countries and therefore universally intelligible?

This was opened by M. SCHODER, as Reporter, by reading the p. 48. report (Appendix 1 to Protocol No. IV.) and sketching the respective symbols.

M. FRADESSO remarked, in a speech of some length, that the Congress should divide the questions which were before it into two categories, those eminently of organization, and those more of secondary importance. In his opinion it was the chief business of the Congress to bring the former to an issue.

Proposed re-
consideration
of Programme.

M. BUYS BALLOT spoke to similar effect, and made the proposal that on all questions which referred to instruments and observations, the reports only should be read, but that no discussions or

4th Meeting.

divisions should take place on them, in order that time enough should be left for the treatment of questions involving organization. This proposal was lost.

Symbols for
Hydrometeors,
p. 48.

After a long debate on the advisability of and the difficulty of the adoption of symbols, in which MM. QUETELET, MOHN, PLANTAMOUR, DONATI, JELINEK, SCOTT, CANTONI, and WILD took part, M. Jelinek's proposal that all delegates should be provided with lithographs of the symbols in use in various countries, and those proposed by the sub-committee, was agreed to, with the addition, by M. Wild, that the division on their adoption should be taken at one of the later meetings. Thereupon the second portion of the report relating to the entry of Fog, Höhenrauch (Dust haze), and of Cloud (*see* Appendix 1 to Protocol No. IV.), was read, and the recommendations of the sub-committee were adopted without alteration.

Barometers.

The next matter on the Agenda was then taken up (Question 1 of the Programme).

What is the best form of Barometers for stations of the second order?

Is the use of Aneroids for such stations admissible?

MESSRS. SCOTT and BUCHAN recommended the Kew barometer as an excellent and cheap barometer, and MM. WILD and QUETELET also discussed the question of what barometers should be recommended for adoption.

Finally a proposal of M. Jelinek's was adopted.

The reply to the question respecting the mercurial barometer is to be postponed, inasmuch as it is desirable previously to obtain reports from all directors on the barometers employed in their systems, in reference to construction and price.

Aneroids.

With regard to aneroids, M. WILD communicated briefly some results according to which Naudet's Aneroids might be admitted with advantage, at least as interpolation or reserve instruments, at ordinary stations.

MM. BUCHAN, FRADESSO, BRUHNS, and CANTONI made observations bearing on the question, and M. BRUHNS having drawn attention to Schreiber's paper, M. Wild's proposal was adopted.

Aneroids should not be employed at stations where there is no other barometer, but they are admissible as interpolation instruments alongside of the mercurial barometer.

Units of
Measure, p. 49.

On Question 17, which was the next for discussion, M. Wild reported. The report, containing the views of several Meteorologists, is given as Appendix No. 2 to the Protocol of the meeting.

Question 17 is as follows:

4th Meeting.
Units of
Measure, p. 49.

Is it desirable to introduce the same Units of Measure (*viz.*, of Length, Degrees, and Time) in meteorological inquiries in all countries, or is it sufficient to lay down certain fixed rules for the conversion of the different measures employed in the several countries?

The discussion mainly turned on the question, whether or not, on political or other grounds, it was advisable to support the introduction of uniformity of measures.

MM. SCOTT, WILD, DÖRGENS, BUCHAN, RUBENSON, QUETELET, NEUMAYER, and BRUHNS, took part in it.

It was unanimously admitted, that all action must be confined to an expression in a decided form of what was most desirable.

In this sense M. JELINEK made the following proposal:—

1. For observations as well as for publications the use of the same units of measure is desirable.
2. The Congress expresses its conviction, that among all the existing systems of measure, the Metric has the best prospect of universal adoption.
3. The Congress declares it to be most desirable, if it be not possible to introduce uniform measures at present, to use henceforth only Metric and English measures (with Celsius and Fahrenheit scales).
4. All action is to be supported which tends to the introduction of the uniform Metric system.

After a short debate the 1st section of the proposal was adopted unanimously, and the 2nd and 4th by all the votes except that of Mr. Scott. The 3rd by all votes except that of M. Quetelet, who wished to exclude all scales except the Metric.

The Congress then confirmed unanimously the resolution adopted at the Leipzig Congress, that the results of observations or the means should be published in the Metric scale, as well as in their original scales.

Mr. SCOTT observed in regard to this resolution that he had begun to carry it out in the Quarterly Weather Report, ever since the time of the Leipzig Conference.

Thereafter M. HOFFMEYER, as Reporter, read the report of the seventh sub-committee (printed as Appendix 3) on M. Plantamour's proposal as to the establishment of a Central International Institute.

International
Institute,
p. 50.

The next meeting was fixed for Wednesday, September 10, 10 a.m.

Agenda:

1. Official communications.
2. Election of the Editing Committee for the publication of the Proceedings of the Congress (§ 8 of the Bye-laws).

4th Meeting.

3. Discussion of the report of the 7th sub-committee (M. Hoffmeyer, Reporter).
 4. Consideration of the Questions 17b, 19, 20, 26, 27, and sections 1, 2, 3 of the Appendix to the programme.
- Close of the meeting, 1.30.
Verified at the meeting of September 10, by the Chairman.

H. WILD.

5th Meeting.

Protocol of the Fifth Meeting, September 10, 10.20 a.m.

PRESENT :

Delegates :—MM. Bruhns, Buchan, Buys Ballot, Cantoni, Coumbary, Czelechowsky, Dörgens, Donati, Ebermayer, Glösener, Hann, Hoffmeyer, Jelinek, Lorenz, Mohn, Müller, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors :—MM. Köppen, Nordenskiöld, Wrangel.
Chairman :—M. Wild.

Communi-
cations
received.

The Protocol of the 4th meeting was read and confirmed, and the Chairman read the following communications :—

1. A letter from Vice-Admiral Baron Wüllerstorff-Urbair, in which he expressed his lively interest in the objects of the Congress, and his regret at being unable to take part in its proceedings.
2. A letter from Director A. Aguilar, in which he expressed his regret at being unable to take part in the proceedings of the Congress, and furthermore contained a reply to the Questions of the Leipzig Conference.
3. A communication from the Austrian "Verein der Freunde der Naturwissenschaften," with the request for information as to the form in which, in future, meteorological observations will be registered, in order that the arrangements of the society might be regulated accordingly.
4. M. BUYS BALLOT handed in, for distribution to the members of the Congress, several copies of a comparison of the differences of Pressure, with the Direction and Force of the Wind, observed at the Helder, Gröningen, and Flushing.

Thereupon Baron Wrangel, who had been deputed by the Imperial Hydrographic Office of Russia to attend the meetings as a visitor, was presented.

Corrected copies of the list of delegates, and facsimiles of the various symbols for Rain and similar phenomena, were distributed.

The CHAIRMAN distributed the first proofs of some of the protocols of the meeting which were in type, and proceeded to the discussion of the first matter on the Agenda for the day.

Election of the Editing Committee for the printing and distribution of the Protocols and Proceedings of the Congress.

M. BRUHNS proposed to nominate MM. Jelinek, Hann, Müller, and Neumayer as the Editing Committee. 5th Meeting.
Editing Com-
mittee.

M. JELINEK requested that his name might be omitted, at the same time expressing his readiness to assist the committee in the discharge of their duty to the utmost of his power, if necessary.

The meeting then unanimously elected MM. Hann, Müller, and Neumayer as members of the Editing Committee.

M. WILD proposed that the protocols should be published in the French language also.

It was then decided that the proceedings of the Congress and the reports of the Sub-Committee should be published in the German and French languages, and M. QUETELET declared his readiness to undertake the editing of the French version. Two editions,
German and
French.

The communications which are to be printed are only to be given in the language in which they are framed.

Mr. SCOTT offered to publish the protocols in English also, as he had done in the case of the Leipzig Proceedings. English
translation.

The Congress accepted this proposal with thanks.

The next matter on the Agenda, the continuation of Question 17 (Units of Measure), was passed over, inasmuch as the question of Time was to be treated in Questions 19 and 9.

In Question 19 :—

What are the rules, and what the intervals of Time for which the means of the several Meteorological Elements should be calculated? Calculation
of Means.

Which is the better plan, to begin the meteorological year with January, or with December?

M. BRUHNS opened the discussion with the proposals :—
As units should be chosen,

1. The Mean Solar Day, reckoned from midnight to midnight, of the place of observation.
2. The Civil Year.
3. The Months; in which case, however, January 31 and March 1 are to be reckoned with February.
4. Dove's Five-day Means (73 per annum).

After a full discussion with especial reference to the 3rd and 4th sections of the proposal, in which part was taken especially by MM. BUCHAN, BUYS BALLOT, CANTONI, DONATI, DÖRGENS, HOFFMEYER, JELINEK, MOHN, PLANTAMOUR, QUETELET, SCOTT, and WILD, section 1 was adopted unanimously, section 2 by all the votes except three. Before dividing on the 3rd section, the 4th was brought on for division, and was considered under two sub-heads.

- (a.) The calculation and publication of 5-day means of Temperature is recommended, in each system of observation, for a considerable number of stations, the choice of which is left to the Central Institute of the country. Five-day
Means.

This proposition was adopted by all votes except three.

5th Meeting.
Five-day
Means.

(b.) Dove's 5-day means (73 in the year) are to be adopted.

The division was by name, and the proposition was adopted by 15 votes to 9. M. Buys Ballot abstained from voting.

Monthly
Means.

Hereupon the division was taken on section 3 of M. Bruhn's proposal, and it was decided to abide by the Civil Month everywhere, and to calculate the Monthly means as pure arithmetical means. Moreover, the mean of the 12 Monthly means is to count as the mean of the Year.

M. BRUHNS further proposed:—

Daily Means.

1. To count the interval of 24 hours in the following way: the first 12 hours, from 1–12, as Forenoon, the following 12 hours, from 1–12, as Afternoon.
2. To count midnight (12 o'clock midnight) always as the end of the day, and similarly noon (12 o'clock noon) as the close of the forenoon.

The first of these proposals was adopted unanimously without discussion. With reference to the second proposal, M. RUBENSON remarked that it might be difficult to introduce this practice at observatories where it did not previously exist.

After some further explanations on the part of MM. QUETELET, PLANTAMOUR, BRUHNS, DONATI, and JELINEK, the proposal was adopted by all the votes except four.

The next question on the Agenda was No. 20.

"Lustral"
Periods.

In what manner and for what intervals are the normal values for the individual Meteorological Elements to be deduced?

M. BRUHNS recommended in accordance with the resolutions passed at Leipzig, to choose as the periods for calculation of normal values, intervals of five years (lustra), so that the next Lustrum should begin with Jan. 1, 1876.

M. QUETELET remarked that the calculation of lustra had been introduced in Brussels ever since the year 1833, and the proposal was unanimously adopted, as was also an additional proposal of MM. Donati and Jelinek, in accordance with which it was recommended that central institutions should recalculate their old observations in accordance with the proposal, as regards the more important data.

Owing to the lateness of the hour the reports of the second and third sub-committees (see Appendices 1 and 2 to Protocol No. V.), and of the latter only the portion which related to Question 10 (Raingauges) were read by the Reporters (MM. Hoffmeyer and Ebermayer), and the next general meeting was fixed for the next day, September 11th, 10 a.m.

Agenda—

1. Official communications.
2. Reading of the reports of sub-committees III. and IV.

3. Discussion of the reports of the sub-committees which had been already read, and
4. Discussions of the Questions 26–27; viz., the Publication and Exchange of Observations, if time permitted.

Close of the sitting at 1.15 p.m.

Verified at the meeting of 11th September 1873, by the Chairman.

BUYS BALLOT.

Protocol of the Sixth Meeting, Thursday, 11th September 1873, 10.15 a.m.

PRESENT:

Delegates:—MM. Bruhns, Buchan, Buys Ballot, Campbell, Cantoni, Coumbary, Czelechowsky, Dörgens, Donati, Ebermayer, Hann, Hoffmeyer, Jelinek, Mohn, Müller, Myer, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohnecke, Wild, Winnecke.

Visitors:—MM. Köppen, Nordenskiöld, Wrangel.

Chairman:—M. Buys Ballot.

The protocols of the former meeting were read and confirmed.

THE CHAIRMAN announced that additional proofs of the protocols of the earlier meetings had been sent in. He welcomed Brigadier General Albert J. Myer, Delegate from the United States of N. America, who was present for the first time at the deliberations of the Congress.

In accordance with the Agenda, the report of the third sub-committee on Rain (Question 11, Appendix 2 to Protocol No. V.), and Evaporation (Question 14, Appendix 2 to Protocol No. VI.), were read by M. Ebermayer, and afterwards the report of the fourth Sub-committee on Question 18 (Hours of Observation) was read by M. Hann (Appendix 1 to Protocol No. VI.).

The discussion of the report of the second sub-committee (Wind: Wind, p. 51. Questions 7–9, Appendix 1 to the protocol of the fifth general meeting), which had been already read by the Reporter, M. Hoffmeyer, was undertaken.

The questions were as follows:

7. In what way can uniformity in describing the Directions of the Wind be attained?
Is the deduction of the Mean Direction of the Wind by Lambert's formula desirable?
Is it desirable or not to include very light winds (force 0) in constructing Wind-Roses for the Direction of the Wind?
8. What scale should be employed for the Force of the Wind when it is determined, not by actual measurement, but only by estimation?

9. Is it desirable to introduce simple dial-instruments for determining the Velocity of the Wind?

What units should be taken for the discussion of the Velocity of the Wind?

On the proposal of the sub-committee to introduce English designations for the Direction of the Wind (abbreviated N. E. S. W.), M. DONATI remarked that he could not agree to adopt it in so far as it had to deal with *national* observations. The reply to this was, in the first instance, that publications of an *international* nature were referred to, and the report of the sub-committee was then adopted unanimously. Similarly, without further discussion, the proposal of the sub-committee to refer the wind to the 16 points only, and in the case of intermediate directions of the wind, to give them alternately to one side or the other, was adopted unanimously.

Considerable discussion arose on the proposal of the Committee with reference to Lambert's formula and MM. PLANTAMOUR and BRUHNS spoke in favour of its conditional employment. M. BUYS BALLOT, although he recognised the theoretical correctness of the formula, felt himself compelled not to recommend it in practice. Finally the proposal of the sub-committee was adopted unanimously.

With reference to the prevalence and the mean force of the various winds, M. RUBENSON recommended their being given in per-centages, in order to afford better means of comparison of results of observations.

M. PLANTAMOUR supported the proposal, while Mr. BUCHAN was ready to allow the giving of per-centages in the discussion, but not in the publication of observations.

On a division the majority of the Congress declared themselves in favour of the proposal of the sub-committee.

The recommendation of the sub-committee to disregard winds of the velocity of less than half a metre per second, and to designate them as Calms, was adopted by all votes to four after certain remarks by MM. QUETELET, JELINEK, BUCHAN, PLANTAMOUR, SCOTT, and the REPORTER.

Similarly the views of the Committee with reference to M. v. Oettingen's proposal were accepted and the proposal was declined.

The Congress then proceeded to discuss the resolution with reference to the general scale for the estimation of the Force of the Wind, and agreed, by all votes except one, to the proposal to introduce as soon as possible at stations of the second order, for the force of the wind, simple instruments proposed by M. Wild and already tested.* On one hand MM. PLANTAMOUR and BRUHNS pointed out the difficulty which observations with such instruments presented at stations of the second order, while, on the other hand, MM. HOFFMEYER, SOHNCKE, and WILD, pointed out in a special way the advantage which would arise if the apparatus

* Supplement No. XI. p. 91.

were used even only in the day observations, because the observers would thereby get a greater degree of certainty in the estimation of wind force, and so greater uniformity would be obtained. 6th Meeting.
Wind.

The recommendation of the sub-committee to give the Velocity of the Wind in metres per second and also that with respect to Tables of Reduction were adopted without discussion.

Finally the recommendations to observe the Direction of Wind in the various strata of clouds were approved by the Congress.

The next subject was the Report of the seventh Sub-committee (carrying out the resolutions of the Congress, and M. Plantamour's proposal respecting the establishment and the maintenance of an International Central Meteorological Institute). International
Institute, p. 50.

M. HOFFMEYER read the report (App. 3 to the protocol of the fourth general meeting). M. BRUHNS in a detailed statement explained the difficulties which would be found at the present time in the establishment of such an international institute by co-operation between governments, while the establishment of an institution which should be independent of governments, such as an International Meteorological Society, seemed quite possible and desirable.

M. PLANTAMOUR, on the other hand, pleaded for an Institute, but thought that union was the chief matter, and that the question of form which, at all events, must be left to the committee, was immaterial. Upon this the REPORTER proposed to replace the expression "Institute" by the more general one "Institution," and to choose at a later meeting a committee consisting of five members, which should make all preparations, in order in the course of the year 1874 to carry out the necessary action, and to publish proposals which should eventually be laid before a future Meteorological Congress. This proposal was adopted unanimously.

The report of the third Sub-committee respecting Questions 10-11 of the programme (measurement of Rain and Snow) was then discussed. M. EBERMAYER, the Reporter, read the separate paragraphs of the report (Appendix 2 to Protocol No. V.). The Congress agreed, by all votes to one, to the proposal of the said committee to adopt as the best form for the receiver of the rain-gauge the circular one with the area of one-tenth of a square metre (diameter 14 inches.) Rain, &c.
p. 52.

It was also adopted by a majority that the receiver of the rain gauge should be placed at a height of not less than one, and better, of $1\frac{1}{2}$ metre above the ground.

Mr. BUCHAN saw himself compelled to protest against this decision. The height of one foot* had been tested by investigations and experiments made for many years, and as a result it had been generally recommended by the Rain Committee of the British Association.

The recommendations of the sub-committee respecting the stating in all publications the height of the receiver from the ground, and as to the size of the collecting vessel, as well as the

* Note to English edition.—And diameter of gauge from 3 inches upwards.—A. BUCHAN.

6th Meeting.
Rain.
p. 52.

best form for it, in order to prevent the evaporation of the water which had been collected, was adopted by the Congress without debate.

With regard to the measurement of the Rain-fall, it was recommended by the Congress, after some remarks from MM. BRUHNS and PLANTAMOUR, to make this, wherever possible, at the close of the fall in question, but on the whole to carry it out at the first reading in the morning, and to put down the quantity measured as belonging to the previous day.

Finally the proposal of the sub-committee to insert in the Remarks, wherever possible, the duration of the fall, in hours, was adopted.

Days of Rain,
&c.
p. 52.

The discussion on the individual points of Question 11 regarding the entry of days of Rain and Snow was then taken up.

The proposal to introduce symbols which should be adopted by the Congress for the character of the precipitation, in the column intended for Remarks, and to give in the monthly resumé the sum of all the days of rain-fall, and besides that of all the days of snow separately, was adopted after some remarks from MM. QUETELET, PLANTAMOUR, and BRUHNS.

Further it was agreed that the Journal should have two columns, one for the quantity fallen, and one for the depth of the unmelted snow, while the duration of the fall, expressed in hours, was to be noted in the Remarks.

With respect to the information as to the depth of the snow-covering, M. LORENZ urged the importance of such remarks for agriculturists, even in the case where they were only approximations, and MM. BRUHNS, HOFFMEYER, RUBENSON, BUCHAN, SCOTT, and WILD, took part in the debate. The proposal of the sub-committee was adopted, with the addition by M. LORENZ that it should always be noted in the Remarks whether the ground was covered with snow or not.

Finally the concluding proposals of the sub-committee to give the maximum fall in 24 hours of every month were adopted, but the proposal of the sub-committee with reference to the falls under one mm. (0.04 in.) and under $\frac{1}{4}$ mm. (0.01 in.) was only recommended.

THE CHAIRMAN then read the proposal of M. Wild, which had been handed in in the course of the meeting (Appendix No. 3. to Protocol No. VI.), and fixed the next general meeting for tomorrow, the 12th September, at 10 a.m., and the following Agenda for the same:—

1. Official communications.
2. Consideration of the report of the sub-committees on Questions 14, 15b, and 18.
3. Consideration of the Questions 26, 27, and the supplements to the Programme.

Close of the sitting at 1.15 p.m.

Verified at the meeting of 12th September by the Chairman.

R. H. SCOTT.

Protocol of the Seventh Meeting, Friday, 12th September 7th Meeting. 1873, 10.20 a.m.

PRESENT:

Delegates:—MM. Bruhns, Buchan, Buys Ballot, Campbell, Czelechowsky, Cantoni, Coumbary, Donati, Dörgens, Ebermayer, Hann, Hoffmeyer, Jelinek, Mohn, Müller, Myer, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohneke, Wild, Winnecke.

Visitors:—MM. Köppen, Nordenskiöld, Wrangel.

Chairman:—Mr. Scott.

The Protocol of the 6th meeting was read and confirmed. THE CHAIRMAN read the proposal of Brigadier-General Myer, in the form of a letter (printed Appendix 1 to Protocol No. VII.), with regard to the organization of simultaneous observations at least once a day, and stated that he would enter the discussion of this question on the Agenda for the next meeting.

The first business on the Agenda was the Report of the 3rd Evaporation, Sub-committee (Rain and Evaporation), with special reference to Question 14 (Atmometers), and was read by M. EBERMAYER, Reporter.

The Congress adopted the report of the sub-committee in all particulars, with the addition that the measurements of evaporation, by means of floating apparatus on large surfaces of water, which had been formerly used by M. Neumayer and lately recommended by M. Buys Ballot, should be used wherever possible.

In the second part of Question 15, which referred to symbols, M. WILD proposed, as the delegates were already acquainted with them, that they should be adopted *en masse*. M. PLANTAMOUR pointed out that on the lithographic sketch the signs of the intensity (exponents) 0 and 2 had been omitted. M. CANTONI recommended that a decision should not yet be taken on the symbols. This proposal was in a minority, and the proposal of M. Wild, as well as that of the sub-committee, was adopted.

M. HANN reported for the fourth Sub-committee respecting Hours of Observation (Appendix 1. to Protocol of the sixth meeting).

M. BUYS BALLOT declared that he must recommend the combination 6^h, 2^h, 10^h for observations, as unconditionally the best, but he expressed the wish that if a station had already adopted this or any other combination, it should maintain it unchanged.

M. CANTONI remarked that in Italy the best results had been obtained by combining the hours 9 a.m. and 9 p.m., or 10 a.m. and 10 p.m. in conjunction with the maximum and minimum.

Mr. SCOTT remarked that two observations daily, in combination with maximum and minimum, with respect to Temperature, must be declared to be admissible in regard to volunteer observers. In England, among 50 Fellows of the Meteorological Society, 41 had expressed themselves in favour of only two observations daily (9 a.m. and 9 p.m.).

Symbols for
Hydrometeors,
p. 48.

Hours of
Observation,
p. 52.

7th Meeting. After a short debate all the proposals of the sub-committee were adopted.

Publications. The Congress then proceeded to discuss Question 26 (Publications).

M. WILD laid before the Congress a scheme for the publication of the results of observations which had been most carefully devised and prepared by M. Köppen. It was arranged that this should be lithographed by next day, and placed in the hands of the delegates, so that it should be discussed at Monday's meeting.

Distribution of Publications.
p. 56.

With respect to Question 27 of the Programme, which was the next for discussion (Notices, and Receipts for Books sent out), M. PLANTAMOUR declared regular receipts unnecessary. M. WILD, on the other hand, thought receipts desirable, and proposed a simple form which had been already used by him, which is appended as a second Appendix to the Protocol of the seventh meeting.

Office for receipt of Publications,
p. 48.

At M. BUYS BALLOT's wish, his proposal which had been brought forward at the second meeting with respect to the organization of transmitting offices in all countries was brought on for discussion, and adopted unanimously. For smaller parcels, M. Bruhns's proposal for transmission by book post was recommended; and similarly M. Wild's proposal to send notice of, and receipts for, larger parcels was almost unanimously adopted.

On this the Report of the 1st Sub-committee (Appendix No. 3 to this Protocol), Questions 2-6 (Thermometers and Hygrometers), was read by the Reporter, M. PLANTAMOUR, and it was decided to postpone the reading of the Report of the 8th Sub-committee (China).

THE CHAIRMAN then distributed some copies of the First Report of the Investigations in the German Seas, Berlin, 1873, which had been sent in by Professor Karsten, of Kiel, as a present, and fixed as Agenda for the general meeting of the next day, at 10 a.m., the following matters:—

1. Official communications.
2. Discussion of Question 28 (carrying out the decisions of the Congress), and choice of the five committee-members for the Permanent Committee.
3. Consideration of General Myer's proposal.
4. Discussion of the reports of the 1st sub-committee (Thermometers) and the 8th (Organization of Meteorological Stations in China).
5. Discussion of the supplements to the Programme (proposals of MM. JELINEK, BUYS BALLOT, and WILD).

The wish was then expressed that all the Sub-committees would have their Reports ready for presentation at the next meeting, and the sitting was then closed at 1.15 p.m.

Verified at the meeting of the 13th September by the Chairman.

H. WILD.

Protocol of the Eighth Meeting, Saturday, September 13th, 8th Meeting. 10.35 a.m.

PRESENT:

Delegates:—MM. Bruhns, Buchan, Buys Ballot, Campbell, Cantoni, Coumbary, Czelechowsky, Donati, Dörgens, Ebermayer, Gloesener, Hann, Hoffmeyer, Jelinek, Lorenz, Mohn, Müller, Myer, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors:—MM. Köppen, Nordenskiöld, Osnaghi, Ricco, Wrangel.

Chairman:—M. Wild.

The protocol of the previous meeting was read and confirmed.

THE CHAIRMAN introduced Prof. Ricco, of the Royal Observatory at Modena, as a visitor. He then stated that the lithographed schemes for the publications had arrived, and distributed them. He further remarked that it would be necessary to hold two more sittings, the last of which, on M. Schoder's proposal, was fixed for Tuesday morning at 9h. a.m., MM. Donati and Cantoni having alone declared themselves against that proposal.

Hereupon M. HOFFMEYER read for the 7th Sub-committee the Report on Question 28 (carrying out the decisions of the Congress; Appendix 1. to Protocol of the eighth meeting).

THE CHAIRMAN proposed to proceed at once to the discussion of this question. The contrary proposal of M. Schoder for the postponement of the discussion was declined. The first two points of the report were adopted. With reference to the third point, in regard to the number of members who should form the Permanent Committee, M. Schoder wished to replace the number 7 by 5. Meanwhile a proposal of Mr. Scott in this sense was declined, and then the proposal of the sub-committee was adopted.

In respect to the next paragraph of the report, which gives the committee the right of completing itself and adding to its number, Mr. SCOTT raised objections to an unlimited increase. THE REPORTER, however, pointed out that by an increase of numbers the possibility was given for France to take part in it, and M. Bruhns's proposal was adopted, to read the sentence in question in the following words: "The committee has the power to fill up the places of members who resign, and eventually to increase itself by the co-option of two members at most."

To the next portion of the Report, M. QUETELET made the proposal that the choice of the President should be left to the committee, but this proposal was not adopted. The proposal of the sub-committee was accordingly accepted, leaving the direct choice of the President of the Permanent Committee to the present Congress.

The Congress then proceeded to the election of the seven members of the Permanent Committee and of its President.

The election took place by voting papers, and the members of the committee chosen were MM. Bruhns, Buys Ballot, Cantoni,

Carrying out decisions of Congress,
p. 59.

Appointment of Permanent Committee.

8th Meeting. Appointment of Permanent Committee. Jelinek, Mohn, Scott, Wild. The meeting chose M. Buys Ballot as President.

The following proposal of M. Neumayer was then adopted: "The Congress revokes its former decision that the question of the establishment of an International Meteorological Institution should be entrusted to a committee, consisting of five members, and hands over the functions to be entrusted to that committee, to the committee which has just been chosen."

The discussion on the proposals of the 7th sub-committee, with respect to the completion and extension of the existing system of Meteorological stations was postponed.

Synchronous observations, p. 56.

The next matter was the discussion of the proposal of Brigadier-General A. Myer (introduction of simultaneous observations over the whole Northern Hemisphere, 1st Appendix to Protocol of the seventh meeting). GENERAL MYER stated that he was commissioned by the War Department of the United States of North America, to bring before the knowledge of the Congress the deep interest with which that department regarded everything which had reference to the progress of the system of Storm Warnings, and its wish that an exchange of International Telegraphic Weather Reports should be extended as far as possible. Passing on to his proposal, General Myer thought that an actual argument for it was unnecessary, because the importance of simultaneous observations would be generally admitted without any question.

The proposal was approved by many members. M. HOFFMEYER remarked that he could only adopt the proposal if no very great practical difficulties were met with, because the scientific results might not be commensurate with *very* great sacrifices.

M. BUYS BALLOT drew attention to his "Suggestions" in which he had cited simultaneous meteorological observations as an object to be attained.

GENERAL MYER remarked again that his proposal only went so far as to say that the Congress should declare the institution of simultaneous observations over the whole earth as *desirable*, and it was adopted unanimously.

Thermometers and Hygrometers, p. 56.

The discussion of the Report of the 1st Sub-committee (Questions 2—6, respecting Thermometers and Hygrometers, M. Plantamour, Reporter, see 3rd Appendix to Protocol, No. VII.) then came on, and the proposals of the sub-committee regarding Questions 2 and 3 of the Programme were adopted simply.

Radiation.

In regard to Question 4 (Radiation), Mr. BUCHAN recommended that to the Report of the sub-committee a few words of recognition should be added for Messrs. Symons and Stow, who, of their own accord and at their own expense, had instituted extensive series of observations, and had deduced valuable results therefrom. Mr. Buchan's proposal was adopted.

Earth Temperature.

Question 5 (Temperature of the Soil). M. LORENZ proposed that the following words should be added to the Report of the sub-committee: "In order to carry the enquiry further it is recommended that classes of rocks and soils should be sought for

which behave similarly with regard to the propagation of heat within them. In order to obtain more special details on this question, it must be specially recommended to the notice of the experimental stations for Agriculture and Forestry." A wish expressed by M. Sohncke was also to be introduced, that the latest complete work of M. Dorn on the observation of Earth Temperature should be mentioned, with recognition, in the Report of the sub-committee.

As to the depths for observations of temperature of the soil, Mr. BUCHAN held three inches as the most important for meteorological purposes, and further expressed his preference for fixed thermometers at all depths not exceeding 24 inches, while M. WILD, especially with regard to the investigations of Frölich and in the interest of pure Meteorology, considered much greater depths necessary for observations of the temperature of the soil. In other respects the Congress adopted the report of the sub-committee on Question 5.

Question 6 (determination of Humidity), M. NEUMAYER recommended, as he had formerly done at the Leipzig meeting, Regnault's hygrometer with an aspirator; M. WILD the Hair-Hygrometer. Mr. BUCHAN considered that the institution of determinations of vapour with Regnault's Hygrometer in connexion with August's Psychrometer and in dry hot climates, was urgently desirable. Upon this the Report of the sub-committee was adopted.

The Report of the 8th sub-committee (organization of a system of meteorological observations on the Chinese coasts, Appendix 2 to Protocol No. VIII.) was read by Mr. Scott.

It was resolved to proceed to the discussion of it.

Mr. CAMPBELL thanked the Congress for the general principles of organization recommended by the committee. He held it his duty to observe that the English scale could scarcely be avoided, as it was the one most generally known to seafaring men and to lighthouse keepers, or other officers who would be employed at the stations. The observations, he feared, would be of little practical value to navigation unless the readings were, in the first instance, in the English scale. They could be afterwards reduced to the metric scale for Russian and any other stations that wished it, and both scales might perhaps be given in the printed periodical returns for purposes of scientific analysis. Mr. SCOTT declared himself to be fully satisfied with Mr. Campbell's explanation.* General MYER also held that in America, for practical objects, such as Storm Warnings, the English scale was the only one possible. He stated that he was ready to adopt, for international exchange, any scale which was recommended by the Congress. M. NEUMAYER then stated that in the opinion of M. v. Richthofen the whole plan and the choice of stations for China was a good one, and the report of the sub-committee was adopted.

* This, the correct version of Mr. Campbell's remarks, appears as a correction in the German edition.

8th Meeting. Earth Temperatures, p. 58.

China, p. 59.

8th Meeting. The next meeting was fixed for Monday the 15th September at 10 a.m.

Agenda:—

1. Official communications.
2. Consideration of the form of publications.
3. Consideration of the remainder of the proposals of the 7th sub-committee, (carrying out the Decisions of the Congress and International Institution).
4. Consideration of the questions not yet discussed.

Close of the sitting at 2 p.m.

Verified at the meeting of the 15th September by the Chairman.

C. BRUHNS.

9th Meeting.

Protocol of the Ninth Meeting, 15th September 10.30 a.m.

PRESENT:

Delegates:—MM. Bruhns, Buchan, Buys Ballot, Campbell, Cantoni, Coumbary, Czelechowsky, Dörgens, Donati, Ebermayer, Fradesso, Gloesener, Hann, Hoffmeyer, Jelinek, Lorenz, Mohn, Müller, Myer, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors:—MM. Köppen, Nordenskiöld, Ricco, and Wrangel.

Chairman:—M. Bruhns.

The CHAIRMAN opened the meeting at 10.30 a.m.

The Protocol was read and confirmed.

Attitude of
the United
States towards
the Congress.

GENERAL MYER requested permission to give the following explanation: The United States have not been prepared to go into a Congress of this description except for expressions of opinion. They could not do so with justice, being the only Government where Weather Report and Signal system is militarily organized, and they could not ask from others what it was not in their power to give. It has been for this reason I have withheld myself from voting upon questions which have arisen, and from other action than advising in particular cases. My duties here are to advance in every way the widest extension of systems of Storm Warning and Weather Report, and my presence is to exhibit the good will of my Government to the Congress and the community of meteorological interests it represents.

Publications. The meeting proceeded to discuss Question 26. (Publications. Protocol of the seventh general meeting).

After a long discussion on the question the following proposals were made relating to it:—

By M. WILD: The Congress recommends that the publication of comprehensive observations by Central Institutes, and Stations of the First Order, should be entirely separated from the publication of the homologous observations of Stations of the Second Order in each country.

The proposal was adopted.

M. WILD further made the proposal: Each director shall choose a number of stations in his district and for them shall adopt a uniform plan, which is to be recommended by the Congress, (within the limits which are laid down by the hours of observation).

To this M. BUYS BALLOT made the following additional proposal: This proposal of M. Wild's should only be adopted in view of an international publication.

On the other hand M. PLANTAMOUR proposed: With regard to the publication of observations a distinction must be drawn between those which should refer to the special study of the climate of each country and those which are intended to indicate the simultaneous condition of the atmosphere over the whole of the surface of the earth. For the former it is left entirely free to each country to adopt the form and manner of its publication according to its requirements and resources. For the latter the Permanent Committee shall make proposals with reference to the indication of the stations, and of the data which are required to attain the object, and which shall be furnished in the same form.

Similarly the committee is empowered to make all proposals with respect to the publications.

In a division by name on these two proposals, the first received 10 and the second 8 votes, while 11 of the delegates took no part in the division.

Mr. SCOTT proposed that the best form of publication for the stations selected for international objects should be determined by the Permanent Committee, in consultation with the directors of the central institutes, and that it should be recommended for general adoption, for which object the scheme proposed by Dr. Köppen should be handed over to the committee.

This proposal was adopted.

The only remaining business was the reading of the reports which the sub-committee 6 (Questions 23, 24, 25, Organization, see Appendix 1. to the Protocol of the meeting), and 5 (Questions 22, Maritime Meteorology, and 21, Weather Telegrams, see Appendices 2. and 3.), had completed, and the first was read by M. Wild; the second, in regard to Maritime Meteorology, by Mr. Scott, and respecting Weather Telegrams and Storm Warnings by M. Neumayer.

The next meeting was fixed for 4h. p.m. this day.

Agenda:—

1. Official communications.
2. Discussion of the reports of Sub-committees 7, 6, and 3.
3. Discussion of the proposals of MM. Jelinek and Buys Ballot.

Verified at the afternoon meeting of the 15th September by the Chairman.

BUYS BALLOT.

10th Meeting.

Protocol of the Tenth Meeting, 15th September, 4.30 p.m.

PRESENT :

Delegates :—MM. Bruhns, Buchan, Buys Ballot, Cantoni, Czelechowksy, Dörgens, Donati, Ebermayer, Gloesener, Hann, Hoffmeyer, Jelinek, Mohn, Müller, Myer, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors :—MM. Köppen, Nordenskiöld, Wrangel.

Chairman.—M. Buys Ballot.

The meeting was opened at 4.30 p.m., and the Protocol of the previous meeting was read and confirmed, whereupon M. HOFFMEYER read the conclusion of the Report respecting the completion and extension of the existing system of meteorological stations (Appendix 1. to the Protocol of the eighth meeting).

After a short discussion all the matters in the Report and the suggested addition of M. Neumayer to paragraph 7, "also in "higher southern latitudes," were adopted. By the adoption of paragraphs α and β of the Report, the proposal made by M. Wild, at the sixth meeting (Appendix 3. to that Protocol) is set at rest.

M. WILD then reported for the 6th Sub-committee on Questions 23, 24, and 25 (Organization, Inspection, and the establishment of uniformity of the normal instruments of the various central institutes). The report on the Inspection of the Scottish Society's stations, which Mr. Buchan had furnished, at the request of the Leipzig Conference, is printed in the Supplement.

The proposals of the Reporter (Appendix 1. to Protocol of the ninth meeting) were discussed and adopted.

On point 2, General Myer made the remark that in North America the inspection of the stations took place regularly *twice* a year. On point 5, MM. HOFFMEYER and RUBENSON proposed not to reject the comparison with good travelling barometers. M. HOFFMEYER also wished that the Permanent Committee should be commissioned to inquire how the comparison of all barometers of all the central stations could be carried out. With regard to the Standard Thermometers the meeting similarly adopted the proposal of the sub-committee in connexion with the suggestion of M. Cantoni, as a result of which it was considered to be the business of each central office to prepare a Standard Thermometer for itself on scientific principles.

At the same time Mr. Scott was requested to convey the thanks of the Congress to the Kew Committee for their readiness to furnish standard thermometers to the individual Central Institutes.

Upon this the report of the 5th Sub-committee with regard to Marine Meteorology was read (Appendix 2. to Protocol of the 9th general meeting).

The Report read by Mr. Scott, as Reporter, was generally

Extension of
Meteorological
Observations,
p. 59.

p. 55.

Organization,
p. 61.

p. 93.

Barometers.

Standard
Thermometers.

Kew Standards.

Marine
Meteorology,
p. 62.

adopted after a brief discussion. With reference, however, to the sub-committee, which should make preparations for sum-
moning a Maritime Meteorological Conference, MM. DONATI and HOFFMEYER proposed to entrust this matter to the Permanent Committee. This modification of the report of the sub-committee was adopted unanimously.

Agenda for the next meeting fixed for Tuesday, 16th September at 9h. a.m. :—

1. Official communications.
2. Discussion of the Report of the 5th Sub-committee (Weather Telegraphy).
3. Consideration of MM. Jelinek's and Buys Ballot's proposals.

Close of the sitting at 6.50 p.m.

Verified at the meeting of the 16th September by the Chairman.

C. JELINEK.

Protocol of the Eleventh Meeting, 16th September, 9.30 a.m. 11th Meeting.

PRESENT :

Delegates :—MM. Bruhns, Buchan, Buys Ballot, Cantoni, Coumbary, Czelechowksy, Dörgens, Fradesso, Ebermayer, Gloesener, Hann, Hoffmeyer, Jelinek, Müller, Mohn, Myer, Neumayer, Plantamour, Quetelet, Rubenson, Schenzl, Schoder, Scott, Sohncke, Wild, Winnecke.

Visitors :—MM. Köppen, Nordenskiöld, Wrangel.

Chairman :—M. Jelinek.

After the Protocol of the previous meeting had been read and confirmed, the consideration of the Report of the 5th sub-committee on Weather Telegrams and Storm Warnings, (Reporter, M. Neumayer), which was read yesterday, was proceeded with.

Some introductory remarks were made by the Reporter, and the individual proposals of the sub-committee were read, and, for the most part, adopted unanimously.

Question 2, B. M. BRUHNS made the proposal :—The Congress agrees to the proposal of the sub-committee, although it is not perfectly correct theoretically. It is hoped, however, by a reduction to the level of the sea at the time, to obtain a greater uniformity among the different systems.

After a short discussion of this proposal, against which MM. MOHN, SCOTT, BUCHAN, and NEUMAYER expressed themselves, M. BRUHNS withdrew his proposal, declaring that he was satisfied with its being entered on the Protocol of the meeting.

On Question 4 Mr. SCOTT remarked that it would be very desirable to have a uniform system of cyphers for Weather Telegrams.

M. WILD then proposed that the Permanent Committee should be commissioned to propose such a system, and to circulate it

10th Meeting.
Maritime
Conference.

Weather
Telegraphy,
p. 63.

11th Meeting.
Weather
Telegraphy,
p. 63.

amongst the directors of the Central Institutes. M. BUYS BALLOT agreed as to the substance, and thought that the Permanent Committee should not receive this commission, but that it should be left to the directors to take steps towards uniformity in this respect. On a division, M. Wild's proposal was adopted.

M. HOFFMEYER declared that in the report in question, he missed a remark which he had made. It was resolved to adopt it supplementarily in the report of the committee.

p. 69.
Telegraphy
with Madeira.

Upon this M. FRADESSO DA SILVEIRA rose to inform the Congress that Portugal would shortly have telegraphic communication with Brazil. The cable between Portugal and Madeira had been already laid, and from the beginning of October in this year the station of Madeira would be able to send daily weather despatches. M. Fradesso handed to the meeting a paper containing the graphical representation of the simultaneous conditions of the weather at Madeira and Lisbon.

THE CHAIRMAN thanked M. Fradesso for his interesting communication.

THE CHAIRMAN on the close of the discussion of the Report communicated the contents of a letter which he had just received from M. Donati, in which that delegate explained that he had been obliged to leave Vienna on that morning, and regretted that he could not be present at to-day's meeting.

International
Fund, p. 48.

In the discussion which next followed, on M. Buys Ballot's proposal at the third meeting, in regard to the formation of an International Fund for the establishment of Meteorological Observatories on islands and at distant points of the earth's surface (Appendix 4 to the Protocol of the third meeting), the Congress decided to leave the further carrying out of the question to the Permanent Committee. M. CANTONI, as well as M. FRADESSO, placed it on record that their Governments were not indisposed to take part in forming an international fund.

The 2nd proposal of M. Buys Ballot respecting the establishment of special offices for the exchange of Meteorological publications had already received a satisfactory solution at the second meeting on the 12th September.

Reports on the
state of
Meteorology,
pp. 47, 48.

With respect to both the proposals of M. Jelinek, in regard to obtaining reports on the organization of the different institutes and systems of observation, as well as in regard to giving information of the series of observations, for a considerable number of years, which exist in each land, the Congress entirely approved of them and decided for M. Hoffmeyer's proposal to hand over to the Permanent Committee the carrying out of both proposals.

Mr. BUCHAN declared it desirable that an accurate Catalogue of all meteorological publications should be prepared.

Thanks to the
Austrian
Government
and the
Academy of
Vienna.

When the Agenda had been completed Mr. SCOTT proposed to express thanks to the Austrian Government and the Imperial Academy of Sciences for the support which had been given to the Congress in its proceedings.

M. JELINEK thanked the delegates in the name of the Bureau. 11th Meeting.
M. CANTONI thanked the Vice-Presidents who had been entrusted with the management of the proceedings of the Congress, viz.: MM. Bruhns, Buys Ballot, Jelinek, Scott, and Wild.

Finally the Congress expressed their thanks, on the proposal of M. Hoffmeyer, to the Committee, appointed by the Leipzig Conference, which had investigated the questions of such extreme importance for practical meteorology, viz.: Weather Telegrams and Maritime Observations, and specially recognised the untiring zeal of the Reporter, M. Neumayer.

In conclusion the thanks of the Congress were expressed to the Secretaries.

Termination of the sitting at 12.15 p.m., upon which the Meteorological Congress of Vienna was declared to be closed, after the Protocol had been confirmed by the Chairman at the meeting itself.

C. JELINEK.

Appendix 1. to the Protocol of the Second Meeting.

ADOPTED BYELAWS.

BYELAWS for the INTERNATIONAL METEOROLOGICAL CONGRESS,
VIENNA, 1873.

§ 1.

Byelaws, p. 9. The Permanent Committee elected at the Meteorological Conference of Leipzig shall open the first meeting of the Congress, and shall superintend the election of the Bureau, consisting of the Honorary President, Vice-Presidents, and Secretaries. In the elections in question, the absolute majority decides.

§ 2.

The Permanent Committee shall present a Report on the constitution of the Congress, and submit the communications and papers which have been received since the meeting at Leipzig.

§ 3.

The Permanent Committee shall submit a Programme of the questions to be discussed, and this programme shall be discussed and finally decided at the second meeting.

Each member of the Congress has the right to submit proposals in regard of new subjects to be brought forward for consideration, but such proposals cannot come on for discussion until one of the subsequent meetings.

Proposals emanating from non-members must be supported by members if they are to be brought forward for discussion.

§ 4.

The Congress shall hold its general meetings between the hours of 10 a.m. and 1 p.m. The days of meeting to be fixed by the Bureau.

§ 5.

The Agenda for the general meeting for each day shall be fixed by the Vice-Presidents, and announced, if possible, at the close of the previous meeting, but at latest at the opening of the meeting in question.

§ 6.

In Divisions at the general meetings the absolute majority of the delegates present shall, as a rule, decide. In case of equality, the vote of the Vice-President who is in the chair shall decide.

It is, however, open to any delegate to demand a division according to countries. In case of such a division, the delegates of one and the same country have, after a previous consultation, only one vote to give, which for countries of less than 10 million inhabitants is counted as *single*, for countries of between 10 and 30 million inhabitants as *double*, for countries of over 30 million inhabitants as *threefold*.

§ 7.

For individual points of the Programme Sub-committees shall be appointed, the members of which shall be selected by the Bureau and nominated by the Congress.

The editorship of the Proceedings of the Congress shall be entrusted to a special committee, which shall make provision for the printing and distribution of the Protocols. App., II. 1. Byelaws, p. 9.

(Adopted at the Second Meeting of the Congress.)

Appendix 2. to the Protocol of the Second Meeting.

PROGRAMME of the PROCEEDINGS of the METEOROLOGICAL CONGRESS
at VIENNA, 1873.

I. INSTRUMENTAL.

1. What is the best form of Barometers for stations of the second order? p. 20.
Is the use of Aneroids for such stations admissible?
2. What mode of exposure of Thermometers for the observation of Air Temperature is the best and most suitable for general adoption?
3. What is the best construction of Maximum and Minimum Thermometers?
4. What instruments should be employed for determining the intensity of Radiation, and in what way can the comparability of the results obtained be ensured? pp. 32, 56, and 77.
5. What apparatus is the best for determining Earth Temperatures? At what depths should the observations be taken in order to attain the uniformity which is desirable? pp. 33 and 58.
6. What apparatus should be employed for the determination of the Hygrometric condition of the air? pp. 33 and 58.
Are the Wet and Dry Bulb Thermometers sufficient?
7. Can the Hair Hygrometer be employed, and under what restrictions?
7. In what way can uniformity in describing the Directions of the Wind be attained? pp. 25 and 51.
Is the deduction of the mean Direction of the Wind by Lambert's formula desirable?
8. Is it desirable or not to include very light winds (force 0) in constructing Wind Roses for the Direction of the Wind?
8. What scale should be employed for the Force of the Wind when it is determined, not by actual measurement, but only by estimation? p. 91.
9. Is it desirable to introduce simple dial instruments for determining the Velocity of the Wind?
9. What units should be taken for the discussion of the Velocity of the Wind?
10. What is the best form, size, and mode of exposure of Rain Gauges? pp. 27, 52, and 86.
At what hour of the day should the fall be measured?
11. Should the days of Rain and Snow be counted separately or together?
12. Is it desirable in giving the falls of Hail to draw a distinction between "Graupel" and true Hail? pp. 14 and 43.
13. a. In counting Thunderstorms, should the Storms, as such, or the Days of storm be given?
13. b. In what way should the instances of Sheet-lightning be noticed?
14. What apparatus is to be recommended for the measurement of Evaporation? pp. 29 and 53.
What is the most suitable exposure for the Evaporation gauge?
15. a. In what way should the proportion of Cloud in the sky be estimated and indicated? pp. 15 and 49.
Is it desirable to introduce for Clouds, Hydrometeors, and for other extraordinary phenomena, symbols which shall be independent of local language, and therefore universally intelligible? pp. 19, 29, 45, and 48.
16. Should other Meteorological Elements than those already enumerated, e.g., Atmospheric Electricity, Ozone, &c., be included in the scope of normal observations, and what are the best instruments for observing them? pp. 16 and 45.

App., II. 2.
pp. 21 and 49.

17. Is it desirable to introduce the same Units of Measure (viz. of Length, Degrees, and Time) in meteorological inquiries in all countries, or is it sufficient to lay down certain fixed rules for the conversion of the different measures employed in the several countries?

II. INSTITUTION AND REDUCTION OF THE OBSERVATIONS.

pp. 29 and 52.

18. Can uniform Hours of Observation be introduced for the general observations to be made at the Meteorological Stations?

p. 23.

19. What are the rules and what the intervals of time for which the Means of the several Meteorological Elements should be calculated?
Which is the better plan, to begin the meteorological year with January or with December?

p. 24.

20. In what manner and for what intervals are the Normal Values for the individual Meteorological Elements to be deduced?

III. WEATHER TELEGRAMS.

pp. 37 and 63.

21. Does the interchange of Weather Telegrams appear so useful that it should receive a fuller development and a firmer organisation?

IV. MARITIME METEOROLOGY.

pp. 36 and 62.

22. In what way can Maritime Meteorology be best introduced into the system of General Meteorology?

V. ORGANIZATION.

pp. 36, 61,
and 93.

23. Is it desirable that in each country there should be established one or more Central Institutions for the direction, collection, and publication of the Meteorological Observations?
24. Can rules universally applicable be laid down for the Verification of Instruments and the Inspection of Meteorological Stations?
And is it advisable to introduce general Instructions for taking and calculating Meteorological Observations?
25. In what manner can the agreement of the Standard Instruments of the different Central Establishments be best effected?

VI. PUBLICATION OF THE OBSERVATIONS.

p. 34.

26. Is it desirable and possible to publish the Meteorological Observations of a limited number of stations in each country in a uniform manner, and within a reasonably short time after the observations have been made?

pp. 30, 48, and
56.

27. How is the exchange of the Meteorological Publications of different institutions and different countries to be carried out most speedily, safely, and simply?

VII. CARRYING OUT THE DECISIONS OF THE CONGRESS.

pp. 31 and 59.

28. What regulations should be adopted in order to carry into effect the decisions and the views of the Meteorological Congress?
Is the appointment of a Permanent Committee and the organization of future Meteorological Congresses requisite for this purpose?

pp. 27, 50, and
71.

29. M. Plantamour's proposal respecting the foundation of an International Central Institute for Meteorology?

Appendix 1. to the Protocol of the Third Meeting.

REPORT of the LEIPZIG SUB-COMMITTEE (Ebermayer, Schoder, Sohncke), on QUESTIONS 12, 13, 15, 16, of the Programme of the Congress.

p. 14.

Question 12. Is it desirable in giving the falls of Hail to draw a distinction between "Graupel" and true Hail?

The separate notation of Hail and "Graupen" assumes that both of the App., III. 1. two phenomena are recognizable by distinct characteristics. It is a question whether or not this be the case, in accordance with the general usage of the German language (for *e.g.* no distinction is made in the English language).

1. "Graupeln": roundish, whitish, loosely-aggregated masses of frozen water, sometimes of the size of peas, and resembling small balls of snow.

2. Hail: larger pieces of harder and denser ice, of a less spherical form, flatter disc shaped or of the shape of a truncated cone.

If the size be considerable, alternate coats of clear, and of opaque white, ice are recognizable, enveloping a nucleus of the nature of "Graupel," at times studded at the outer surface with large crystals of ice. It is easy to distinguish between these extreme cases, but with intermediate types, it is optional whether they should be described as Hail or "Graupel," and for such another special term "Schlossen" is employed.

It is quite inadmissible to avoid the difficulty of drawing the distinction, by the attempt which has been made to take into consideration the distinct origin of each phenomenon, as there are as yet nothing beyond hypotheses to account for their origin. If therefore the two phenomena cannot be distinguished from each other with absolute certainty, it is neither scientifically justifiable, nor practically possible, to record them separately.

Agriculture has certainly a real interest in drawing the distinction, but for this it is certain that the records of Hail Insurance Companies furnish better materials than Meteorological Journals.

As a result of these considerations the committee recommends that there shall be only one column for "Hail", and that falls of "Graupel," but only such as are absolutely indisputable, should be indicated by a small star, inserted close to the entry, or by a symbol differing slightly from that for Hail. This will render it possible, besides counting the falls indiscriminately, to pick out the one exceptional case. Furthermore it is desirable that in the column "Remarks" more special details should be given of the entire phenomenon, size of stones, direction of motion and superficial extent of the hailstorm, existence or the contrary of thunderstorms, damage done, &c.*

Question 13.

- (a.) In counting Thunderstorms, should the Storms as such or the Days of Storm be given?

- (b.) In what way should the instances of Sheet-lightning be noticed?

(a.) It is of course inadmissible for a single observer to speak of several storms prevailing at the same time (as is often popularly done), inasmuch as, at most, two distinct clouds are present and influencing each other. Accordingly the enumerations of several storms for one and the same day, can only refer to storms distinctly separated from each other as to time. It is however often difficult to decide if two thunderstorms occurring successively are independent of each other, or if the one is only to be regarded as the continuation of the other, so that it would be a matter of choice for the observer whether he recorded two storms or one. It is recommended only to count the days of storm in order to obtain more easily comparable figures.

This is not meant to preclude the individual observer from recording in his "Remarks" the number of Storms, the time of their commencement, their duration, direction of their motion, &c.†

(b.) It must first be settled what phenomenon is to be described as sheet-lightning. Some authors extend this description to the ordinary flashes of lightning without audible thunder. This use of the word is however scarcely justifiable. It is very improbable that a discharge of that nature is unaccompanied by sound at the place of its occurrence, inasmuch as the electrical sparks in laboratories are always accompanied by sound. On the other hand the non-

* The definition adopted at the Third Meeting (p. 14) was as follows:—"Hail is to be described as a precipitation of frozen water, in which the stones attain such a magnitude that they may be expected to do damage to agricultural products."

† Adopted at the Third Meeting (p. 14).

App., III. 1.
Sheet-lightning.

occurrence of thunder in such instances of lightning, which is in other respects quite normal, is easily explained by the operation of different causes, which perhaps often act in common; they are as follows: 1. Great distance. 2. Discharge in very rarified air (at a great height), so that the *vis viva* of the mass originally set in motion is too small to be able finally to affect appreciably the ear of the observer when it has been translated to greater and greater strata of denser masses. 3. Repeated reflections at the limits of strata of air and clouds of unequal density, whereby the sound transmitted is weakened at every time. It seems therefore better to follow the authors who exclude flashes without thunder from the category of sheet-lightning, and then we have this definition.

p. 14.

Sheet-lightning is a sudden expansive illumination, unaccompanied by any noticeable thunder, which is observed in the clouds, and also in the clear sky, mostly in the neighbourhood of the horizon.

It hardly admits of a doubt that the phenomenon so defined is attributable in various cases to two or more agencies. Firstly, the reflection of distant flashes which either take place below the horizon, or are themselves invisible owing to the thickness of the intervening clouds, will appear as sheet-lightning. (Arago, in his essay on Thunderstorms, cites the fact that in the year 1803 luminous signals which were made on the Brocken by less than half a pound of powder were noticed at a distance of more than 120 miles, when the Brocken was no longer visible owing to the curvature of the earth.) Secondly, weak surface discharges (Flächenblitze) with slight noise (which according to Kundt's observations give the same lines in the spectrum that Schimkov observed in the faint-glow and brush discharges of the electrical machine, and which must accordingly be regarded as such discharges from the clouds) produce the phenomenon of sheet lightning.

The sub-committee is unanimous that on the whole, in the case of the co-existence of a thunderstorm at any time, sheet-lightning should not be specially noted, because in every storm inaudible discharges of one or the other origin will occur. Specially remarkable cases of sheet-lightning ought to be recorded by the observer in the "Remarks."

The opinions of the sub-committee are divided as to the mode of recording sheet-lightning on a day when there was no actual thunderstorm. The majority are against counting a day on which only sheet-lightning had been observed among the days of thunderstorm. The minority think that by such a practice many storms which took place below the horizon would be neglected, and that no other limits than those of *visibility* could be laid down for the area of observation of any given station, so that accordingly days with sheet-lightning should be counted with days of thunderstorm; they might, however, be distinguished from the others by a star or other mark.*

Question 15.

p. 15.

pp. 19, 29, and 48.

- In what way should the proportion of Cloud in the sky be estimated and indicated?
- Is it desirable to introduce for Clouds, Hydrometeors, and for other extraordinary phenomena, symbols which shall be independent of local language, and therefore universally intelligible?

The first part (a) of Question 15 has been already settled at the Leipzig Conference, inasmuch as it was agreed that the amount of Cloud should be estimated from 0 to 10, 0 indicating a perfectly cloudless, 10 an entirely over-cast sky.

As to the second question, the following Table gives the designations which have been hitherto employed.

* The definition adopted at the Third Meeting (p. 14) was as follows:—"As days of storm, only those are to be noted on which both lightning and thunder have been observed. If only lightning without thunder has been noticed, the entry for the day must be sheet-lightning."

These for the most part consist of the initial letters of the respective words, and are therefore dependent on the individual language. App., III. 1. Symbols, pp. 29 and 48.

	Rain.	Snow.	Rain with Snow.	Thunder-storm.	Lightning.	Thunder.	Hail.	"Graupel."	Mist (Fog).	Hoar frost.	Dew.
Prussia and Saxony.	R	Sch	R, Sch	G	Bl	D	H	Gr	N	Rf	Th
Baden - -	R	S	-	-	-	-	-	-	-	-	-
Bavaria - -	R	S	-	-	-	-	-	-	N	Rf	-
Württemberg -	Rg, rg	Schn, schn	-	Gew	-	-	Hgl, hgl	Grp	Nb, nb	R	Th, th
Austria - -	II	*	-	↑	↑	-	△	-	●	-	-
Switzerland -	R	S	-	G	-	-	H	Gr	N	Rf	Th
France - -	●	*	-	-	-	-	■	□	○	△	••
Italy - -	pl	nv	-	-	l	t	gr	-	nb	br	rg
Holland - -	R, r	Sn, sn	-	-	{ ⊕ with ○ without }	Thunder	Ha, ha	-	⊙	-	-
England - -	r, r, r	s, s, s	-	-	l	t	h	-	m	-	w
Denmark and Sweden.	R, r	S, s	Sl	-	Z	Ta	H, h	-	T, t	-	-
Russia before 1870.	pl	Ng	-	-	E	T	gr	-	Br	gbl	-
Russia since 1870.	●	*	●*	⊳	⊳	T	■	□	○	⊗	S
United States -	Ⓐ	Ⓢ	-	-	-	-	-	-	-	-	-

The Sub-Committee proposes the following Symbols:—

Rain -	-	-	●
Snow -	-	-	*
Thunderstorm	-	-	⊳
Hail -	-	-	△
"Graupel" -	-	-	△
Mist (Fog) -	-	-	⋈
Hoar frost -	-	-	⌈
Dew -	-	-	Ⓐ

The Sub-Committee furthermore recommends, that if in any publication additional Abbreviations or Symbols are employed, the explanation of them should be given in some prominent place, and in several languages, not in the individual language only.

Question 16.

In respect of Atmospheric Electricity the questions are,

- Should Atmospheric Electricity be included in the list of normal observations?
- What are the best instruments for observing it?

p. 16.

App., III. 1.
Atmospheric
Electricity,
p. 16.

(a.) Atmospheric Electricity is at the present time one of the phenomena of terrestrial physics which is least understood, therefore its enrolment among the normal objects of observation is at the least as great a want (for theory, though not as yet for practice) as the observation of the other elements; but, in consideration of the difficulty and delicacy of such a class of observation and of the fact that ordinary observers should not be overloaded with too many different observations, the observation of Atmospheric Electricity can be recommended only for Head Observatories.*

(b.) In treating of instruments for the observation of Atmospheric Electricity the measuring apparatus must be considered separately from the collecting apparatus.

A. Measuring Apparatus.

The most sensitive and accurate Electrometer, on the whole, is Thomson's Divided Ring Electrometer with mirror and light. This may also be employed for the measurement of atmospheric electricity (for which purpose it was specially invented). None of the other electrometers, whether they be instruments on the principle of the Torsion Balance, or on that of the gold leaf electroscope, are equal to Thomson's. In using it, however, special attention must be paid to one point. Inasmuch as the needle on which the quadrants, charged with atmospheric electricity, act, is itself kept in an electrical condition by a Leyden jar placed within the apparatus, the extent of its deviation depends upon the charge of the jar. It is therefore important to keep the charge of the latter constant. This is rendered possible by the fact that a charging apparatus ("replenisher"), constructed on the principle of Holtz's electrical machine, and a gauge are attached to the jar. By means of the gauge a knowledge of the condition of the charge is obtained, and by means of the "replenisher" the loss is easily replaced. With good instruments the charge does not decrease more than 1%, at most, within 24 hours, thus it is enough to complete the charge twice or thrice a day to keep it as good as constant. The same end might be attained in a simpler, if not in altogether as certain a way, by regulating the charge so that the electromotive force of a Daniell's cell should always produce the same deflection of the needle.

B. Collecting Apparatus.

The water collector proposed by Thomson works best. It is an insulated metallic vessel containing water, standing in a room, with a long pipe reaching outside the window, from which the water runs in a fine stream. Instead of this in winter a burning match of paper, soaked with nitrate of lead, is used; an insulated wire connects the collector with the divided ring of the electrometer. *Ceteris paribus* the instrument charges itself equally by both kinds of collecting apparatus; the deflection of the needle measures the difference of the potentials, i.e. of the electrical tension of the air at the place where the stream is dispersed, and the potential of the earth.

The advantages of this collecting apparatus over all others, be they fixed rods with points, or metallic bodies projected to a height, connected during a short part of their flight with an electrometer at rest, are the following:—

1. Simplicity of manipulation (you only turn the water-cock).
2. Strong and rapid collecting action. In a few seconds the maximum of charge is attained, while a fixed pointed collecting rod requires about a quarter of an hour.
3. Good insulation, as the apparatus stands in a room.

Owing to the almost instantaneous indication of the intensity of atmospheric electricity, Thomson's complete apparatus is also especially adapted for continuous registration, if the reflected image of the light be allowed to play on a strip of photographic paper passing slowly under it.

In order to make different observations comparable two things are requisite:—

1. The indications of different instruments must be referred to each other. This is done by comparing their behaviour when the same source of electricity is employed, e.g. the electromotive force of a Daniell's cell.

* It was resolved at the Third Meeting (p. 16), "That the institution of observations on "Atmospheric Electricity be recommended only for Head Observatories, and that the decision, "as to the choice of the best methods of observation and of the most suitable instruments, must "be left to them."

2. Inasmuch as the deviation of the needle measures the difference between the tension at the point of dissipation of the stream of water and that in the earth, the observations of all stations must be reduced to the same height of point of dissipation above the ground, for atmospheric electricity increases with height. For this purpose the indication of the instrument at the station must be compared with the simultaneous indication of another instrument, erected at the normal height above the ground, in an open level place in the neighbourhood, the action of the latter instrument having previously been compared with that of the instrument at the station.

In this way all the results from all stations may be reduced to the same normal height, and may thus be rendered really comparable with each other.

Among the meteorological elements which must be considered in addition to atmospheric electricity, the next are Ozone measurements, which increase in importance the more we are convinced of the importance of the ozone in the atmosphere. Unfortunately Schönbein's ozonometers, which have been employed for this purpose, are insufficient, and leave much to be desired in regard of their sensitiveness and accuracy. The Iodide of Potassium and Starch papers recently prepared by Kroll & Co. at Berlin are somewhat more sensitive, but on the other hand the ozone scale prepared by Kroll & Co., with 16 different grades, cannot be recommended, inasmuch as the last four numbers do not permit of any detection of difference in regard to the intensity of colour. A scale of 10 or 12 degrees appears to be the most suitable, but the colours must correspond better with the real conditions than is the case with Schönbein's scale.

The measurements themselves should be made every 12 hours, and in the choice of the respective localities, the vicinity of sewers, dung-hills, open drains, in short everything which can cause a de-ozonization of the air should be avoided. Neither sun-light nor rain should have access to the ozone papers.*

There are a series of other subjects which require regular observation, as e.g., measurements of water in the soil, determination of the amount of water soaking through the soil, determination of the carbonic acid and vapour contained in the air in the soil, &c., &c. But these matters fall outside the domain of Meteorology, and the carrying out of these observations must be left to such departments as have a special interest in them.

Prof. Dr. EBERMAYER, Aschaffenburg.
Prof. Dr. SCHÖDER, Stuttgart.
Prof. Dr. SOHNCKE, Carlsruhe.

July 1873.

Appendix 2. to the Protocol of the Third Meeting.

The Congress should take into consideration whether it would not be well to request the heads of the various systems of Meteorological observation to furnish reports, of as uniform a character as is possible, on the organization of their systems of observations, and especially of their Central Institution (if there be one) and on the condition of Meteorological investigations and publications, as well as on desirable developments and improvements. These reports should be collected and printed in a publication to be selected by the Congress.†

C. JELINEK.

Appendix 3. to the Protocol of the Third Meeting.

The Congress should take into consideration whether it would not be well in the interest of facilitating meteorological investigations to request the heads of the various systems of observation to state how many long-continued series

* It was resolved at the Third Meeting (p. 17), that "The present methods of determining "the amount of Ozone in the air are insufficient, and the Congress therefore recommends "experiments for the discovery of better methods."
† Adopted at the Eleventh Meeting (p. 33).

App., III. 3. Existing series of observations, p. 38.

of observations, printed or not, exist in their respective countries. In the case of printed observations the title of the publication (including publishers' name and the price) should be given, and in the case of unprinted ones the mode in which either extracts or copies can be procured. For the most important meteorological elements the mean values should be given, with indication of the years from which they have been deduced.

The contents of these communications should be published by a special committee to be chosen by the Congress, and in a manner to be determined by that committee.*

C. JELINEK.

App., III. 4.

Appendix 4. to the Protocol of the Third Meeting.

International Fund, p. 38.

1. Should we not express the hope that an International Fund should be established, out of which observatories on islands, and at out-lying localities, can be organized and maintained?†

Exchange of publications, p. 30.

2. Is it not desirable, in order to facilitate the exchange of publications, to organize, on the model of the Smithsonian Institute at Washington, and the Central Bureau at Haarlem, a similar office in every country?‡

BUYS BALLOT.

App., IV. 1.

Appendix 1. to the Protocol of the Fourth Meeting.

Symbols,

REPORT of the SUB-COMMITTEE chosen at LEIPZIG on Question 15, discussed at the Meeting of September 7th; 10 a.m. till 1 p.m.

44.

Present: the Sub-Committee, consisting of—
Ebermayer, President.
Schoder, Reporter.
Sohncke,

and in addition the co-opted members,
Wild, Lorenz, Plantamour.

1. For the designation of the hydrometeors and other phenomena, the following symbols were proposed:

1. The following Symbols are proposed for the indication of Hydrometeors and other phenomena:—

Rain - - - - ●	Glazed Frost ("Glatteis") - ~
Snow - - - - ✕	Snow-drift - - - - †
Thunderstorm - - - - ⚡	Ice crystals - - - - †
Lightning without Thunder, or Sheet Lightning. } <	Strong wind - - - - †
Hail - - - - ▲	Solar Corona - - - - ⊕
"Graupel" - - - - △	Solar Halo - - - - ○
Mist, Fog - - - - ≡	Lunar Corona - - - - ⊕
Hoar-frost - - - - L	Lunar Halo - - - - e
Dew - - - - P	Rainbow - - - - (
§Silver-thaw("Rauh-frost," "Duft") V	Aurora - - - - ☄
	Dust haze ("Höhen-rauch") - ∞

* Adopted at the Eleventh Meeting (p. 38), with the modification, that the carrying out of this and the preceding proposal be entrusted to the Permanent Committee.

† At the Eleventh Meeting (p. 38) it was resolved that the further carrying out of this question should be entrusted to the Permanent Committee.

‡ Adopted at the Seventh Meeting (p. 30).

§ "Rauh-frost" or "Duft-anhang" is the phenomenon of the deposition of a large quantity of frozen moisture on trees when the weather suddenly becomes warm after great cold, sometimes called, as above, "Silver-thaw."

In respect of their intensity, the individual phenomena are to be distinguished by the figures 0 and 2, which should be used as exponents of the symbols, in such a way that 0 should indicate very slight, 2 strong.

e.g. ●⁰ slight Rain.

●² heavy Rain.*

It is further to be remarked that Fog (mist) is only to be entered when the observer is quite enveloped in it. Höhenrauch (dust haze), moreover, is not only to be indicated by the proper symbol, but at the same time the concomitant obscuration of the atmosphere is to be noticed under the head of Amount of Cloud.

Clouds.

1. Entries as to the extension of clouds on the visible sky according to the scale 0—10 are to be made without reference to the thickness of the cloud. The latter is to be indicated by an exponent applied to the figure for the amount of Cloud (0 slight, 2 great).

2. As to the Forms of Cloud, or rather, classes of cloud, the matters most urgently desired are more thorough observations and more accurate drawings, which will correspond to the variety of clouds which are in reality observed; as all the systems which have as yet been proposed, e.g. that of Poëy, are not of such a nature that they can at once be recommended for general adoption.

3. For the present it is recommended to add to Howard's designations and their combinations, epithets as characteristic as possible, according to the choice of the individual observer, in order to express the actual appearance as clearly as possible.

4. In order to facilitate a correct understanding and designation of the clouds, it is recommended,

- That Central Offices should prepare as completely as possible lists and characteristics of the forms of cloud which occur in the district.
- That on the part of the Congress the preparation of sketches of the principal forms of cloud be set on foot, which should be added to the Instructions for the observers.
- That the study of the connexion between the form, constitution, and origin of the clouds be undertaken and supported, special attention being paid to the circumstance that one and the same mass of cloud presents a different appearance when seen from different sides or under different angles.†

Reporter, SCHODER.

Appendix 2. to the Protocol of the Fourth Meeting.

App., IV. 2.

Question 17 (Units of Measure).

A resolution was adopted on this question at the Leipzig meeting, to the effect that the results of observation or the means should be published in the Metric (and Centigrade) scales in addition to appearing in the original scales. (See Report of the Conference, p. 12).‡

At the meeting at Bordeaux the proposal was made (Report, p. 67) to publish in uniform scales the observations of a selection of stations which are of pre-eminent importance for the Science in general, while those stations which are rather intended to serve for the study of the local conditions of climate should for a long time yet content themselves with the various scales in use in the country.

This has been recommended in the same way by W. Köppen in the Journal of the Austrian Meteorological Society (1873, No. 2, p. 19), and agrees with the proposal made there, and also by Prof. Wolf, in his letter to the Swiss Meteorological Commission, to consider in general only a certain minimum of stations as appertaining to the general international scheme of observation,

* Adopted at the Seventh Meeting (p. 29).

† Adopted at the Fourth Meeting (p. 20).

‡ The references in this Appendix refer to the pages of the English translation of the Report of the Leipzig Conference (Stanford), price 1s.

App., IV. 2.
Units of
Measure, p. 21.

but that for these the observations and publication should be carried out nearly or entirely in an uniform manner.

In their letters to the Leipzig Committee, M. Fradesso da Silveira (Report, p. 47), Mohn (Report, p. 56), and Wolf (Report, p. 66), express themselves decidedly for the necessity of the general adoption of uniform scales, viz., of Millimètres and Centesimal degrees; while, M. Fritzsch (Report, p. 49), and Mr. Symons (Report, p. 65), as well as the French meteorologists, in view of the difficulty of attainment of a general uniformity, recommend the improvement and further consolidation of reduction tables, and Prof. Dove (Report, p. 46), with Mr. Scott (Report, p. 12), raise the question whether, if a general uniformity be attainable, it would not be wiser to attempt this in respect of English inches and Fahrenheit degrees, instead of the millimètres and centigrade degrees which are usually proposed.*

Reporter, WILD.

App., IV. 3.

Appendix 3. to the Protocol of the Fourth Meeting.

REPORT of SUB-COMMITTEE VII. on QUESTION 29 (Foundation of an International Central Institute for Meteorology).

International
Institution,
pp. 27 and 71.

Questions 28 and 29 were referred to the seventh sub-committee, but that committee thought that it would be best to separate the reports on these two questions, and to bring forward to-day the results at which they had arrived on Question 29, and at a later period to hand in a report on the first question.

In the discussion of the questions which are included under Question 29 the sub-committee has had an advantage, in that several members of the Congress have had the kindness to take part in it, and to give full expression to their opinions on the question.

The Sub-Committee thereby has been placed in a position to gain information as to the more general conception of the meaning of such an international Institute ("Anstalt"), and thereby has obtained a better insight into the various difficulties which the question presents.

From these proceedings it appears to be absolutely unanimously conceded that there is a general want for the establishment of an International Meteorological Institute, to which, as principal duties, should be confided, to collect the necessary data for a comprehensive view of the course of meteorological phenomena over as much of the earth's surface as is possible, and to publish them internationally.

On the other hand it appeared in the discussion which took place that on various grounds it was not considered that the moment had quite arrived, nor was the matter ripe enough to lay before the Congress definite proposals for the immediate establishment of such an Institute.

In consideration of the generally admitted importance of the question for the progress of meteorology, and that it may not be altogether shelved, the sub-committee is perfectly unanimous in proposing to the Congress the following resolutions:

1. The Congress holds the establishment of an International Institute for the advancement of Meteorology as really useful and desirable.†

2. The Congress at once names a special committee of five members with instructions to investigate all the questions bearing on the establishment of this Institute, and to propose a detailed scheme. The committee should publish the result of its inquiry and proposals in the course of the year 1874 and should disseminate them as widely as possible, so that they can be taken into consideration by a future Meteorological Congress.‡

Reporter, HOFFMEYER.

* The following resolutions were adopted at the Fourth Meeting (p. 21):—

1. For observations as well as for publications the use of the same units of measure is desirable.
2. The Congress expresses its conviction, that among all the existing systems of measure, the Metric has the best prospect of universal adoption.

3. The Congress declares it to be most desirable, if it be not possible to introduce uniform measures at present, to use henceforth only Metric and English measures (with Celsius and Fahrenheit scales).

4. All action is to be supported which tends to the introduction of the uniform Metric system.

† Adopted at the Sixth Meeting (p. 27), with the modification that instead of the expression "Anstalt" (Institute), the expression "Institution" (Institution) should be inserted.

‡ It was further resolved at the Eighth Meeting (p. 32), that the resolution bearing on the appointment of a Special Committee consisting of five members be revoked, and that the functions designed for that Committee should be entrusted to the Permanent Committee.

Appendix 1. to the Protocol of the Fifth Meeting.

App., V. 1.

REPORT of SUB-COMMITTEE II. on QUESTIONS 7-9 (Wind; Observation Wind, p. 25. and Calculation).

Question 7.

In what way can uniformity in describing the Directions of the Wind be attained?

Is the deduction of the mean Direction of the Wind by Lambert's formula desirable?

Is it desirable, or not, to include very light winds (force 0) in constructing Wind-Roses for the Direction of the Wind?

The Sub-Committee proposes:—

1. To introduce the English designations of the directions of the wind:—
N. = North, E. = East, S. = South, W. = West.

2. To give only 16 directions of the wind in the wind rose. In the case of intermediate directions of the wind being observed, it is proposed to count them alternately to the one side or the other.

The Sub-Committee is further of opinion that the application of Lambert's formula is not to be recommended, but on the other hand, that the frequency and mean force of the winds which correspond to the different directions should be given in numbers. In the distribution in the wind-rose those winds whose velocity is less than $\frac{1}{2}$ metre per second ($2\frac{1}{2}$ miles per hour) are not to be regarded, but counted as Calms.

The proposal of M. v. Oettingen to reduce the wind, in Direction and Force, immediately, to the four cardinal directions is considered as only suitable for special investigations.

Finally, the Sub-Committee recommends that the direction of the wind in the various strata of clouds (the cloud drift) should be observed and noted.

Question 8.

What scale should be employed for the Force of the Wind when it is determined, not by actual measurement, but only by estimation?

MM. Buys Ballot, Jelinek, and Scott, at the suggestion of the Leipzig Conference have commenced investigations on the comparison and regulation ("Normirung") of scales of Wind Force, but the experiments are not completed.

The Sub-Committee is not in a position to recommend a general scale for the estimation of wind force, but expresses the wish that a gradual advance should be made towards giving the velocity of the wind in metres per second.

Question 9.

Is it desirable to introduce simple dial instruments for determining the Velocity of the Wind?

What units should be taken for the discussion of the Velocity of the Wind?

The Sub-Committee recommends that the simple apparatus for measuring Wild's Wind—the force of the wind, which has been proposed by M. Wild, and is already gauge, used in Switzerland, Baden, and Russia, should be introduced as soon as possible at stations of the second order.

Furthermore, the Sub-Committee proposes that the velocity of wind obtained by means of anemometers should be expressed in metres per second, and recommends the preparation of tables for facilitating the mutual conversion of the velocity of the wind when given in metres per second, kilometres per hour, or English miles per hour.*

Reporter, M. HOFFMEYER.

* Adopted at the Sixth Meeting (p. 25).

Appendix 2. to the Protocol of the Fifth Meeting.

REPORT of SUB-COMMITTEE III. on QUESTIONS 10 and 11 (Observations of Precipitation).

Question 10.

What is the best form, size, and mode of exposure of Rain-gauges?
At what hour of the day should the fall be measured?

After a thorough discussion the Sub-Committee thinks, with regard to those two questions, that it can propose the following rules of general applicability.

According to the comparative observations carried out in Scotland and England, rain-gauges whose receivers have diameters of only three English inches are said to give results nearly the same (with not more than 2% difference) as such as have larger receivers (up to 24 inches diameter).

The Sub-Committee considers it best to propose for all rain-gauges a circular receiver of one-tenth square metre surface,* and to provide the edge with a strong turned ring of brass formed conically.

In the erection of rain-gauges, care must be taken that the receiver should not be less than one metre (or still better 1½ metre) (from 3 to 4½ feet) above the ground, to admit of the inspection of the receiver and of the easy removal of it. Under all circumstances, in the publication of the results, the distance of the receiver from the ground ought to be given. As to the size of the collector, no general rules can be given, inasmuch as this must be regulated according to the local amount of rain, but under all circumstances the construction of the rain-gauge must be of such a kind that the evaporation of the water collected is prevented as much as possible.

In all cases, where it can be done, the measurement of the amount should take place immediately at the end of the fall; in other cases the first observing hour of the day is recommended. The amount measured in that case is to be put down in the register for the previous day.

In a special column in the register, wherever possible, should be given the duration of the fall, expressed in hours, in addition to the quantity of rain.

Question 11.

Should the days of Rain and Snow be counted separately or together?

The proposal of the Sub-Committee is, that in the register, under the column of "Remarks," the character of the precipitation should be indicated by the symbols adopted by the Congress, and that furthermore, in the monthly *resumé*, the sum of all the days of precipitation should be given and the number of days with snow, hail, and *graupe* should be especially noticed. The days are to be counted as snow-days on which both snow and rain fell.

In the register three columns are to be introduced for precipitation; one for the amount of fall, the second for the depth of snow, and the third for the duration of the fall, expressed in hours.

In the publication of the yearly *resumé* should be further shown—

- The maximum fall in 24 hours from month to month.
- The number of days of fall which are below one millimetre (0.04 in.), and the number of those which are below ¼ millimetre (0.01 in.)†

Reporter, M. EBERMAYER.

Appendix 1. to the Protocol of the Sixth Meeting.

REPORT of SUB-COMMITTEE IV. respecting QUESTION 18. (Hours of Observation.)

The Sub-Committee are not prepared to propose a definite combination of hours for the meteorological observations of all countries, since regard must

* About 14 inches diameter.

† The proposals of the Sub-Committee were adopted at the Sixth Meeting (p. 27), with the modification that the suggestion in b should be only recommended.

be had for the customs of the country; but it would urge that the various hours of observation which should be chosen should give a daily mean of the temperature, which should be as near as possible to the true one; and more particularly, in taking means, that the giving of too great weight to observations taken at a warm part of the day should be avoided. As suitable combinations of hours the Sub-Committee recommends—

h.	h.	h.	h.	h.	h.
6	2	10	8	2	8
7	2	10	9	3	9
7	1	9	10	4	10
7	2	9			

With minimum
temperature.

h.	h.
8	8
9	9
10	10

As the three last-mentioned observations, twice a day, at equidistant hours, give good daily means of temperature, but do not allow of the recognition of daily variations of temperature, the simultaneous use of maximum and minimum thermometers must be recommended, in addition to these combinations (but with the necessary care which these instruments require).

In each system of observation, investigation should be made, at a sufficient number of normal stations, as to the corrections for the most important meteorological elements (especially Temperature, then Pressure and Humidity) which should be applied to the means of the adopted observations in order to bring them to true 24-hourly means; but monthly means of the observations should be given for the various hours of observation, and it seems furthermore desirable, when it is considered that such means may be directly used, to give the monthly means of Temperature reduced to true means.

Inasmuch, as between the Equator and 35° North and South Latitude, there are only very few stations existing—

35-30	30-25	25-20	20-15	15-10	10-5	5-0
1	0	2	2	1	2	0
Cape Town.	Rio Janeiro, Calcutta.	Bombay, St. Helena.	Madras.	Trevandrum, Batavia.		

whose daily march of temperature is known, and not one of them has a *continental situation*, the Congress should express the urgent wish, that by the introduction of hourly, or at least two-hourly, observations at suitable places, a commencement should be made to fill up this hiatus as far as possible. The systems of observations of Turkey, East Indies, Australia, the Southern States of the Union, and eventually Brazil, should be specially requested to institute such observations at inland stations.*

Reporter, M. HANN.

Appendix 2. to the Protocol of the Sixth Meeting.

REPORT of SUB-COMMITTEE III. on QUESTION No. 14. (Evaporation observations.)

Question 14.

What apparatus is to be recommended for the measurement of Evaporation? Evaporation, What is the most suitable exposure for the Evaporation gauge (At- p. 29.
mometer)?†

All atmometers as yet known may be divided into two groups:—

- 1st. Those in which the determination of the quantity of water evaporated is effected by *weighing* in a delicate balance, and
- 2nd. Those in which the evaporated quantity of water is ascertained by *volume*, consequently by *measurement*. From a theoretical point of view it is certain that the former method gives the most accurate results, but weighing twice a day, or even once a day, requires much time, and a delicate balance is required for it, the use of which presupposes a certain amount of practice. For the regular meteorological observations, evaporation gauges or atmometers of the second class are certainly more to be recommended.

* Adopted at the Seventh Meeting (p. 29).

† It seems best to adopt Leslie's term for an evaporation gauge. It possesses the merits of seniority and of a correct classical derivation.

The requirements which we have to expect from a good atmometer of this class may be laid down in the following propositions:—

- a. The evaporating dish should not be too small, and if we are to aim at comparable results, the diameter as well as the depth of the evaporating dish must be absolutely identical in all apparatus. For smaller instruments an evaporating surface of 250 square centimetres (0.7 in. diameter); for larger ones, one of 1-10th square metre (14 ins. diameter) would be best suited.
- b. The level of the water which is evaporating in the dish must remain constant, as the evaporation is less, the deeper the surface of the water stands under the edge of the vessel.
- c. The measurement of the quantity of water evaporated must be made with the requisite accuracy, and it should be possible to read off the quantity of water evaporated in millimetres (0.04 in.) of depth.

In the choice of the apparatus we have first to regard the object which it is intended to attain. If the atmometer be to serve as a control for hygrometric data, and if it be wished to ascertain the influence of the individual elements of weather on evaporation, observations at least twice a day should be instituted; but for this purpose only the smaller apparatus is suited, and this should be erected similarly to the thermometer and hygrometer, sheltered from sun and rain.

If however the object of the observation be to ascertain the amount of evaporation under all circumstances which occur in nature, if the combined action of the elements of weather should express itself in the amount of evaporation, if the evaporation should thus in some measure serve as a representation of local climate, the apparatus must be left exposed to the action of the free air and the sun.

In this case we do not want readings daily, but only at intervals of about every five days, and the best form of apparatus that can be employed is the larger form, with a surface of 1-10th sq-metre (14 ins. diameter).

It is self-evident that the results of the large and small apparatus cannot be immediately compared with each other.

Inasmuch as according to the decision of the Congress, the receiver of the rain gauge should also be 1-10th sq-metre in size, we can by the help of this larger apparatus determine the difference between the quantity which has fallen and that which has evaporated, with much greater accuracy than with the smaller apparatus, and accordingly the former would be much better suited for practical purposes, as for instance, for Agriculture and Forestry, and for Sanitary Inquiries, than the latter.

A.—Smaller Atmometers for Scientific Objects.

Of the best known atmometers of this kind, Lamont's, Greiner's and Wild's apparatus may first be considered.

Lamont's atmometer has been used for three years at the Bavarian Meteorological stations with the best results.

The apparatus constructed lately by the optician Greiner in Munich is simpler and cheaper, and it also gives accurate results.

Wild's atmometer, in which the measurement of the quantity of water evaporated is ascertained by a bent-lever balance, has the advantage that it can be used in summer as well as in winter.

The instruments mentioned have all the disadvantage that in consequence of the progress of the evaporation, the surface of the water in the evaporating dish does not remain constant, but sinks. This error, which appears even in observations taken twice a day, is removed in Prestel's and Ebermayer's apparatus, of which the latter can be obtained from Greiner in Munich.

B.—Larger Apparatus for Practical Purposes.

Disregarding the most primitive evaporation gauge of this kind, which consists of a round or rectangular zinc vessel, of proper diameter, and which either contains, for the determination of the quantity of water evaporated, a vertical measuring rod (like a river pole), or which has a cock, by means of which the water can be let off into a graduated cylinder of glass, and measured. Dufour's Siccimeter should be noticed, which is described in Vol. VII. No. 8, p. 113, of the Austrian Meteorological Society's Journal, and serves to

measure the difference between the rainfall and evaporation. As this apparatus can only be read after some days, the error which arises from the variable level of the water which is being evaporated is much more serious in this instrument than in the smaller apparatus of the first class.

Closely connected with these instruments are those which serve to give the extent of the evaporation from the earth, and from the various kinds of soil in the shade as well as in the sun, covered or open. Experience of several years has shown that the evaporation apparatus of M. Ebermayer described in the recently published work: "Die physikalischen Einwirkungen des Waldes auf Luft und Boden," entirely fulfils its object.

As to the second question, which concerns the best mode of erection of the atmometer, it would be best to place the small atmometers of the first class (for scientific objects) under the same protection as that which is given to the hygrometer. Special care should be taken in setting them up, to give the air as free access as possible, to keep off the direct sun light, radiant heat, and rain water.

In the erection of the larger apparatus of the second class (for practical purposes) in the open air without any protection, the evaporating surface must be brought to the same level as the receiving surface of the rain gauge. The direct action of the sun on the sides of the apparatus must be prevented as far as possible, by enveloping it with bad conductors of heat (hay, straw, or moss); but the surface of water which is evaporating must be exposed to the complete action of the wind, and of the sun's rays.

It may also be recommended to plunge the apparatus partly into the earth, and in order to prevent water being removed from the evaporating vessel by animals, such as birds, &c., it should be covered with a wire net of large mesh. Wherever the conditions allow, it is desirable to plunge the atmometer in a lake or pond, to keep it floating, and to compare the results of these observations with those which have been obtained by means of apparatus placed on the open ground.

During winter months, when the freezing of the water causes damage to all the atmometers which have been described, measurements of evaporation can only be carried out with apparatus as simple as possible. The amount of evaporation is determined either by weighing or by measurement, when the ice is thawed. For the observations on a small scale, Wild's apparatus, above mentioned, seems to be the one best to be recommended.

For measurements on a larger scale, a round zinc vessel of 1-10th sq-metre area (14 ins. diameter) should be used, with a cock for letting off and measuring the ice melted. During winter months both instruments must be protected by a screen from the access of snow and rain. Inasmuch as the evaporation at a low temperature is only very slight, the inaccuracies attaching to this mode of observation cannot be of serious importance.

As the results to be obtained from atmometers have not yet been sufficiently determined, the Sub-Committee recommends:—

1. As a general rule, for the present, to introduce observations of evaporation only at meteorological stations of the first order.
2. By careful investigation to determine what will be the influence on the results of the nature of the material of which the apparatus is made (metal, glass, baked earthenware), as well as from the colour of the apparatus, and the height of the rim of the atmometer.*

Reporter, M. EBERMAYER.

Appendix 3. to the Protocol of the Sixth Meeting.

App., VI. 3.

Proposal of M. Wild:—

Does it not appear desirable that in order to investigate the weather phenomena of the higher strata of the atmosphere, more numerous observations should be made on isolated mountain peaks, as well as in captive balloons?†

Observations in the upper regions of the atmosphere, pp. 36, 59.

* Adopted at the Seventh Meeting (p. 29), with the addition that the measurements of evaporation, by means of floating apparatus on large surfaces of water, should be introduced wherever possible.

† Introduced into the Report of the Seventh Sub-Committee (p. 59), and adopted at the Tenth Meeting (p. 86).

App., VII. 1.

Appendix 1. to the Protocol of the Seventh Meeting.

LETTER FROM GENERAL ALBERT J. MYER to the CONGRESS.

Meteorological Congress, Vienna,
Sept. 11th, 1873.

To the Congress.

Synchronous
observations,
p. 32.

GENTLEMEN,

I HAVE the honour to submit the following proposition:—

That it is desirable that, with a view to their exchange, at least *one* uniform observation of such character as to be suitable for the preparation of synoptic charts be taken and recorded daily and simultaneously at as many stations as practicable throughout the world.*

I am, gentlemen, very respectfully,

ALBERT J. MYER, Brigadier General,
(Signed) Chief Signal Officer, U.S.A.

App., VII. 2.

Appendix 2. to the Protocol of the Seventh Meeting.

PATTERN of a FORM for ACKNOWLEDGMENT of RECEIPT.†

St. Petersburg, Sept. 1872.

Acknowledg-
ments of
Receipts, p. 30.

SIR,

I HAVE the honour to inform you that we have forwarded to you, through Messrs. Leopold Voss, of Leipzig, "Annals of the Central Physical Observatory, year 1870."

H. WILD,

Director of the Central Physical
Observatory.

You are requested to be good enough to impress your stamp on the opposite side, immediately after the receipt of the above work, to tear off this second half of the form, and return it, in acknowledgment of receipt, as a prepaid letter, *unsealed*.

The undersigned has received from the Central Physical Observatory of St. Petersburg, "Annals of the Central Physical Observatory, year 1870."

(Stamp of the receiver.)

Address (on back):—

To

The Central Physical
Observatory, &c. &c.,
St. Petersburg.

App., VII. 3.

Appendix 3. to the Protocol of the Seventh Meeting.

REPORT of SUB-COMMITTEE I. on QUESTIONS 2-6 (Thermometers and Hygrometers).

Thermometers,
p. 32.

Question 2.

Exposure.

What mode of exposure of Thermometers for the observation of Air Temperature is the best and most suitable for general adoption?

The Sub-Committee considers it impossible to lay down fixed rules and regulations for general adoption in the exposure of Thermometers, because regard must be had to local conditions, and the mode of exposure which is most to be recommended, in a space which is open and accessible to all winds, and at a height of $1\frac{1}{2}$ to 2 metres, cannot be used everywhere. As for the influence of height, M. Wild has carried on investigations at the request of the Leipzig Conference of the previous year, a special report of which will be furnished in a Supplement.‡ It appears from these investigations, which were conducted on an open scaffolding to a height of 80 feet, that if Thermometers are protected against radiation in the same way, the mean temperature is the same within an insignificant amount, and the difference of the results at various heights, at the same moment, amount on an average to less than $1^{\circ}8$ F.

* Adopted at the Eighth Meeting (p. 32).

† Adopted at the Seventh Meeting (p. 30).

‡ Supplement No. V. (p. 77).

Mr. Scott reports that investigations have been begun on the same subject App., VII. 3. at the Chinese pagoda in the Royal Gardens at Kew to a height of 120 English Thermometers, feet; the results will be published later, when a sufficient series of observations p. 32. is in existence.

At the request of the Leipzig Conference M. Wild has also instituted investigations on the best method of protecting thermometers against Radiation from the soil and from neighbouring objects, in order to obtain as closely as possible the true temperature of the air. The results will be given in the Supplement,* as will be also a Report from M. Cantoni on the mode of exposure of thermometers and hygrometers at some of the chief stations in Italy.† According to the observations of M. Wild, as appears from his Report, the so-called rotary thermometer (thermomètre fronde) is not to be recommended.

In these reports all the precautions which should be recommended for the exposure of thermometers are to be found. It would be desirable that investigations on the influence of height and exposure should still be carried on at the central or chief stations.

Question 3.

What is the best construction of Maximum and Minimum Thermometers?

Maximum and
Minimum
Thermometers,
p. 82.

A report has been received from M. Cantoni, on an apparatus constructed by M. U. Marchi, of which a specimen has been submitted, and which has been introduced at Florence and Pavia, with good results. It would be desirable if experiments with this instrument could still be carried on at other stations, and among other things it should be tested how far it would resist the shaking of carriage and other influences. Against Casella's minimum and Hermann and Pfister's metallic thermometer, the result of long experience is that these instruments are frequently deranged, and that therefore they cannot be recommended for stations in which they cannot properly be controlled and regulated. For minimum thermometers it is better to adopt Amyl-alcohol, instead of ordinary alcohol, because the boiling point of the former is 356° F.,‡ and therefore there is less fear of distillation. Finally, it should be recommended in all instructions for observers to add the rule:—*by continual comparisons of the indications of maximum and minimum thermometers with an ordinary thermometer placed beside it, to obtain a control on their uniform action, and the corrections which are to be applied to them.* As the Congress has fixed the end of the meteorological day at midnight, it is desirable that the maximum and minimum should be noted at the last observation of the evening, and entered on the day on which they are taken.

Observations
to be taken in
the evening.

Question 4.

What instruments should be employed for determining the intensity of Radiation, and in what way can the comparability of the results obtained be ensured?

Radiation,
pp. 32, 83, 87.

A report from Mr. Symons has been received on the instrument which has been used by many observers for several years in England, of which a copy is laid before us.§

According to this report we can obtain quite useful and comparable results of the intensity of Radiation, by the difference of temperature between this instrument when exposed to the sun, and a thermometer in the neighbourhood in the shade. On the other hand, it may be remarked that a thermometer contained in the exhausted envelope is exposed, not only to the direct action of the sun's rays, but also to the radiation of objects standing near and exposed to the sun, and, furthermore, that the air surrounding the apparatus may have a different temperature from that surrounding the thermometers in the shade. From the experiments that M. Soré conducted for several years at Geneva and other stations, and published in the "Archives des Sciences Physiques et Naturelles" it is proved that a very special and complicated arrangement must be adopted, if it be wished to obtain an accurate and

* Supplement No. V. (p. 77).

† Supplement No. VI. (p. 80).

‡ For 356° read $279^{\circ} 6$ F. (R. H. S.) The true boiling point is $279^{\circ} 6$ F. (Pierre.)

§ Supplement No. IX. (p. 87).

App., VII. 3. direct measurement of the Radiation, which shall be free from all other influences. Experiments on this subject are recommended to physicists and directors of the central and normal stations, but cannot as yet be brought into the sphere of regular observations.*

Question 5.

What apparatus is best for determining Earth Temperatures?

At what depths should the observations be taken in order to attain the uniformity which is desirable?

Reports on this subject have been received from Professor Bruhns and Director Wild, and are added in the Supplement.† From the experiments of Professor Bruhns it is clear that Lamont's method, with the use of a wooden tube, gives more trustworthy results than the thermometers with long tubes which reach into the ground, because in the latter the influence of the metal case affects the accuracy of the reduction. But on the average of the year the differences nearly compensate each other. From the same experiments it appears that the aspect in which the thermometers are sunk has a great influence, and so has also the nature of the soil, so that attention must be paid to these circumstances, in order to obtain comparable results.‡ Director Wild has begun experiments with a thermo-electric chain, and instituted comparisons with the results obtained by Lamont's method, but these experiments are not finished, and are being continued.

As to the second question, the depths at which the observations were made in Leipzig and St. Petersburg were not quite the same, and the greatest depth is not more than three metres. New experiments should therefore be recommended in other countries, in order to decide the question at what depths observations should be taken.

Question 6.

What apparatus should be employed for the determination of the Hygrometric Condition of the air?

Are the wet and dry bulb thermometers sufficient?

Can the Hair Hygrometer be employed, and under what restrictions?

Although the defects of the Dry and Wet Bulb Hygrometer are not to be denied, and it is most important to recommend to physicists experiments towards the discovery of new apparatus, and some other method for the determination of Humidity, yet that hygrometer cannot as yet be replaced by any other instrument. The use of hair hygrometers can only be made with safety, if their indications are constantly controlled by comparison with the psychrometer, and their corrections from time to time determined, especially near the point of saturation, where they often give too low readings. According to the experiments of Director Wild, the psychrometer gives very good results down to 0°, if only care be taken, as soon as the temperature falls to near 32°, to wet the bulb half an hour before the observation. As this operation can frequently not be carried out with the necessary care at stations of the second order, the experiments in Russia lead to the conclusion that the use of the hair hygrometer can be recommended under the former conditions, especially for low temperatures. Finally, experiments on the applicability of usual tables for hygrometric reductions in damp or in very dry air are very much to be recommended, and especially the experiments of M. Cantoni, according to which the production of an artificial movement of the air about the psychrometer brings its results into uniformity with those of the chemical method, whatever the degree of humidity may be: these should be repeated under other climatal conditions.§

Reporter, M. PLANTAMOUR.

* The Congress resolved at the Eighth Meeting (p. 32) that it would express its recognition of the services of Messrs. Symons and Stow, who, of their own accord and at their own expense, had instituted extensive series of observations, and had deduced valuable results therefrom.

† Supplement No. X. (p. 88). Prof. Wild's paper not given in German original.

‡ In regard to the influence of the nature of the soil, and especially to the amount of moisture in it M. Cantoni gives the results which have been obtained in the Po valley, in the plains which have been flooded for the purpose of rice cultivation, according to which in the summer months, temperatures at a depth of 5 c.m., remained constant during the daily and monthly periods. This must be attributed to the evaporation.

§ Adopted at the Eighth Meeting (p. 33).

Earth Temperature,
pp. 32, 88.

Humidity,
p. 33.

p. 84.

Appendix 1. to the Protocol of the Eighth Meeting.

REPORT of SUB-COMMITTEE VII. on QUESTION 28, respecting the carrying out of the Decisions of the Congress, and the completion and extension of the existing system of Observations.

App., VIII. 1.

Resolutions
of Congress,
p. 31.

It being considered self-evident that the delegates who are present here will consider themselves pledged to use their utmost efforts to induce their respective Governments to adopt the decisions and wishes of the Congress, the Sub-Committee makes the following further proposals:

- a. To express to the different Governments the wish that a new International Congress should be convoked in three years' time.
- b. In the meantime to determine on the appointment of a Permanent Committee.

The Committee should consist of seven members chosen by the present Congress, and should have the right of completing itself in case of the resignation of any members, and if judged expedient reinforcing itself by the addition of new members.* The president shall also be chosen by the present Congress.

The Committee will have the duty of taking care for the carrying out of the decisions of the Congress, and of arranging for the convening of a future Congress; and it shall, by continual communications, place the delegates of the present Congress in cognizance of its action and proceedings.

The Sub-Committee further recommends that the Congress shall indicate the following rules for the extension of meteorological knowledge as desirable and very useful:—

- a. The establishment of permanent stations of observation on high mountain tops, if possible, provided also if possible with self-registering apparatus.
- b. The institution of experiments on the possibility of making continuous Meteorological Observations with captive balloons.
- c. The institution of Meteorological Stations in the North Polar regions, the meteorological conditions of which are as yet either very slightly or not at all known, and in the first place at Spitzbergen.
- d. The institution of new supplementary stations on the north coast of Africa, as well as the regular publication of the observations which already exist on this coast.
- e. The more perfect organization of the stations in Turkey, and especially the central observatory at Constantinople, with regard to the advantage which is to be expected, both for science and navigation.
- f. The maintenance of the Meteorological Station at Athens, and the publication of its observations.†

Reporter, M. HOFFMEYER.

Appendix 2. to the Protocol of the Eighth Meeting.

REPORT of the EIGHTH SUB-COMMITTEE on the proposed Establishment of METEOROLOGICAL STATIONS in CHINA.

App., VIII. 2.

The Sub-Committee have read with great interest the documents which have been submitted to them by Mr. Campbell, on behalf of Mr. Hart, the Inspector-General of Customs for China, and they would commence their report by offering to the Chinese authorities their sincere congratulations on the public spirit and the desire to further physical science in every way which is evinced by the letters of Mr. Hart.

Many of the matters touched on by Mr. Hart are such as hardly require an authoritative opinion from the Congress, but it will be convenient to notice Nos. 2, 3, and 4 of the memorandum of March 11, 1873, taken in connexion with the views of the Astronomer Royal for England, also submitted to the Sub-Committee.

* Adopted at the Eighth Meeting (p. 31) in the following form:—"The Committee has the power to fill up the places of members who resign, and, if found expedient, to increase itself by the co-option of two members at most."

† Adopted at the Tenth Meeting (p. 36), with the modification that to section γ the following words were added:—"and also in high Southern Latitudes."

China, p. 33.

App., VIII. 2.
China, p. 33.

2. "Instruments to be procured to bring observations into accord with those of stations elsewhere established."

On the subject of *scales*, the Sub-Committee recommends the employment of the Metric scale and the Centigrade Thermometer.

They recommend the following supply of instruments for the ordinary stations, which should all be verified by competent authority:—

Barometers, Kew pattern, two in number, with a large Aneroid, to be used in case of emergency, when the mercurial barometers are out of order, &c. &c.

Thermometers, to be graduated on stem to $0^{\circ} \cdot 2$ C. to range from -30° to 60° , six in number, for fear of accidents, of which two will be used for the Hygrometer.

Maximum Thermometers, two in number, Negretti and Zambra's pattern.

Minimum Thermometers, two in number, Rutherford's pattern.

Furthermore, M. Jelinek recommends that a Hair Hygrometer (Saussure's), made by Hermann and Pfister, in Berne, should be provided for each station, to meet the difficulty of hygrometric registration with the Hygrometer at low temperatures.

Rain Gauge, Glaisher's pattern, and of the size recommended by the Congress* in case of all future orders.

Wind to be estimated, or the simple apparatus recommended by the Congress to be employed.

3. "Registers similar to those in which stations elsewhere record their observations."

It is hoped that the present Congress will recommend a form of register for general adoption.

4. Printing of observations, &c. &c.

As to the publication of data, the opinions of the present Congress will, it is hoped, be universally adopted, so that it is not necessary to dwell on this point.

The observations to be taken would be those which are expected from stations of the second order, where more than four observations a day are not obtainable.

They should refer to *Pressure, Temperature, Hygrometry, Rain, Wind, Cloud, and Weather*, with especial notice of extraordinary phenomena.

The special subject of Weather Telegraphy has been treated more fully in the memorandum of April 15th, 1873, but the Sub-Committee cannot, without a knowledge of the special requirements of the China seas, attempt to enter into details on this question.

The establishment of Weather Telegraphy in China cannot fail to be of the highest importance, and the experience to be obtained from Brigade-General Myer, of Washington, Mr. Blanford, Meteorological Reporter for Bengal at Calcutta, and Mr. C. Meldrum, Secretary of the Meteorological Society of the Mauritius, will probably be of considerable practical value.

The Sub-Committee are of opinion that the arrangement of the duties of such a system cannot be effected except by an officer specially charged with the direction of the entire system.

Such an officer is absolutely requisite, and he should be entirely independent of the proposed chair of Astronomy in the Peking College, as suggested in the memorandum of March 11th, 1873, already cited.

A considerable portion of his duty would consist in travelling about to establish and inspect his stations, and he would require, at least at first, the assistance of a skilled mechanic who could erect the instruments with his own hands at each station, and could effect certain slight repairs which are constantly requisite at Meteorological Stations.

The Sub-Committee consider that there should be four stations of the first order, of which *Shanghai* should be the chief. The others should be *Peking, Hankow, and Amoy*. These stations should have an outfit of the best instruments obtainable, and should perhaps have appliances for verifying instruments received from Europe.

It will, of course, be understood that as the stations must be established under the personal inspection of the officer to be charged with the control of the system, it will necessarily require some time before they can all be in operation.†

Reporter, ROBERT H. SCOTT.

* 14 ins. diameter (p. 52).

† Adopted at the Eighth Meeting (p. 33), with the modification that the employment of English Units of Scale (Inches and Fahrenheit Degrees) was declared admissible.

Appendix 1. to the Protocol of the Ninth Meeting.

App., IX. 1.

REPORT of SUB-COMMITTEE VI. on QUESTIONS 22-25 respecting ORGANIZATION.

Organization,
p. 36.

On Question 23—

Is it desirable that in each country there should be established one or more Central Institutions for the direction, collection, and publication of the Meteorological Observations?

A discussion took place and a decision was adopted at the Leipzig Conference.

The Sub-Committee proposes that the first portion of the Leipzig Report should be adopted, but that the second portion should be handed over to the Sub-Committee for Maritime Meteorology for a report. As a resolution on this question it is therefore proposed:—

- 1°. The Congress considers it necessary that in every country at least one, but in case of necessity several, Central Institutions, should be established for the management, collection, and publication of Meteorological Observations.

On this occasion the Sub-Committee considers it necessary, in order to determine the ideas, to propose the following definitions of the various classes of meteorological observing stations:—

- Central Office*, or *Central Institute* is the chief office entrusted by the Government with the management, collection, and publication of the Meteorological Observations of the country.
- Central Station* is a subordinate centre for the management and collection of observations from a certain province.
- A Station of the First Order* is an observatory in which, without the collection of observations from other stations, Meteorological Observations are conducted on a great scale, i.e., either by hourly readings or by the use of self-recording instruments.
- Stations of the Second Order* are the stations where complete and regular observations on the usual meteorological elements, viz., Pressure, Temperature, and Humidity of the air, Wind, Cloud, Rain and Hydrometeors, &c., are conducted.
- Stations of the Third Order*, finally, are the observing stations, where only a greater or less portion of these elements are observed.

In reply to the first part of Question 24—

Can rules universally applicable be laid down for the Verification of Instruments and the Inspection of Meteorological Stations?

The Sub-Committee makes the following proposal:—

- 2°. The Congress considers the careful verification of all the instruments which are to be distributed to the Meteorological Stations, as well as the inspection of stations of the first and second order to be necessary, and the latter should take place if possible yearly, but at least once in the course of every five years.

As to the method of the regular inspection of Scotch Meteorological Stations, Mr. Buchan has submitted a report which is appended to this report, and which is printed in the Supplement,* but the Sub-Committee does not think it possible to institute rules of general applicability on this question, and therefore only proposes the following resolution on the subject:—

- 3°. The mode of verification of the instruments and of regular inspection is left to the decision of the Central Offices, and the Congress only expresses the wish that with regard to the instrumental errors which are thereby detected, corrected results only should be published, but that the amount of the corrections which have been applied should be given.

App., IX. 1.

To the second part of Question 24—

Organization.

And is it advisable to introduce general instructions for taking and calculating* Meteorological Observations?

General

Instructions.

p. 36.

the Committee proposes as a reply:

4. The Congress recommends the Permanent Committee, if possible by April 1874, to prepare Instructions for the institution and discussion of Meteorological Observations, to distribute them then in separate copies to all members of the Congress, and subsequently, if possible, after paying all possible attention to the remarks which have been received, to proceed, at the latest in June, to edit and publish them definitively.

Question 25 runs:—

In what manner can the agreement of the Standard Instruments of the different central establishments be best effected?

Standard
Barometers.

p. 36.

The Sub-Committee is of opinion that this question only refers to Standard Barometers and Standard Thermometers.

As far as concerns Standard Barometers the Sub-Committee considers the usual comparison of various standard barometers by travelling instruments as quite insufficient, and propose therefore:—

5. The Congress recommends all central offices to adopt real standard barometers, *i.e.*, instruments which allow of the determination of atmospheric pressure according to its definition in absolute measure. The Permanent Committee is commissioned to determine the conditions which such an instrument should fulfil.*

Standard
Thermometers.

p. 36.

With regard to the Standard Thermometers, the Sub-Committee considers the following rule as the best:—

6. The Congress recommends all central offices to forward all the Kew Standard Thermometers, which they either already possess, or will presently procure, to a gentleman to be indicated by the Permanent Committee, who shall be entrusted by it with the careful comparison of all these with each other, and, if possible, also with the Air Thermometer.

The Kew Committee, according to the statement of Mr. Scott, will always be ready to furnish Standard Thermometers to Central Offices.†

Reporter, H. WILD.

App., IX. 2.

Appendix 2. to the Protocol of the Ninth Meeting.

REPORT OF SUB-COMMITTEE V. ON MARITIME METEOROLOGY.

Question No. 22 runs:—

In what way can Maritime Meteorology be best introduced into the system of General Meteorology?

Marine
Meteorology,

p. 36.

The Chairman of the Committee, M. Buys Ballot, suggests the following proposals for discussion:—

- 1st. The Sub-Committee declares it to be very desirable that each country should, if possible, collect all its meteorological observations at one place, in order to undertake the organization of the investigations at the same place. The Institute should be established as near as possible to the sea.

* Adopted at the Tenth Meeting (p. 36), with the modification that at the same time the comparison by means of good portable barometers should not be rejected, and that the Permanent Committee be instructed to investigate the best manner in which the comparison of the Standard barometers at the several Central Offices can be effected.

† Adopted at the Tenth Meeting (p. 36), with the following modification:—"The Congress considers it to be the business of each Central Office to prepare a Standard thermometer for itself on scientific principles, and it recommends all Central Offices, &c."

At the same time it was resolved to request Mr. Scott to convey to the Kew Committee the thanks of the Congress for their readiness to furnish standard thermometers to the individual Central Offices.

- 2nd. The Sub-Committee is of opinion that the Institute for Maritime Meteorology, named in the first proposition, might best be placed under the general management of the Chief Institute of the country.

App., IX. 2.
Maritime
Meteorology,
p. 36.

These two proposals were adopted unanimously. Whereupon a lengthened discussion took place on the third question.

3rd. In what way should this Maritime Institute work?

The Sub-Committee is of opinion that the resolutions of the Leipzig Conference on the subject of Maritime Meteorology should be upheld.

The proposals in question of the Leipzig Conference run as follows:—

"1st. Thorough uniformity in methods and instruments should be aimed at in the same measure as for observations on shore. This will be most satisfactorily attained by the chiefs of the central institutes—the establishment of which in all countries, in which they do not already exist, and in which the maritime interests demand them, must be declared as absolutely necessary—entering into relations with each other and agreeing on the separate details, the construction of the instruments, the hours of observation, the journal, &c."

"2nd. Unity of measures and scales is desirable, and to this end the introduction of millimètres for the barometer and the centigrade scale for the thermometer should be aimed at. While, however, the comparison of standard instruments of the individual central stations must be insisted on, the uniformity of scales is at present only declared as desirable.

"3rd. The committee would urge the importance of the co-operation of the navies, inasmuch as by their assistance, and by the opportunities afforded thereby of completeness in certain observations, the determination of factors and constants is rendered possible, which can be used with advantage for the reduction of certain results derived from the general system of observations.

"4th. With reference to the utilisation of the results, the committee would urge similarly the importance of uniformity in the methods employed. In close relation therewith was the carrying out of the division of labour of the central stations of the individual states. This principle must be recognized as of the greatest importance for the further development of Marine Meteorology. The repetition of work over definite regions, with reference to the area to be investigated, must be declared as indefensible in the interests of this development."

Mr. Scott repeats the statement already made at the Leipzig Conference that the Meteorological Office in London would not be in a position to undertake the copying of observations *gratis*.

Finally the Sub-Committee adopts the proposal of M. Neumayer in the following words:

In consideration of the fact that it will not be possible to devote to Maritime Meteorology at the present Congress a comprehensive consideration, corresponding to its importance, but, on the other hand, as it seems that a mutual understanding of the individual maritime nations in regard thereto is necessary, the Meteorological Congress declares that the convening of a Maritime Meteorological Conference is desirable.

The preparation for this Conference is to be entrusted to a Sub-Committee, to be named by the Congress.*

Reporter, R. H. SCOTT.

Appendix 3. to the Protocol of the Ninth Meeting.

REPORT OF SUB-COMMITTEE V. ON WEATHER TELEGRAPHY and STORM WARNINGS.

The Sub-Committee has adopted as a basis of its discussion the six questions which have been proposed by MM. Buys Ballot, Neumayer, and Scott, who

* Adopted at the Tenth Meeting (p. 37), with the modification that the Permanent Committee was entrusted with the measures for the preparation of the Marine Conference.

had been entrusted by the Leipzig Conference with the duty of discussing the question of the practicability and utility of weather telegrams and of storm prognosis, and it has arrived at the following results:—

Question 1:—

What are your opinions in respect of the action of the systems of Storm Signals hitherto in use, either from your own experience, or from a consideration of the Bulletins published in the United States, in England, and in France?

It is sufficiently evident, from the various answers of the scientific men who have been asked for their opinion, as well as from the other official and non-official reports of the individual Directors of Meteorological Institutes, that there is a general conviction of the importance of Weather Telegraphy for the purposes of practical life, and that the existence of such a system is considered a necessity. This is shown from the results obtained hitherto from the systems already in existence.

The Sub-Committee therefore expresses its opinion in the following words:—

It seems desirable that the system of Weather Telegraphy should be developed as generally as possible, and on as uniform a plan as possible. In all countries in which up to the present time such systems have not been organized, steps leading to such an organisation should be taken as soon as possible.

The Sub-Committee is further of opinion that it would be desirable to institute this organization on the following principles:—

1. The systems of observation which are already organized or to be organized in the various countries should be in as close relation to each other as possible, and this is of importance, not only with reference to the general arrangement, but also especially with reference to the telegraphic communications.
 2. The system of each country must have a Central Office, which, if possible, should be combined with the central office for Maritime Meteorology but, in any case, like the latter, must be subordinate to the Central Institute in each country. The observing stations belonging to the system should be placed under the central office for Weather Telegraphy and Storm Warnings, and their officers must be always ready to send to this Central Office weather reports, or to answer its inquiries for information.
 3. The observers at the stations belonging to the system must be well instructed, for the purposes of Weather Telegraphy.
 4. The choice of a locality as a station for Telegraphic Weather Reports must be made with consideration to all local circumstances and requirements, and with especial reference to the Wind; furthermore, with reference to the series of observations which have already been recorded and reduced for the station, and with reference to the general system. Regard must also be had for the interests of the adjacent systems. But the final decision must always rest in the hands of the respective directors.
 5. In order to make the system of warnings as perfect as possible, according to the present state of the Science, the Sub-Committee must indicate that it is desirable that the observations and reports based thereon should be made as complete and continuous (as regards the former) as is possible, i.e. neither Sundays nor holidays should make a difference to them, and there should not be a complete interruption during the night.
 6. Representations should be made to the respective Governments to facilitate Weather Telegraphy as much as possible. This is of importance, not only with reference to the expense, but also with reference to time, in respect of the telegrams within each system, and from one central office to another. If Telegraphic Weather Reports are delayed from the consideration of other despatches, the operation of the system will, in the opinion of the Sub-Committee, be seriously interfered with.
- It is desirable, in order to carry the arrangements which are required according to the above views, that the respective Governments in granting a

concession to a private telegraph company should take care that most thorough concession should be paid to the interests of Weather Telegraphy.

Question 2—

Is it your opinion that in addition to communications of the Direction and Force of the Wind which is actually blowing, the Barometrical "Gradients" should be given, in order to give warning of approaching wind?

To what should these Gradients be referred? Viz.:

A—To the differences between the actual readings at the different stations.

B—To 30 ins., at sea level.

C—To the mean normal heights of the barometer at the stations taken into consideration.

With reference to this question the Sub-Committee is of opinion that besides communications of the Direction and Force of the Wind, the Barometric Gradients at the time of observation should also be added, in order to give warning of the wind which is coming.

Although the concordance of opinion within the Sub-Committee, with respect to the first part of the question, is great, this cannot be asserted with reference to the second part, inasmuch as the opinions of the scientific men who have been consulted are partly for the mode of reduction given under B, and partly for that given under C.

However the various opinions within the Sub-Committee have been brought to agreement on this point, that for stations which are not above 300 metres above the sea, the reduction of the barometer readings to the Mean Sea-Level will be admissible. This agreement was attained with special reference to the drawing of isobars for the purposes of Storm Warnings, and in recognition of the theoretical difficulty of carrying out this method of reduction for elevations greater than those named.

Question 3—

In what way should we take into consideration Temperature, Vapour, &c., &c.?

With regard to Temperature and Moisture, as well as with regard to Cloud, Appearance of the Sky, State of the Sea and Tides, and Precipitation, it was recommended by most of the gentlemen consulted that some attention should be paid to these subjects; but in what way attention should be paid has not been indicated by any of them; therefore the Sub-Committee is of opinion that this question should be considered as not answered, and it therefore recommends its examination most specially to the notice of scientific men who occupy themselves with the study of storms and their causes, and draws attention to the investigations in this direction by Dove, Mohn, Rev. Clement Ley, Peslin, Buchan, and Reye.

Question 4—

If we assume that each Director will institute the proper arrangements in his own district, what do you recommend as a minimum that each Director should communicate to the Director of another district, and should receive from him in return?

The answers to this question must be considered as a *resumé* to those given to Questions 2 and 3, and they have frequent reference to communications within one and the same system, but not to the mutual communications between the directors of the individual systems. The Sub-Committee is of opinion that a distinction should be drawn between the theoretical and practical treatment of the question. For theoretical investigations all the elements are requisite and they should all be taken into consideration, but this can take place at any subsequent period. For practical purposes, with regard to which each director must consider the special requirements in his own country, they must be confined to a minimum.

It is sufficient that each director of a district should receive from his neighbour, as a minimum of what is to be communicated, the following elements:—

Wind, according to Direction and Force, Pressure (including the Pressure for the evening of the previous day); Air-Temperature, Humidity, amount of Rain, Cloud, Weather, Sea, and when atmospheric disturbances are approaching, the magnitude and direction of the most important and most recent Gradient.

The Sub-Committee is further of opinion that these data should all be sent reduced, in order that a more rapid treatment of the materials should be rendered possible.

It must be left to the individual directors to determine among themselves the arrangements of a more special nature. This has special reference to the magnitude of the gradient which should be considered as an indication of atmospheric disturbance.

Whenever the International Institution, which is considered as very desirable by the Congress, is called into existence, all the evening observations should be sent to it, in order that a general view of the conditions of the weather of the whole of Europe can be given early in the morning to the individual systems.

Question 5—

Are you of opinion that the present condition of our weather knowledge justifies us in issuing distinct prophecies or forecasts of weather in contradistinction to the simple Telegraphic communication of facts, or should we confine ourselves to indications of the condition of the atmosphere in adjacent countries, from which the recipients of the Report must draw their own conclusions? In the latter case should we communicate the general conditions by Signals visible from a distance, posting up, at the place itself, the detailed information received from other localities?

Question 6—

In what way can it be arranged that intelligence of the conditions of weather can be conveyed to ships at sea, by means of Semaphores or by Signals from Lighthouses?

From an analysis of the various opinions on the practicability of storm-warnings which have been received, it appears that the great majority have declared for Storm-Warnings.

If we give to the opinions of individual societies, as well as to those of prominent authorities on the subject of Storm-Warnings, a weight = 10, to the other practised investigators of this subject a weight = 5, while less experienced men receive a weight of 1 or 2, the result is as follows:—

For Storm-Warnings of a more or less detailed and decided character, but certainly above the simple communication of facts, we find 72 votes. Against Storm-Warnings, and for restriction to a communication of facts, only 24 votes.

The majority of the opinions which have been received tends to the view that these warnings should be given in connexion with communications of facts, only a few hold these communications as quite unnecessary, while other and important voices are only for communication of facts without warnings; but it must be kept in mind that almost all the opinions expressed refer to the north and north-west of Europe, and are only in the first place to be understood as applicable to these districts; in fact the limits should be drawn even more narrowly, it being only the coasts of the districts described which are meant.

On these grounds the Sub-Committee expresses its opinion that Telegraphic Weather Reports have become a necessity, as has been proved by the answers to the first question, and furthermore that the results of the systems which have been or are to be organized for this purpose, can and must be utilised by the communication of simple facts of weather, with such developments, in the sense of storm-warnings, as may be justifiable by the further development of our knowledge of atmospheric disturbances.* The results which have been

* This sentence differs from the German original, Dr. Neumayer having pointed out a misprint in the latter, which made the sense unintelligible. The present version is submitted by Dr. Neumayer.—Trans.

obtained empirically, and by the statistics of weather knowledge, can be utilised for the benefit of navigation and agriculture, &c.

In the present condition of the development of weather prognosis, the matter of most importance is to define as accurately as possible, the character of that which comes under the head of communication of facts. Among all the opinions which are submitted there is not a single one which does not reject for weather prognosis the title of *prophecies* or *predictions*. The most decided protest is lodged by everyone against the idea of infallibility being implied in this use of such a term. All that is said, is, that "an opinion should be given on the weather to be expected,—or probability of the approach of a storm should be given—or possibility of prediction of wind, direction and force, &c."

In the opinion of the Sub-Committee, a considerable difficulty in the practice of storm warnings consists in the careful avoidance of too special indication of probable wind and weather. The objection which is made by several of the gentlemen whose opinion was asked, that the reports would be discredited, owing to non-fulfilment of the "prophecies," loses its force if only such atmospheric disturbances are communicated, as will probably be accompanied by serious results. Accordingly warnings by signals should not be issued for winds of forces 5 to 7 of Beaufort's scale, but above those numbers. Such warnings would meet with fulfilment with incomparably greater certainty. On the other hand, according to the experience which has yet been made, only few dangerous phenomena would escape notice. A general rule for storm gradients cannot be given, as many of them will be of a local nature; the director must therefore gradually form his opinion on this question, according to his experience, so that in the opinion of the Sub-Committee it appears desirable that actual storm warnings should not be attempted in newly organized systems immediately after the establishment of the system, but that the director should first gain for himself the experience necessary for the purpose.

If we were in a position to give from time to time, by means of signals, the accurate definition of the communications on conditions of weather, and on the indications of coming weather, the greatest portion of the difficulty would be removed; still we must endeavour to meet this difficulty by notices posted up on flagstaffs, containing explanations of the weather, and the opinion of the director thereon, which must somehow or other be more widely communicated.

This, however, can only have reference to communications in harbours, while for ships passing at a distance, and at sea, means must yet be found to give them an explanation of the signals.

In consideration of all these circumstances, and on the supposition that the conditions indicated in the answers to Question 1, will be strictly fulfilled, the Sub-Committee expresses its views on this very difficult question in the following words:—

1. Communications on the state of the weather should be given by telegraph by the central office to the public daily, and, wherever possible, twice a day, in the first place with reference to the objects of practical life, and especially of navigation.

These communications should be distributed as widely and as rapidly as possible by publication in the newspapers, or by synoptic charts, &c., with opinions on the conditions of the weather. The extent of these communications must be regulated by the means at the disposal of each system, and therefore nothing determinate can be settled on the question.

In case of disturbances in the atmosphere which are expected or have already commenced, telegrams should go to the signal stations, harbour-masters, &c., and rapid distribution must be afforded to them.

2. With reference to these latter telegrams—in cases of atmospheric disturbances—the following distinction may be drawn, according to the opinion of the Sub-Committee.

a. If they are intended for ships lying in larger harbours, in order to afford their captains the opportunity of forming an opinion of a disturbance which is expected, and perhaps has already commenced to be developed, it is possible by a suitable apparatus, perhaps by the *aeroclinoscope* in a somewhat altered form, to bring to the knowledge of the public the

conditions of pressure, motion of the wind, &c. Moreover, the receipt of the information must also be announced at the signal stations, and at the open spaces of the harbour, in forms prepared for it, and must be posted up.

While the public thus interested obtains an idea of the progress of the disturbance not only at the locality itself, captains, from the movements of their own instruments on board, and from comparison with the telegrams, can form for themselves an opinion on the state of affairs.

- b. If such telegrams are intended for harbours for small shipping, fishing, &c., in which case meteorological instruments cannot be supposed to be in the hands of the receivers, any more than a complete comprehension of the rules according to which the disturbances take their course, the apparatus mentioned above can be of little use.

Explanatory notices from the central office, posted up, are therefore above all things necessary, while that office has also to take care that at any very little port of this kind, a barometer and a thermometer are erected at easily accessible places.

3. In consideration of the circumstance that we cannot pre-suppose in the receivers of the communications the degree of meteorological knowledge which is requisite for drawing correct conclusions from the conditions of wind and weather, and from the movement of the meteorological instruments; and, moreover, that these receivers necessarily cannot come into possession of the requisite information until many hours later than the central office,—and inasmuch as the rapid progress of the development of a disturbance hardly leaves them any time for independent prognosis,—and in further consideration that our knowledge, being gained in an empirical way, puts us in a position of being able to foresee for certain districts the course of the atmospheric disturbance, the Sub-Committee is of opinion that the Director of the Central Office should give his opinion on this probable course of atmospheric disturbances which are expected, or have already commenced, not in the form of a prophecy, but in the form of *probabilities*. This opinion must be brought to the knowledge of the public by the Director in question, according to his own circumstances, by the printing and posting up of notices.

It is only when from the conditions of pressure, serious storms of 7-8, according to Beaufort's scale and upwards, are to be expected, according to the opinion of the Sub-Committee, that the views of the directors of the central offices on the direction, course, and force of the storm should be announced by signal apparatus on prominent points of the coast and in harbours and roadsteads.

The Sub-Committee is further of opinion that complicated apparatus cannot be recommended for this object, and proposes, therefore, the use of the drum and cone by day, and the corresponding signal lanterns by night, and recognizes that an expansion of this system of signals, as by the addition of a truncated cone, will be desirable; but under any circumstances the warning signals must be International.

4. In order to insure for these Storm Warnings, which are a benefit for shipping, as great effectiveness as possible, and to avoid misunderstanding, the Sub-Committee considers that the issue of explanations for the comprehension of the signals is very desirable. These explanations should contain, in a series of propositions, explanations of the signals and their meanings for various cases serving as illustrative examples, which propositions can be applied to the several signals in some manner which has yet to be determined.

The Sub-Committee is of opinion that while some such course of action would afford protection against misapprehension and discredit of the warnings issued, the public will gradually be educated by it to a clear comprehension of the reality and meaning of weather prognosis.

6.* Such an explanation cannot, according to the nature of the case, be the same for all coasts and waters, and must, therefore, be prepared in consideration of that, but should certainly be international and added to every Code of Signals.

7.* Finally the Sub-Committee requests the Congress to express its opinion

* So in original; No. 5 is omitted.

that on the part of the respective Governments, action should be taken to perfect as far as possible the storm-signal system, especially the apparatus and the explanations for the comprehension of the signals, and that special investigations and inquiries which are calculated to promote the signal system should be most warmly supported.*

Reporter, M. NEUMAYER.

According to a resolution of the Congress at the eleventh meeting on the 16th September 1873, the following proposal of M. Hoffmeyer is to be introduced into the foregoing report of the Sub-Committee.

As it is, in my opinion, of the greatest importance to be able to give the daily meteorological communications as early in the morning as possible, I permit myself to draw the attention of the Congress to the question whether it would not be desirable that these communications should be principally based on the observations of the previous evening. If a well-constituted central institute could receive telegraphic despatches every evening from a sufficiently large number of European stations, in order to be able to deduce from them a *resumé* of the general meteorological conditions, these *resumés* could be communicated to the respective national systems during the night, or else very early in the morning, in order to be utilised in communication with the despatches of the individual stations received in the morning.

The special national systems would, therefore, not only obtain a better and more complete grasp of the circumstances, and of the changes of the great barometric maxima and minima, but by such a centralisation of evening observations, it would be possible to content ourselves in each individual system with morning telegrams from a more limited area than at present, when almost every meteorological institute is compelled gradually to extend its meteorological network on all sides, far over the frontiers of its own country, in order to obtain the requisite knowledge of the weather conditions. The telegrams from foreign and distant stations arrive so irregularly and so late, that the daily weather summaries, as well as the storm warnings, cannot be published before noon, or even later, while they could be ready at least two hours earlier if they depended only on the telegrams of a smaller area.

* Adopted at the Eleventh Meeting (p. 38).

SUPPLEMENT.

I.

Suppl. I.

Prof. Wolf.

EXTRACT from a CIRCULAR addressed by PROFESSOR RUDOLF WOLF to the OBSERVERS of the METEOROLOGICAL STATIONS in SWITZERLAND, 12th July 1873.

I HAVE used the opportunity of the meeting of the Geodetical Commission, on the 11th May 1873, which brought me into contact with Professors Plantamour and Hirsch, to prepare a few important notes for a programme for the Swiss delegate at the Congress at Vienna.

We agreed upon the following points:—

International stations.

1. That he should urge that Switzerland, in consequence of its character, should have more international stations than would be allowed to it according to its superficial extent; as a minimum, five stations, in which, in the first rank, St. Bernard and Geneva; next Chaumont: then, for northern Switzerland, Zürich or Basle, and, finally, for southern Switzerland, Castasegna or Lugano. These stations, if adopted into an international réseau, will form the normal stations of the country, to which, as required, a larger or smaller number of secondary stations will be added. The former should be inspected yearly; the latter at least every two years, by the Central Office of the country.

Instruments.

2. That he should maintain the view that, in general, even for the normal stations, the outfit which has hitherto been usual for the Swiss stations—Barometer, Thermometer, Psychrometer (if possible, with the addition of a Hair Hygrometer for times when the last-named instrument is out of action), and a Rain Gauge—should be sufficient, and that the only addition should be that of a Robinson's Anemometer to the wind vane for the determination of the force of the wind. On the other hand, he should energetically maintain that on the Barometer scale only millimètres, and on the Thermometer scale only Centigrade (at all events no Reaumur) degrees should be admitted.

Hours of observation.

3. He should stand out for the proposition that, for the normal stations, the hours of observation which are usual in the country (thus, for Switzerland, 7h, 1h, 9h) may be maintained; but that, on the other hand, whether by two-hourly observations or by self-recording apparatus, the elements of reduction must be determined for each country, in order to be able to deduce the true Daily Mean from the mean of the observations. Switzerland has now in Geneva, on the St. Bernard, and on the Simplon, two-hourly observations; in Berne and Zürich complete self-recording apparatus, from which the former are already taken, but the latter at the present date are still in want of the necessary working power. If the International Congress, as possibly may be proposed, should determine to supply at common cost, at a few such mountain points, self-recording apparatus, the Swiss representative has to take measures that, if possible, Switzerland should also obtain such an apparatus, whether it be for an isolated point, as the Rigi Kulm or the Faulhorn, or a high pass like St. Bernard, or even St. Theodule. It is specially desirable, for the measurement of Rain, that it, at least at the central stations, should be taken not only at one hour of observation (1 o'clock), but at every hour, and that the greatest care should be devoted to the determination of the duration of the fall.

Means.

4. He should propose that, for the calculation of the Daily Means, the beginning of the day should be set at midnight, but, for the calculation of the daily fall of Rain, should be set at the noon observing hour. For the calculation of Five-day Means 73 means should be maintained, in opposition to 72, which are also proposed. For the calculation of Seasonal and Annual Means from the Monthly Means, regard must be had to the length of the month. For the commencement of Five-day Means, the beginning of the civil year is to be

recommended; for the commencement of the Seasonal and Yearly Means, December; but if a general uniformity of commencement should be demanded, it might be voted that it should be postponed to the beginning of March.

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5. He should co-operate in preparing a general scheme for publication for all normal stations. For secondary stations every country retains its own freedom of publication, but the wish should be expressed that in general a form which approaches as nearly as possible that of the normal stations should be chosen.

6. Finally, he should vote for the establishment of an International Central Institute (for instance, in Utrecht), on the idea that each country, in proportion to its population, should bear a share of the cost of the expenses arising from it. It is probable that a sub-committee must be appointed for the discussion of the special arrangements of this Central Institute.

International
Institute.

II.

LETTER from PROFESSOR E. PLANTAMOUR to DIRECTOR C. JELINEK, in VIENNA.

Suppl. II.

Prof.

Plantamour.

International

Institute.

pp. 9, 27, 50.

Geneva, August 8, 1873.

I TAKE the liberty to make a proposal to you and the managing committee named in Leipzig, on the order of business, and on the sequence in which the various questions should be taken into consideration by the Congress which is in prospect. The chief object of the Congress is, without doubt, the foundation of an International Central Institute, in which the data which have reference to *Comparative Meteorology*, and which are forwarded from the stations in the various countries, should be collected, sifted (where necessary, converted to the same scale), and published. On this account, it appears to me that the questions which refer to the foundation of such an Institute, and the responsibilities which will fall upon it, should be submitted to the Congress first and before all other subjects.

It can scarcely be doubted that the establishment of a Central Institute will be unanimously voted by the Congress, and there will be no difficulty in coming to an agreement with regard to its title. If, moreover, the task which is laid on the Institute by the Congress should be confined to *Comparative Meteorology*, omitting all questions which have a special local interest, the data which are to be sent in by any one station may be collected into a very small series of numerical values. It is clear that the Central Institute cannot undertake the detailed publication of all the records and observations which form the bases of these data, partly on account of their unmanageable extent, and partly because the objects would be missed, inasmuch as a general view of this ocean of figures would be perfectly impossible.

The demands which should be made to each station for the requirements of *Comparative Meteorology* would be as follows:—

1. The deviation of the 24 hourly means from the normal values (deduced from many years' means) for Pressure, Temperature, Vapour Tension, Humidity, Wind Direction and Force, Amount of Cloud, Precipitation (quantity and duration). These data might be furnished in the scale or unit of measure which is used in each country, and should be converted at the Central Institute into the units of measure which are adopted by the Congress for publication. In this way one of the most difficult questions, which occupied much time at the Leipzig Conference without being settled, and on which the Vienna Congress will perhaps fail to arrive at a conclusion, may, so to speak, be set aside; at least it would receive quite another meaning, and agreement might easier be expected. If the question which is proposed for the Congress to be discussed at first has reference to the scales or units of measure which are to be adopted, and this question should be so interpreted that every country should have to adopt for the entry of meteorological observations the units fixed by the majority of the Congress (a step which naturally requires a change of all the scales of the instruments wherever a different unit has been used, and brings with it, for data of local interest, a breach of the habits of many years), I fear that an agreement on this question will scarcely be obtained.

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If, however, it remains open to every country to hold to the units to which it is accustomed, it will be much easier to come to an agreement on the unit for publication which is adopted by the Central Institution. It is evident that the same unit should be adopted for all stations, and also that the labour which is imposed on the Central Institution will be lessened if that unit is adopted in which the materials sent in from the majority of stations are expressed. This labour would, however, not be too great if we had regard to the comparatively small number of values which would have to be recalculated, and to the means which would have to be placed at the disposal of the Central Institute. The publications of the Utrecht Institute, which are so valuable, and which have been continued for so many years, and which in many respects might serve as a pattern, are a proof of this. But as in any case it would be necessary to effect a copy for the monthly tables, which must be prepared for printing, a conversion into another unit, when properly copious tables are used, would scarcely take a longer time. Further, I think it should be left open to the meteorologists of every country, or to the Central Stations or Institutes which already exist, to retain the system of meteorological observations which they have adopted, whether it be based on self-registering apparatus, or on direct hourly, two-hourly, or three-hourly readings of the instruments, provided that the system is sufficient to show with requisite accuracy in how far each day differs from the normal circumstances at the same epoch of the year, with respect to Pressure, Temperature, Vapour Tension, and Humidity. The wish to introduce absolute uniformity into the observing system at all stations, in all countries, would be extremely difficult, if not impossible, to be carried out, and the following objection could not be overcome, that at certain stations the normal values are calculated from a long series of years, while in others meteorological observations have only been a few years in existence. The greater the independence which is allowed to the local committees, the easier will an understanding be arrived at. At all events, one should not look for absolute completeness in the first publications of the International Institute as far as concerns the uniformity of the data of the various stations. Nevertheless, they would be in a position to give very important information on the subject of Comparative Meteorology; and, besides, we may safely expect that gradual progress will be made towards completeness.

2. In case of unusually great disturbances, of which only few occur in the year, each station should have to furnish, for the few days in question, the hourly deviations from the normal values, in order that the Central Institute should be in a position to follow the course of the disturbance by a comparison of the deviations which take place at the same absolute moment.

3. Lastly, each station should send in the mean values, which are to be used for the calculation of the deviations, in any unit of scale which may be preferred, and it should be converted into the adopted unit by the Central Institute and published. Of course this publication cannot be made at the same time for all stations, but must take place gradually, and for this a comparatively very small number of data are sufficient, no matter how large the number of observations on which they are based may be, whether one is content with publishing the formulæ of daily and yearly values, or gives the mean values for a sufficiently large number of epochs, separated by equal intervals.

I believe that the order which I propose for the sequence of the questions laid before Congress would materially contribute to shorten the debates, and would ensure for many of them a satisfactory result, which might otherwise meet with serious obstacles.

III.

LETTER from M. ANTONIO AGUILAR Y VELA, Director of the Astronomical and Meteorological Observatory of Madrid, to the PRESIDENT of the METEOROLOGICAL CONGRESS of VIENNA.

Madrid, 1st September 1873.

WHILE staying at Vienna, as a Juror for the Exhibition, I had the honour of explaining in detail to M. Jelinek my opinion on the different

points which should be discussed by the learned body of meteorologists assembled in the capital of Austria. I have requested M. Jelinek, who knows my opinions, to represent me at the Congress, as I found it impossible for me to attend it, for reasons which you will perfectly understand, which do not allow me to be absent from the Observatory so long, having been obliged to remain at Vienna six weeks on account of the Exhibition.

I shall confine myself therefore in this letter to condensing my opinions into a very few words, which can be developed by the Director of the Meteorological Observatory of Vienna.

Question 1.* In my opinion this question is completely answered, since the International Geodetical Congress has decided upon the adoption of the decimal Metric system for all nations.

2. The Observatories should all have a mercurial Barometer.

3. This question is very complicated and very difficult to settle definitively. The experiments which doubtless will have been made since the meeting at Leipzig in 1872 will throw much light on the best method of placing the thermometers. At the Madrid Observatory they are in an open space, far from buildings, under a revolving pent-house roof, and protected on all sides from the sun's rays by means of louver-screens.

4. The maxima and minima thermometers by Casella of London give us excellent results, care being taken, however, to compare them from time to time with the standard thermometer.

5. For the daily observations of Radiation we use the black-bulb maximum thermometer in vacuo, and minimum thermometers placed on the ground and in a parabolic reflector.

6. At the Madrid Observatory we have five thermometers, placed at depths of 2 ft., 3.9 ft., 5.9 ft., 9.8 ft., and 12.2 ft. I am not acquainted with the management of Becquerel's thermometer.

7. The psychrometer in preference to the hair-hygrometer. In Spain we have less than anywhere else to fear from the irregularities of the psychrometer, when the temperature sinks below zero, because that rarely occurs.

8. In Observatories which have apparatus to record observations in a continuous manner the matter is very simple, but for stations of the second order the eight principal points are sufficient.

9. Our stations of the second order use only the scale 0-4. 0 indicates Calm, and 4 a violent wind.

10. We have begun to introduce Robinson's anemometer with the metric scale at our stations of the second order, for determining the velocity of the wind.

11. At the Madrid Observatory this observation is made every three hours at the same time as the others. At stations of the second order it is made at 9 o'clock in the morning.

12. Without doubt days of Rain and Snow should be distinguished, and the quantity of water which falls under these two forms.

13. It would be desirable to do so, but very difficult to obtain it at stations of the second order.

14. Days of thunderstorm must be distinguished from the number of storms, and account must be taken of sheet-lightning, but these observations also are very difficult at stations of the second order.

15. Evaporation should be observed in a vessel exposed to the free air and to the sun, placed in identical conditions at all Observatories, according to the decisions of the Congress.

16. The amount of cloud should be estimated by the scale 0-10. 0 indicates clear sky and 10 overcast.

17. It is very difficult to introduce everywhere electrical observations, as they require altogether special conditions in the Observatories. It would be very useful if they could be instituted at central Observatories.

18. It is very difficult to satisfy this want without having self-recording instruments, owing to the very inconvenient hours which would result, especially for western countries.

* The numbers of the questions refer here to the programme settled by the Meteorological Conference of Leipzig.

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19. Very desirable, and inspection is necessary in order that the observations may be subjected to the check which is indispensable. My opinion is that the observations should be few in number, but that all measures possible should be adopted to ensure their accuracy.

20. It is immaterial whether the meteorological year begins with December or January. We shall follow the decision of the Congress. Means should be taken for Days, Decades, Months, and Years, without introducing Five-day periods, which I do not think important, regard being had to the labour they entail.

21. The normal values should be deduced from the greatest possible number of observations.

22. The desirability is evident. The rules which will be established by the Congress for settling the question should be followed with the greatest exactitude.

23. By the measures which the Meteorological Congress will adopt, and the sanction which the respective Governments represented will give, by giving all means necessary for carrying it out.

24. The reply to this question can only be in the affirmative. Otherwise the establishment which should centralize the works of the different countries cannot attain its object.

25. The utility is incontestable; the difficulty consists in the realization of this project. In calm weather the despatches arrive with great regularity, but when a storm is announced, they arrive very irregularly, precisely when they are most important. The support of all the telegraphic administrations is necessary, and therefore I think that at present we must not complicate matters by requiring too much work, but, on the contrary, limit ourselves to that which is absolutely necessary. A few points of observation, suitably chosen in each country, and embracing the greatest possible surface of the globe will, doubtless, give excellent results.

26. The approval by the different Governments of the decisions of the Congress, the institution of a Central Office to watch over the carrying out of these decisions, the assembling of the Congress at least every three years in a central country to discuss, and, if necessary, to modify the previous decisions according to the results of experience, and the new arrangements to be proposed in order to improve the system established, will be, in my opinion, the points to be settled at the Congress at Vienna.

One of the greatest difficulties in suitably establishing the meteorological service is without doubt the securing observers for stations of the second order, badly or not at all remunerated. Every possible effort must therefore be made to give a little more stability to this staff, and no means are more certain of succeeding, than by giving them salaries proportional to the responsibility which is required of them. As this staff may be attached to other services, such as Public Instruction, Telegraph Stations, &c., according to the country, a small remuneration might suffice.

It only remains for me to assure you, Sir, that I shall do all in my power to induce the Spanish Government to accept in all particulars the decisions of an international character which will be taken by the Congress, and as to the other decisions, the carrying out of which may be decided by myself, you may rely on my following them with the greatest exactitude, according to the means at my disposal.

Accept, sir, &c.,
ANTONIO AGUILAR.

IV.

METEOROLOGICAL SOCIETY.

30, George Street, Westminster, S.W.

June 16th, 1873.

SIR,

In pursuance of a resolution of the meeting of this society held on 21st of May, I have to forward you a copy of the discussion upon some of the questions submitted to the Leipzig Conference, and to request that you will,

upon the form below, favour the Council with your opinions thereupon. Your reply will be materially facilitated by previous perusal of the discussion. Please answer this on or before June 30th.

I am, sir, your obedient servant,
WILLIAM MARRIOTT,
Assistant Secretary.

Suppl. IV.
The Meteorological Society.

Questions.

- No. 2. What is the best form of barometer for stations of the second order? Is the use of an aneroid for such stations admissible as an independent instrument or otherwise?
- No. 4. What is the best construction of maximum and of minimum thermometers?
- No. 5. What instruments should be employed for determining the intensity of solar radiation, and in what way can the comparability of the results obtained be ensured?
- No. 18. Can uniform times of observation be introduced, and if so at what hours, say 9 a.m. and 9 p.m.? Do you consider that local or Greenwich mean time (railway time) should be adopted?
- No. 20. What divisions of the year are the best for the calculation of mean results? Do you think that one day should be subtracted from January and from March, and added to February, so as to make up that month to 30 days?

Report on the Replies received in answer to the Questions issued with the Circular of June 16th.

No less than 52 of the Fellows have favoured the society with their opinions on the various points under discussion, and in addition communications have been received from Professor Buys Ballot and from Mr. Plummer of the Durham Observatory. In several cases the questions have not been answered directly, more than one answer having been given; in all such instances the author has been taken as adhering simply to the solution for which he expresses his preference.

We shall now proceed to an analysis of the replies, but it must be remembered that in many instances the writers have only answered the questions relating to the subjects with which they were specially familiar, so that a simple comparison of the number of votes would be fallacious.

The replies regarding the best form of Barometer were 46, with a very decided opinion in favour of the Kew barometer, 33 gentlemen recommending it, while the remaining 13 mostly supported the use of Fortins' Standard. Barometers.

On the subject of the utility of Aneroids opinions were more divided; out of 47 votes 22 were decidedly unfavourable to their use, 19 suggested their employment as auxiliary instruments, while only six were for their general admissibility. Aneroids.

The choice of Maximum Thermometers was limited to Negretti and Zambra's and Phillips'. It is not easy to give a precise analysis of the views entertained. 32 Fellows wrote in favour of Negretti's and 17 in favour of Phillips', but several replies suggested that both instruments might be used; 42 answers were received. Maximum Thermometers.

As to Minimum Thermometers the sense of the society was nearly unanimously in favour of Rutherford's spirit minimum, 40 out of 42 replies taking that line; a few gentlemen also recommended the use of Casella's mercurial minimum, if sufficient precautions were taken in its management. Minimum Thermometers.

For Solar Radiation 25 votes out of 28 were for the black bulb *in vacuo*, dull black extending one inch along the stem. No suggestions of much importance were made as to ensuring the comparability of results, but a wish for the adoption of 4 feet above the ground as the height of exposure, was expressed by 12 gentlemen.

On the important subject of Hours of Observation, the unanimity in favour of 9 a.m. and 9 p.m. was very great, 41 out of 50 of the fellows expressing their Hours of Observation.

Suppl. IV. Meteorological Society. Hours of Observation. approval of those hours. Some few proposed the addition of an 8 a.m. observation to work up with the Telegraphic Reports.

As might be expected the question of local *versus* Greenwich time elicited a difference of opinion; 48 answers came in, which were divided into 30 for local, 16 for Greenwich time, while two made special propositions.

No very decided wish about the division of the year was elicited, 38 gentlemen expressed their opinions, but most of them voted for several classes of means.

- 11 simply wished the civil divisions of the year to be kept,
- 22 asked for monthly means,
- 7 " weekly means,
- 12 " five-day means (mostly Buys Ballot's),
- 6 " seasonal means,

and a few mentioned daily means.

The sense of the society is rather decidedly against any alteration in the length of February; out of 42 answers 27 being unfavourable and 15 favourable.

The remarks of Messrs. Birt and Bloxam on uniformity in hours of observation deserve attention. Mr. Forbes gives a good table of corrections for the 9 a.m. and 9 p.m. readings for the north of Scotland.

Mr. Rundell and also Mr. Plummer make suggestions for artificial divisions of the year.

Professor Buys Ballot has honoured the society by again putting forward in his reply to their circular some of the views which he has already advanced in his valuable "Suggestions on a Uniform System of Meteorological Observations."

On the whole the Form Committee cannot but congratulate the council on having elicited such an extensive expression of opinion on the various points contained in the circular.

Appendix to Report.

The remarks of Mr. Birt are as follows:—"It appears to me that the first element of usefulness in a series of observations is the object the observer has in view. There are two distinct objects which meteorologists may recognize. First, climatic relations (having reference to time only) which must be deduced from observations made at stations where observers reside, and for such observations the hours of 9 a.m. and 9 p.m. (to the minute) are the most suitable, and these, of course, to be of any value, must be *local* mean time. Second, the progression of the two principal meteorological elements, temperature and pressure, having reference to space as well as time. If the observer be interested in these progressions and makes choice of working in concert with the Meteorological Office his hour of observation is 8 a.m. *Greenwich* mean time (also to the minute). A system of three daily intervals of eight hours each would greatly facilitate the study of the great movements of the atmosphere; the hours of observation being 8 a.m., 4 p.m., and 12 p.m."

Mr. Bloxam writes as follows:—"It appears to me that if the observations of many persons are to be used for the purpose of deducing laws in the science of Meteorology, it is of the greatest importance that "uniform times of observation" should be adhered to. The system of simultaneous observation is incompatible with uniformity in the ordinary work of meteorological observation, and in my view the use of local time is indispensable. I believe 12 o'clock, noon, to be the best hour for observing and recording the ordinary meteorological phenomena. I believe this to be the best hour, because the sun's influence upon temperature must, as a rule, be more uniform as regards diurnal progression at different stations at this hour than at any other between his rising and setting, and tables for diurnal range will apply more correctly to all stations for this hour than for others. The diurnal progression of temperature is different on an elevated situation from what it is in a valley. . . . Of course it is very desirable that the convenience of the observers should be consulted, and if another hour would be more convenient generally, it might be better to select another hour for general use, but 12 o'clock observations would then be available if made in addition to the other or others."

V.

On the EXPOSURE of THERMOMETERS for the CALCULATION of AIR-TEMPERATURE.—By H. WILD.

Suppl. V.

Prof. Wild.

Report to the first sub-committee appointed to discuss Questions 2-6 of the programme.

The investigations which I have originated at the Central Physical Observatory at St. Petersburg, in order to determine the influence of the exposure of thermometers on their indications, were carried out in three directions. Firstly, the action of screens to prevent the disturbing action of Radiation towards surrounding bodies was examined, then the effect of rapid movement as well of the Thermometer itself, as of the air which surrounds it, in reducing the effect of Radiation, was determined, and finally the influence of the height of the thermometer above the ground on its indication was strictly inquired into. As these investigations are not yet quite complete, I can only here communicate a few preliminary results to which they have hitherto led me.

1. Influence of the Screen. It may at the present moment be considered as universally admitted that thermometers which are put up without a screen, on a window or anywhere else on buildings, or are even exposed perfectly freely, do not give the true temperature of the air at the place in question, but give something intermediate between that temperature and that of the surrounding objects which radiate towards the thermometer, so that it seems superfluous at this place to waste any words against the free exposure of thermometers. In the March number of Symons' Monthly Meteorological Magazine for 1869, among the Strathfield Turgiss experiments on comparative exposures of thermometers, one with an unprotected bulb was mentioned, the thermometer being suspended quite freely 13 feet above the ground, on a wire stretched between two posts. According to Glaisher* a thermometer so exposed, even in strong sunshine, should give the temperature of the air much more accurately than any other one suspended nearer to the ground, or in the shade of houses. An assertion expressed so positively in the Philosophical Transactions seemed to call for a corresponding experiment. In an open space, far from any buildings, I suspended a thermometer by means of a cord on a telegraph wire stretched between two telegraph posts, 66 feet apart, in such a way that its bulb was 13 English feet above the grass. The instrument was read at the same time with the thermometers erected in the shade and protected according to my method, at times from below and from a distance with a telescope, at times by bringing a ladder which was mounted quickly.

Exposure of Thermometers.

My own readings as well as those of the other observers of the Observatory, gave, between 7 and 1 o'clock in sunshine a temperature about 5°·0 F. higher for the open thermometer than that in the shade; at 9h p.m. if the sky was clear, a temperature to the same extent lower than it. I think this is sufficient to do away with thermometers suspended freely at a height of 13 feet, and the more so because the assertion of Mr. Glaisher is chiefly based on the comparison with a thermometer which is erected in his thermometer screen 4 feet above the ground, and thereby in his opinion is completely protected against Radiation. This, however, as we shall see later, and as has been already stated on other authority, is distinctly not the case.

Passing to the consideration of *protection*, I cannot suppress the remark that here, as often in Meteorology, the simplest physical laws have been transgressed. It was thought that the thermometers were sufficiently protected against Radiation when they were enclosed in *wooden boxes*, which were at times half open, at times enclosed on all sides, except the bottom, by louver boarding, and for the most part were very small. If the physicist, in experiments on radiant heat, wishes to stop the radiation of any warm body towards the thermoscope he generally uses a single or double screen of thin sheet metal. It is in my opinion not merely considerations for the elegance of the experiment which determine him to choose this material instead of a wooden board, which is equally athermanous. At the place where the rays of heat strike the screen and are absorbed by it, the temperature of the metal, in consequence of its low

* Philosophical Transactions for 1847. Part I. pp. 124 and 142.

specific heat, will be raised at the first moment, somewhat more than that of the wood, but on account of the much higher conductivity of the former, the heat will be conducted equally on all sides in the sheet, and restored again to the surrounding air; while in the wooden board it remains more concentrated, and so gradually a great rise of temperature can take place at the point in question which subsequently can only disappear slowly. In a few words the thin sheet of metal places itself much more rapidly in thermic equilibrium with the surrounding air than the wooden board, and is therefore much better adapted for preventing Radiation.

By such considerations I was induced, as long ago as the year 1860, to introduce, as a protection for thermometers in the meteorological stations which had been newly erected in the Canton Berne, cylindrical screens of thin sheet zinc, open below and enclosed above by a conical roof.* In order to ensure the free access of the air to the thermometers and to prevent its stagnation in the screen, the sides were not continuous, i.e. they were formed of segments of 12–13.5 in. diameter, which were separated by open spaces, and so arranged that to every opening in the inner cylinder a portion of the outer cylinder corresponded and *vice versa*. The walls of the cylinder, which were about 16 ins. in height, are separated from the roof, which overhangs them slightly, by the space of 0.8 in., so that you can see freely under the eave of the roof; and similarly the conical roof consists of two portions, one above the other, and separated by a similar distance. One of the outer segments is fitted up as a door, for observing the enclosed thermometers. If this screen could be erected on the north wall of a house, it was suspended on hinges before a window by two iron rods 14 ins. in length, which are fastened to its sides, so that it could be drawn, for the purpose of reading the thermometers, towards the window, while otherwise it is kept standing at a distance straight out from the house. Where this was not possible, as, for instance, at the Observatory at Berne, the metal screen was erected, for protection against the sun's rays at noon, in a wooden box supported by two poles, quite open on the north side and below, and with two walls above and on the south side, at a distance of about 1 foot from the screen. Similar screens were introduced in the year 1863 at all the newly-founded meteorological stations in Switzerland. Similarly, at my proposal, in the Instructions for meteorological stations in Russia, published in the year 1869 by the Academy of Sciences of St. Petersburg, a thermometer screen arranged according to the same principles has been adopted.† The only difference is that the sheet-zinc screen is rectangular, the sides are louvred, with horizontal openings, and, in order to prevent birds getting in, the bottom is formed of wire net. This is erected with its side walls attached to two wooden supports, which are either placed before a north window of a house, or are better erected in a wooden house standing quite free to the north and quite open below. The lateral walls of the wooden house are also louvred, the south wall and the roof are massive and double.

By repeated special experiments, which are partly contained in the above quoted paper in the Bernese *Mittheilungen*, I have convinced myself that the temperature of the walls of such a metal screen may be $3^{\circ}.5$ different from that of the air, without its altering by radiation the temperature of the enclosed thermometers to the extent of two tenths of a degree F., owing to the motion of the air within the screen which is immediately produced; similarly the ground under the screen may have a temperature 36° higher than the air, before it warms by radiation to the extent of $0^{\circ}.2$ the thermometer, which is placed about 10 feet above it. The influences of Radiation which, in their direct action on the thermometer, do not exceed $3^{\circ}.5$ are thus, by means of protecting metal screens, eliminated entirely, to the extent of the usually adopted limit of error of observations for temperature of $\pm 0^{\circ}.2$. In the erection of the metal screens on the north side of a house in the mean latitudes simply, and in higher latitudes with the addition of a wooden or linen screen at the distance of one foot on the east and west sides, or in a wooden house which stands perfectly open, of the nature described, no influences of Radiation exceeding $3^{\circ}.5$ in their effects are to be feared, and it is as little to be expected,

* H. Wild, on the Calculation of Air Temperature. II., Exposure of the Thermometer at the ordinary Meteorological Stations. *Mittheilungen der Naturforschenden Gesellschaft in Bern*. 1860, p. 108.

† Instruction for Meteorological Stations, by H. Wild. *Repertorium für Meteorologie*. Vol. I. p. 96. And Additions to these Instructions. *Ibid*, Vol. II. p. 4.

considering the small mass and the good conductivity of the metal sides that, even in rapid variations of air temperature, the temperature of the metal walls will differ more than $3^{\circ}.5$ from it. If then the openings in the metal screens are arranged in such a way that the air cannot stagnate within, it is more than probable that by this mode of screen the true temperature of the air can be obtained. That this method protects the thermometers as well from Rain as from Radiation scarcely needs to be mentioned.

To employ wooden screens alone for the protection of the thermometers, in my opinion, should be entirely rejected, in consequence of their great mass and bad conducting power, and I therefore think that not one of all the thermometer screens which were used in the Strathfield Turgiss experiments* is suited to give the true temperature of the air. Of old thermometer screens, as far as I know, it is only Kreil, at the Austrian stations,† and Kupffer at the Russian, which have used them of metal. The first of these, however, seems to me not to afford sufficient protection against Radiation or Rain, while the latter represents a case of metal and glass, almost hermetically closed, with the exception of a few openings at the bottom, and accordingly the exchange of the air between the inside and outside is much too limited.

Comparative observations which I have already made in Berne showed me that if thermometers be placed in various points in such metal screens, they scarcely differ $\pm 0^{\circ}.4$ in their simultaneous indications, while thermometers exposed perfectly open, close to the screens, give differences of $\pm 1^{\circ}.1$ and more.‡ Observations in the same direction which have been instituted at St. Petersburg, more when occasion offered than systematically, have given similar results.

From February to May, and in June and July of this year, I have further instituted, in a large wooden hut at our magnetical observatory, which has been built according to the above-named principles, comparative observations of the simultaneous indications of thermometers enclosed in the metal screen and of one suspended freely near it. The most decided result of these observations which has hitherto been obtained seems to be that the difference of the extremes of the open thermometer in the winter was $0^{\circ}.5$, and in summer as much as $1^{\circ}.3$ less than of that enclosed in the screen, and in the case of sudden oscillations of the temperature, the open thermometer was behind that in the metal screen. This, if it were confirmed by more complete observations in this direction, would unmistakably prove the disturbing influences of badly-conducting simple wooden houses. The same effect is indicated further by the circumstance that in summer the mean temperature of the enclosed thermometers, was on the average $0^{\circ}.4$ less than that of the open one, and consequently agreed much better with that which was erected in the open and airy hut in the second court and was also enclosed in a metal screen.

In the year 1869, on the other hand, comparisons with thermometers, of which some were erected in an open metal house on the N.N.W. side of the magnetical observatory 8 feet above the ground, and the others 4 feet above the ground in the well-known Glaisher's stand, gave for the latter an amplitude of the daily variations of temperature in summer, which was on the average $1^{\circ}.8$ greater, a result unmistakably attributable to the Radiation from the soil, and from the portion of the sky which was opposite to the sun, against which no protection was afforded.

Finally, I have to enumerate experiments to protect the thermometers, even against the direct rays of the sun, by surrounding them with four concentric metal cylinders and double cones, the openings of which alternate with each other. These have as yet only led to negative results.

2. *Influence of motion*.—Experiments in this direction have been as yet conducted on two principles; firstly according to the proposal of Dr. Rühlmann at the Meteorological Conference in Leipzig, similar thermometers were fastened with corks into brass cases, with double walls, and closed all but a few small openings. Both of them were erected in a wooden hut in the magnetical observatory, close to each other, and by means of centrifugal bellows during the observation a current of air was driven through one while the other remained at rest. In the months February to May, on the average, the thermometers placed in the air current gave a temperature $0^{\circ}.2$, but in the maximum $0^{\circ}.7$ higher; in July the differences were still less.

* Symons' Monthly Meteorological Magazine, April, 1869.

† Jelinek, Anleitung zur Anstellung Meteorologischer Beobachtungen, Vienna, 1869, p. 40.

‡ *I.c.* pp. 116, 118.

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Then a psychrometer with thermometers placed in a slanting direction, and leaning outwards, and movable round a vertical axis passing through the middle was erected in the same hut, near the metal house. Every time after the reading of the thermometers in the latter, the readings of these thermometers were noted, first in a position of rest, and then twice after a *rapid rotation* round a vertical axis on each occasion. This may represent a sort of *thermomètre fronde* which is swung in the shade.

The observations instituted at the end of June and beginning of July, gave for the free thermometer on the mean, in the first position of rest, a temperature higher by $0^{\circ}12$ than that enclosed in the screen and this difference contrary to expectation, still further rose on rotation, so that after the first rotation it was $0^{\circ}18$, and after the second $0^{\circ}34$ higher.

Further experiments will show whether the elevations of the temperature observed in both these cases, are really to be attributed, as seems to be the case, to the heating of the air by compression or friction.

3. *Influence of height.*—The observations hitherto instituted on the influence of small heights, i.e., up to 30 metres (100 feet) above the ground, on the temperature of the air, seem almost without exception to have this defect; that from the mode of exposure which has been employed for them, it is uncertain whether the differences of temperature which have been found are not altogether, or at least partly, to be attributed to differences arising from radiation, and not to differences of height. The observatory at Pulkowa possesses a geodetical signal scaffolding 24.7 metres, or 81 feet high, standing in an open field, is of timber lightly put together, and its storeys are very well suited for the erection and exposure of thermometers at various heights, under exactly similar conditions. M. O. v. Struve, Director of Pulkowa Observatory, kindly allowed me to use this scaffolding for such observations. By the kind assistance of M. Block, Assistant in the Observatory, I had three psychrometers with minimum thermometers in metal screens, with outside wooden cases, of the nature above described, erected on the scaffolding at various heights. The first is 6 feet above the ground, the second 52 feet, and the third 86 feet. M. Schwarz undertook the observations himself even in the winter, once a day, at 1 o'clock, and at the other seasons three times, viz., at 7 h. or 8 h. a.m., and 1 h. and 8 h. p.m. They began on the 15th Sept. 1872, and extend now almost over a year.

These observations, thanks to the similarly exposed thermometers, which exclude the effect of radiation, indicate on the average a much less influence of height on the temperature, than the analogous observations of other investigators in general. The mean values of the temperatures at the different heights only differ about $0^{\circ}2$ in the summer as well as in the winter months. It must be admitted that at the individual hours of observation on the average the upper thermometers read lower in the morning and higher in the evening than the lower thermometers; but the differences between the highest and lowest, on the mean is only $0^{\circ}9$ and on the whole year they only amounted to $3^{\circ}5$ or $4^{\circ}5$ a few times.

From this it appears that for the exposure of thermometers for the determination of the temperature of the air near the surface of the ground, if they are sufficiently protected, their height above the ground need not necessarily be the same, but may vary very well between 6.5 and 33 feet without having to fear greater differences in the indications than will be found in exposures at somewhat different points on the same horizontal plane.

VI.

LETTER from PROFESSOR J. CANTONI, Delegate for the Ministry of Agriculture of Italy to the METEOROLOGICAL CONGRESS OF VIENNA.

Considerations and experiments on Questions 2, 4, 5, and 6 of the Programme.*

2. What mode of exposure of Thermometers for the observation of Air Temperature is the best and most suitable for general adoption

When in 1860 I undertook a series of Meteorological Observations at the University of Pavia, I occupied myself first of all with making experiments on

* The Nos. of the Questions refer to the Programme of the Vienna Congress.

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the most suitable form for and exposure of the thermometer in order to determine the temperature of the air at a given moment.

Professor Belli, my predecessor, had already set forth the difficulties of this investigation. Several mercurial thermometers whose scales had been previously compared carefully with each other, being exposed together in the same place in the open air, and read at the same time, gave very different indications, when the form, capacity, and thickness of their bulbs were not exactly similar; that is, they showed with a different degree of sensitiveness the influence of the variations which took place in the temperature of the air. The spherical form, *ceteris paribus*, is the least suitable in this respect, and the cylindrical form is the best, provided that the diameter be small enough with respect to the length. Of course the sides of the bulb should be very thin, as it is made by blowing the bulb of the same material as the stem. Then different thermometers with cylindrical bulbs give very nearly the same readings of the temperature of the air, although the dimensions of the respective bulbs differ somewhat from each other. But these differences will diminish much more and will become almost inappreciable if, by some artifice, a rapid motion be produced in the air of which we wish to determine the temperature. And, particularly, for Meteorological Observations the thermometers must be well protected against the thermic radiations of adjacent bodies, and the air must be allowed rapid circulation round the bulb.

To attain the first of these ends, I have first of all made attempts to silver the thermometric bulbs by the cold process; but I found it very difficult to obtain a metallic deposit sufficiently thin and polished on its exterior surface to ensure securing the maximum reflecting power. Moreover, at certain seasons of the year, we cannot prevent the thermometer, although exposed to the north, from being struck by the direct rays of the sun. Then I tried to protect the instrument by a double cylindrical brass tube, whose axis coincided with that of the bulb, and whose height was at least four times that of the bulb itself; the inner tube had a diameter of at least 2 ins., and the outer one of more than 3 ins.; they were open at top and bottom, so that the air could circulate freely all round the bulb and between the two tubes. But although their thickness was very small, I perceived a sensible influence exerted by radiation and by the circumstance of the screens communicating their own heat to the air.

It is well known that by swinging the thermometer rapidly round in the air, the influence of radiation on it is much reduced; so that, by this means, we may attain the two ends above mentioned at the same time and reduce to a minimum the influence of the different dimensions of the bulbs. But instead of swinging the instrument, which is dangerous and makes the reading difficult, I preferred to give a rapid movement to the air surrounding the bulb by means of a small wheel, as I shall afterwards explain, when speaking of the psychrometer.

As to the other question, that of the best exposure of the thermometer, we must first of all decide whether the thermometrical observations are for the purposes of Agriculture and Sanitary Science, or only for Meteorology, properly so called. In the former case it is well known that the thermometer should not be placed on the top of a tower or large building, but in a garden, or, better, in an open field, at a little height (one or two yards) over a soil covered with grass, and sheltered by a suitable roof, so arranged that the instrument should never be struck by the sun's rays, and that the air should circulate round it freely. M. Charles Martins, at Montpellier, and many other meteorologists have shown that, for a given locality, the differences of the results between these two modes of exposure are considerable. I resolved to determine them under the conditions afforded by the town of Pavia (latitude, $45^{\circ}11'$). We compared, during four years, the march of maximum and minimum instruments, some of them being exposed outside a window to the north of the tower of the meteorological observatory of the University, at the height of 66 feet above the court, and others in the botanical garden, at the height of 5 feet above the cultivated soil, and protected to the north by an enclosing wall 11 feet high. Both were equally protected against radiation by a metal screen which surrounded them, while leaving the movement of the air free above and below; and, moreover, the bulbs of all the thermographs were gilded on their exterior surface, and were cylindrical in form, with a vertical axis, and none of them were in contact with the scale.

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		MEANS.				
		Winter.	Spring.	Summer.	Autumn.	Year.
Means of the daily maxima:		°	°	°	°	°
Botanical garden	-	48.52	70.38	89.22	69.71	69.46
University tower	-	43.90	64.17	83.77	63.54	63.85
Differences	-	+4.62	6.21	5.45	6.17	5.61
Means of the daily minima:						
Garden	-	27.93	44.73	60.69	46.78	45.03
Tower	-	29.86	46.69	62.82	48.16	46.88
Differences	-	-1.93	-1.96	-2.13	-1.38	-1.85
Means of the daily extremes:						
Garden	-	38.23	57.56	74.97	57.90	57.25
Tower	-	36.86	55.42	73.29	55.85	55.36
Differences	-	+1.37	2.14	1.68	2.05	1.89
Mean range of the daily extremes:						
Garden	-	52.59	57.64	60.53	54.95	56.43
Tower	-	46.04	49.48	52.95	47.37	48.96
Differences	-	+8.55	8.16	7.58	7.58	7.47

It is seen from these numbers, which differ from each other considerably, that the characteristic data of the climate, that is, the mean temperatures of each season of the year, and still more the mean variations of the extreme temperatures, differ greatly with the height. The maxima are always higher in the garden than on the tower, and, on the contrary, the minima are lower; the diurnal variations of the temperature are much greater in the garden than on the tower. Hence the importance of determining well the conditions of the exposure of the Thermometers.

On Question 3:—

What are the best Maximum and Minimum Thermometers?

Maximum and
Minimum
Thermometers.

It may be observed, first of all, that these instruments, as to their construction, should satisfy, much more closely than in the case of ordinary thermometers, the conditions of quickness in their indications, so that they may give the extreme temperatures, the highest and lowest, which occur during the day. For this purpose, their bulbs should be cylindrical, and their length many times greater than their diameter, and the axis vertical, in order to facilitate the continual renewal of the air over their whole surface. Further, it is necessary that the glass of the bulb should be very thin, and that the bulb itself should not touch any part of the scale. But, in reality, these conditions cannot be carried out in the registering thermometers, because the tube, in order to contain an index, cannot be so fine as in ordinary thermometers, and therefore it is necessary that the bulb should contain a considerable quantity of liquid. Nevertheless we must endeavour to realise as nearly as possible the above conditions as to quickness of indication. Instead of that, the registering thermometers used at many meteorological stations are not very sensitive. For instance, Mr. Casella's instrument, besides the defects inherent to the union of the two scales by means of a long column of mercury, has a bulb whose form and position on a slab, covered by a little metal shield, is the least suitable for a complete and rapid circulation of the air round it. At most of the Italian meteorological stations the two instruments are separated. The maximum thermometer is mercurial, with the column easily separable by a contraction of the glass in the bend of the tube, and the minimum is of amyl alcohol, which is very slightly vaporisable, as its boiling point is much higher than that of ethyl alcohol, generally used for minimum instruments. In both the bulb is cylindrical, with the axis at right angles to that of the tube, and with

diameter small in proportion to its length. At some stations the registering thermometer of M. Marchi, of Florence, has been used for several years, which possesses the advantage of having mercury as the thermometric liquid even for the minimum, and of the two scales for maximum and minimum being united in the same tube by means of a liquid not easily vaporized, which contains the two indices (see the description given by M. Donati); but it is necessary to modify its form by making its bulb vertical and also isolated.

On Question 4:—

What instruments should be employed for determining the intensity of Radiation, and in what way can the comparability of the results obtained be ensured?

I cannot reply by quoting any direct personal experiments, but I shall nevertheless express my conviction that the black bulb thermometer *in vacuo* is the only one that can give mutually comparable results, if it be a question of a determinate instrument always exposed in the same conditions; on the contrary, the results will be no longer comparable if there be the least difference in the conditions of construction and exposure of the different instruments. Nevertheless, this kind of instrument may serve well for certain investigations into the influence of solar light on vegetation; but with regard to this I would recommend meteorologists to try to perfect a very ingenious instrument by Canon Bellani, called the *Caloric Collector*, the principle of which seems to me susceptible of useful applications. Two hollow globes of very thin glass, one black and the other transparent, are united by a tube which is not too fine, and contain a quantity of water, the volume of which corresponds to a little more than half the capacity of the globes, but they are otherwise void of air. Before taking an observation, the water is made to descend into the black globe: the instrument is then re-adjusted, and exposed to the open air and to the sun. Then the black globe getting hotter than the other, the vapours become condensed in the latter and continue to liquefy in a quantity proportional to the successive values of the solar radiation, so that the volume of water which, in a given time, is condensed in the transparent globe, and is collected in a graduated tube attached below it, should be proportional to the sum of all the differences in the heating of these two globes which will have occurred at the different times of the day, and therefore to the successive values of the relative clearness of the day and of the elevation of the sun above the horizon of the place. On an overcast day this complex work of evaporation and condensation will be very small in comparison with that which will be produced on a continuously clear day. This element will have some importance for agriculturists, perhaps greater than that of a few observations made at a given instant by an ordinary black bulb thermometer, as I have stated above. I propose to make further experiments upon this subject.

As to Question 5:—

What apparatus is the best for determining Earth Temperatures? At Earth what depth should the observations be taken in order to attain the Temperatures, uniformity which is desirable?

I think it proper to remark, that, according to a long series of experiments made in the years 1865-6 by my brother, Professor Cajetan Cantoni, when he was director of an experimental institute of agriculture, it is very important for the different kinds of crops, and for the different natures of arable soil to observe the temperatures of the soil by several thermometers, the middle of the bulbs of which are placed respectively at depths varying by 4 inches from 4 to 20 inches. To give an idea of the amount of the first of these influences I shall limit myself to quoting one example. A thermometer placed in the soil of a rice field at 13 inches below the level of the covering of water which is kept over it during the months of July and August, presented very small variations of temperature; for the fluctuation in the course of a day (day and night) kept on an average between 0°·9 and 1°, as well when the day was clear and the air much agitated by the wind, as when the day was calm and overcast; that is to say, that the cooling produced by evaporation in this thin bed of water which covered the soil was almost completely proportionate at

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every moment to the heat received from the sun according to his different elevations above the horizon and to the different degrees of clearness and movement of the atmosphere. And the mean daily temperature of this soil, so covered by water, remained at more than 10° lower than that of the surrounding air. Matters were very different in cultivated land, only watered occasionally or not at all.

Observations made at depths greater than 3 feet have but little interest for agriculture, and can only be useful for investigations of terrestrial physics or of geology on the different thermic conductivity of the various soils and various rocks.

As to the first part of Question 6 :—

Hygrometers.

What apparatus should be employed for the determination of the Hygrometric condition of the air?

Disregarding chemical hygrometers and condensation hygrometers, which are inconvenient to use, although theoretically preferable, I shall limit myself to saying a few words on psychrometers, such as are adopted at a greater number of meteorological stations in Italy.

In treating of the 2nd question, I have already referred to the experiments of Professor Belli and myself on the utility of the agitation of the air for rendering comparable thermometers whose indications have a different degree of sensitiveness. Well, this artifice shows itself to be still more useful, and I will add even necessary, for diminishing the appreciable differences of the indications given by these same thermometers, when their bulbs are moistened. It is known that August's theoretical formula for the psychrometer supposes that the layer of air which, by contact with the covering of water upon the bulb of a thermometer, charges itself with vapour, is renewed at every moment, that is to say, with extreme quickness. Thus Professor Belli showed that bulbs of a spherical shape were less convenient for that purpose, because the differences obtained, even with the agitation of the air, in several thermometers with bulbs of different diameter, were much greater than those given by other thermometers, with a cylindrical bulb, of various dimensions, although they were all similarly plunged in the same mass of air, and the differences of these last thermometers became very small when the motion excited in the air was increased by a continuous current by means of bellows or by an aspirator. These experiments, which I have myself continued and varied in several ways, have convinced me that we could give to the psychrometers a sufficient comparability and make them serve at the same time, as I have stated with respect to Question 2, to determine the temperature of the air in good conditions. I have compared under different circumstances the data for psychrometers with those of an excellent condensation hygrometer by Belli, and even with those of a chemical hygrometer by Brunner, and I have found that, by a rapid circulation produced by a pallet-wheel, we find a constant value for the coefficient to be introduced into Regnault's psychrometrical formula for calculating the real tension of aqueous vapour disseminated in the air and the relative humidity of this air; and that, on the contrary, it was necessary to adopt for that purpose different coefficients if the psychrometer was observed without any movement of the air.

VII.

REMARKS by G. T. KINGSTON, Superintendent of the Meteorological Department of Canada, on Two of the QUESTIONS brought forward at the CONFERENCE at LEIPZIG in 1872.

Exposure of Thermometers.

I think that before Meteorologists take up the question of the mode of exposing thermometers, they should settle once and for all what the height of the stratum of air is to be whose general temperature near the station observers should endeavour to discover at a proposed instant.

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Mr. Kingston.

Exposure of
Thermometers.

In choosing a level we have to consider—

- 1st. What the level is whose temperature, irrespective of convenience and facility in determining it, we most *desire* to know, and—
- 2nd. What the level is, the knowledge of whose temperature is most *attainable*, either on account of the physical circumstances of the air at that level, or on account of convenience and accessibility.

As regards desirability, a level chosen with reference to animal and vegetable life would be 4 to 5 feet or less; one where changes of temperature are most influential in a meteorological sense, would be much higher.

Apart from considerations of *convenience* the temperature of air at a high level is more attainable than at a low level, because at a high level the temperature is less affected by the more minute accidents of locality, a change produced by passing from level to level or from point to point in the same level, is more slow, and if a thermometer be placed at random in any part of such a stratum the air in contact with the thermometer is more likely to be a fair average sample of the air at that level, than if a lower level had been chosen. With reference to convenience of access, the question should not be complicated by considerations as to the probable height of windows, because windows and indeed positions generally near to large buildings should be avoided.

A fair compromise would be to place the bulbs at some uniform height between 4 and 10 feet, or rather to recommend such a height for universal adoption, since in many cases the adherence to any standard height will be impracticable.

At a height lower than 4 feet the air is liable to be affected too much by local accidents, and a higher level than 10 feet would necessitate structures that would be expensive, if placed (as I consider they always ought to be placed) in an open field or garden, and thus tend to diminish the number of observers.

In the absence of an universal rule I have adopted $4\frac{1}{2}$ feet in Canada, but I would gladly change it for another higher level.

The exposure of a thermometer involves two conditions :—

- 1st. That the air in which it is immersed be a fair sample of the horizontal stratum of which it forms a part, and
- 2nd. That the thermometer be acted on (as far as possible) by contact with that air and by no other cause of change.

The first condition concerns the *place* and the second the *mode* of exposure. Proximity to a building should be avoided, as the air is affected by contact with walls, which have the temperature which the *general* stratum of air had in a *past* time, and not that which the air for the time being has, on an average, at that level. The *direct* effect of the walls upon the thermometer may be cut off, but not its effect on the *air* in which the thermometer is immersed.

If the temperature be recorded by photography, a building must of course be used, but it should be of a form suited to meet all the requirements of the case.

At most of the Canadian stations the thermometers are attached to a light metallic support in the interior of a small safe or screen formed on the four sides and bottom by very thin sheet iron louvres.

This inner screen is supported by light iron brackets in the interior of a shed usually formed of wood. The back or South side consists of three parallel walls from 1 inch to half an inch thick, separated by spaces from 4 to 6 inches wide, which are open to the East and West. The back walls, or at least the two nearest to the South, extend to the ground. The Southern walls are made close, and not of louvres, to diminish the introduction of air that has been overheated by contact with the Southern face.

The Eastern and Western sides, as well as the doors which face the North, are of light wooden louvres, and extend a little below the bottom of the inner screen.

The bottom of the outer shed is open. The back extends to the East and West beyond the sides in order to prolong the time in which the latter are in shade.

Snow between the partitions of the back or on the louvres is speedily removed.

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Intimately connected with the question of exposure are the following:—
1st. What methods should be adopted to render intercomparable the various observations of temperature that have been taken, and that hereafter may be taken, at different levels and in different circumstances as regards locality and modes of exposure?
2nd. If tables of diurnal variation have been derived from observations taken in given circumstances of level, locality, and modes of exposure, by what modifying process can they be made available for reducing observations taken in different circumstances?

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Mr. Symons.

VIII.

LETTER from Mr. G. J. SYMONS in LONDON to Mr. CH. JELINEK,
VIENNA.

62 Camden Square, London, N.W.

August 20th, 1873.

Rain gauges.

DEAR SIR,

As it will be impossible for me to have the honor of attending at Vienna I must content myself with expressing my earnest wish for the success of the meeting.

I enclose herewith report upon the modes adopted in England for the observation of Solar Radiation* as requested by the Conference at Leipzig, and my friend Mr. Buchan will present to the Congress a specimen of the instruments used.

I do not quite understand from the *Bericht* what decision was arrived at at Leipzig respecting *rain gauges*, but I rather fear that the very extensive series of experiments made in this country were not known to some of the speakers, I therefore think it may be desirable, in order to avoid needless repetition, to state briefly what has been done.

The gauges used in these experiments were constructed in the year 1863 for the purpose of determining with precision whether any difference really existed in the amount of rainfall recorded by gauges differing in the size of their receiving areas. The area of the circular ones varied from 0.8 in. to 452 in. and the square ones had areas of 25 and 100 inches respectively. The largest gauge therefore had a receiving surface more than 500 times as great as that of the smallest.

During the past eight years these instruments have been in nearly constant operation, in three localities, different both in their physical and geological characteristics, and in the character of their rainfall.

After experience had been gained as to the points requiring attention it was found that gauges of any size not less than 3 inches (76mm.) diameter, provided that they are constructed on one pattern, and have their orifices at the height of 1 foot (0.3m.) above the soil, give results agreeing within 1 per cent.

The following table gives an epitome of the results obtained from experiments continued during seven years with gauges of the following diameters:—

Place of Observation.	inch. 1	inch. 2	inch. 3	inch. 4	inch. 5	inch. square 5	inch. 6	inch. 8	inch. square 10	inch. 12	inch. 24
Calne - -	.93	.96	—	1.00	1.00	.97	1.03	1.03	.98	1.00	1.00
Strathfield -	.96	.97	—	.99	.97	.97	.98	.98	.97	.98	1.00
Turgiss - -	.97	.99	.99	1.01	1.00	—	1.01	1.02	—	.99	1.00
Hawsker - -	.97	.99	.99	1.01	1.00	—	1.01	1.02	—	.99	1.00
Mean - -	.953	.973	.990	1.000	.990	.970	1.007	1.010	.975	.990	1.000

The completeness with which this problem has been worked out renders it less necessary that similar comparisons should be repeated; but if such a course be resolved upon, it may save trouble to those who may be charged with the design, construction, or observation of the instruments, to be forewarned that,

* See Supplement No. IX.

unless the very greatest care is taken in every particular, and at every stage of the comparison, discordant results are sure to be obtained.
The recommendation that all gauges should be 14 inches (0.36m.) in diameter and 8 ft. 2 in. (2½ metres) above the ground, appears inexpedient for the following as well as other reasons.

1. A gauge so placed will collect nearly 7 per cent. less than the true rainfall reaching the surface of the ground, and the advantage gained by so great an elevation is not obvious.
2. The use of a gauge having so large a receiving area possesses no advantage over that of one having one-fourth of the area.
3. So large a gauge does not accord with the suggestion of Dr. Mohn to the Leipzig meeting, nor with the practice of this country, of France, America, India, or Australia, in which countries collectively about 5,000 gauges are in operation, very few of which exceed 8 in. (0.20m.) in diameter, or 3 feet (say 1m.) above the ground.

As it is improbable that absolute uniformity will be attained, I hope that it will be resolved that in every annual publication the height of the orifice of every rain gauge above the ground shall be stated.

It is also of vital importance that every change in the rain gauge or in its height should be distinctly noticed, and desirable that such note should be at the foot of any record of observations rather than in any other part of a publication.

Perhaps I may in conclusion be allowed to state that if the records of the experiments on other branches of rainfall, such as the influence of elevation, the best materials of which to make gauges, the relative amount collected by gauges with funnels inclined to the horizon, are desired, it will afford me pleasure to forward any information in my power.

IX.

On the MEANS adopted in ENGLAND for the DETERMINATION of the AMOUNT of SOLAR RADIATION, by Mr. G. J. SYMONS.

62, Camden Square, London, August 20th, 1873.

The determination of the amount of Solar Radiation may be defined as that of the greatest heating power of the direct rays of the sun, which probably varies with four causes:—(1) Changes of solar energy; (2) the Sun's altitude; (3) the height of the place of observation, and (4) the state of the atmosphere through which the rays have to pass. Almost every apparatus designed for the determination of this element has been constructed on the principle of the expansion of fluids by heat, but in many cases the direct action has been replaced by indirect action, with no obvious advantage. In England the apparatus used by the large majority of observers has always taken the form of a registering maximum thermometer. The instrument now generally adopted is the final result of many years' experiments by many observers, and as each feature in its construction has a special object, it is necessary to explain each.

1. The bulb of the thermometer is very small, to secure rapid action (great sensibility).
2. The bulb and 1 inch (25 mm.) of the stem are coated with dull black; dull black because it was found that black glass (which was formerly used), having a vitreous surface, reflected many of the heat rays, while the dull black absorbs nearly all which fall upon it. It was found necessary to blacken part of the stem, because otherwise the unblackened stem, being cooler than the bulb, reduced its temperature by conduction.
3. The thermometer is enclosed in a thin glass jacket, of which the bulb has a diameter of about 2½ in. (57 mm.), from which the air is removed by an air pump.

The object of this outer jacket is the elimination of purely local effects, such as dampness, eddies of wind, &c.

This size of jacket has been found to render the instrument more exactly comparable than a smaller size. The jackets have been tried with (1) open

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ends, (2) ordinary air, (3) chemically dried air, (4) various gases, (5) partial exhaustion, (6) nearly perfect exhaustion. Of these various methods the last mentioned proves the best.

The instrument thus constructed may be regarded as having only one disturbing element, viz., the temperature of the external jacket. The difference between the temperature of the black bulb and the external jacket is an exact measure of the intensity of the sun's rays. It is found that this difference is the same in whatever position the instrument is placed. By exposing it, therefore, freely to sun and air at a considerable height above the ground we have the jacket so little heated above the temperature of the air that the excess of the reading of the thermometer with blackened bulb above the temperature of a thermometer in the shade may be regarded as a very accurate measure of the intensity of the sun's rays. This object is effected in the manner shown by the accompanying figure. (Cut not given).

Thus arranged, it will with the least possible trouble give results not only strictly comparable at all times and places, but equal, if not superior, in accuracy to any of the costly instruments known to the writer, while in facility of observation and lowness of price it surpasses them all.

In conclusion the writer begs to refer for further particulars to a very able paper by the Rev. F. W. Stow in the Quarterly Journal of the Meteorological Society, April 1873, of which a copy is sent herewith.

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X.

Prof. Bruhns.
Earth
Temperatures.

On the OBSERVATION of EARTH TEMPERATURES.—By C. BRUHNS.

Since the year 1866, I have had observations of Earth Temperature made in the gardens of the Leipzig Observatory, both with long thermometers with rather large quicksilver bulbs and fine bore, which can be read above the surface of the earth, as also with short ordinary thermometers which are fastened on rods and plunged in holes.

The bulbs of the first kind of thermometers were placed at depths of 9·8 7·9, 7·9, 6·2, 4·3, 3·3, 2·4, 2·0, 1·3, and 0·7 feet below the surface, and I have published the results of the observations made with them in the "Results of the Meteorological Observations at the Stations of the Kingdom of Saxony," (years 3-7.)

The thermometers were very carefully tested before they were sunk and the correction of zero determined accurately to about $0^{\circ}\cdot 10$. As the column of quicksilver in the soil is exposed to different temperatures, and extends to more than 18 ins. above the surface, the reduction of the thermometer observations is difficult, in consequence of the variations of temperature, for it is well known that the temperature of the soil in the upper strata depends on that of the air, and is rather changeable. Strictly speaking therefore the corrections which have been applied to the readings of these thermometers must be calculated afresh for each reading, and the thermometers which are sunk, and which are to give the temperature in the ground at different depths, give also data for the corrections. Inasmuch, however, as the continual change of the corrections causes a very troublesome piece of work in the reduction, I as well as the observers at other stations, have contented myself with deducing monthly values for the corrections which have to be applied, and carrying out the reductions with these mean values. Such a table, with the corrections for the Leipzig earth thermometers, will be found in the third and fourth volumes of the above-mentioned "Results," and the values of the readings have been corrected by means of them.

The thermometers which are plunged cannot easily be taken out of the soil, and therefore changes which may take place in them cannot easily be investigated, accordingly in course of time unavoidable errors arise from this. I have not been able to apply the most exact means of determining such corrections, and generally the temperature in the earth, viz., the thermo-electric chain with galvanic action, by means of which method, as is well-known, Oberberggrath Reich, of Freiberg in Saxony, determined the temperature of the rocks in the mines.

After all, the uncertainty of the temperatures read by long thermometers sunk in the ground and afterwards corrected seems to me to amount to some tenths of a degree and even more.

The earth temperatures which have been obtained from short thermometers at the same time as from these thermometers which have got continuous tubes, have been obtained from instruments plunged in earthen pipes sunk in the ground. The earthen pipes were closed as air-tight as possible on the outside, and the thermometer bulbs were surrounded by a bad conductor of heat, so that when the thermometers are taken out they would keep their temperature for the space of 10 minutes to within $0^{\circ}\cdot 2$. We may assume that a state of thermic equilibrium exists between the temperature at the bottom of the pipe and the temperature of the surrounding soil, and so by such short thermometers we can obtain the true temperature of the soil, as soon as we know the conditions of this equilibrium. We have then the great advantage of being able at any moment to examine the thermometers and to compare them with standard thermometers. I have not yet been able to determine accurately enough what these conditions of equilibrium are, or how far the temperature of the air in the earthen pipes differs from the earth temperature, especially when the outside air is colder than the latter. For the present it appears that for temperatures in depths down to 3 feet, on an average, the temperatures of the continuous thermometer, and that of the movable thermometer, agree almost exactly, while in greater depths, (to 10 feet), the yearly mean remains nearly the same, while the annual oscillation in the movable thermometers is almost 2° greater.

The amount of agreement in the monthly means, between the continuous and short thermometers, is shown by the temperatures obtained in the years 1871 and 1872 with thermometers at 10 feet and 3 feet in depth.

MONTHS.	Continuous Thermometer 10 Feet.	Short Thermometer 10 Feet.	Continuous Thermometer 3 Feet.	Short Thermometer 3 Feet.
1871.				
January -	38·97	42·26	35·65	36·27
February -	38·17	40·51	35·37	35·01
March -	38·97	40·41	37·25	37·81
April -	42·26	41·90	42·49	42·08
May -	45·45	44·37	47·66	47·84
June -	50·13	47·17	52·70	52·16
July -	53·60	51·80	57·61	57·02
August -	55·71	54·55	59·67	59·23
September -	55·27	54·91	57·15	57·56
October -	54·32	53·11	50·90	51·31
November -	45·86	49·95	43·47	44·96
December -	41·59	45·73	40·15	40·51
1872.				
January -	39·20	42·26	35·47	36·86
February -	38·71	40·69	35·78	36·73
March -	39·74	40·41	38·84	39·56
April -	43·21	42·49	45·19	45·01
May -	47·91	46·35	51·44	50·49
June -	51·85	49·77	55·94	55·27
July -	54·50	52·57	59·72	59·23
August -	57·51	54·99	60·80	60·85
September -	56·35	56·30	58·69	59·59
October -	53·29	54·99	52·75	53·83
November -	48·97	51·80	46·58	47·71

The earthen pipes had rather large mouths, and I thought that by narrower mouths I should obtain better agreement. I therefore took wooden pipes, with openings of about $0^{\circ}\cdot 2$ in. in diameter. Since December 1872 we have obtained the following figures for the short thermometers in wooden pipes and the long thermometers —

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Earth
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MONTHS.	Continuous Thermometer, 10 feet.	Short Thermometer, 10 feet.	Continuous Thermometer, 3 feet.	Short Thermometer, 3 feet.	Continuous Thermometer, 1 5 feet.	Short Thermometer, 1 5 feet.	Continuous Thermometer, 8 ins.	Short Thermometer 8 ins.
1872 December	45.46	49.42	42.26	44.49	40.50	41.58	40.60	39.88
1873 January -	42.69	46.69	39.88	41.94	38.84	40.06	38.98	38.52
February	40.93	44.56	36.10	38.52	35.35	35.85	34.94	33.98
March	40.28	43.16	38.16	39.74	39.02	38.77	39.09	37.69
April	43.02	44.24	43.59	44.56	43.81	44.46	43.12	43.41
May	46.00	46.40	47.08	47.80	47.52	47.88	46.47	47.41
June	50.29	49.21	54.28	54.18	56.98	56.52	56.77	56.84
July	54.54	53.17	59.79	59.76	62.82	61.84	63.21	61.95
August	56.95	55.90	61.56	61.05	62.85	62.49	63.10	62.31

As to the depths which should be chosen for the thermometers, two systems may be adopted; you may either choose definite depths, as I have done lately, of 0.3, 0.8, 1.6, 2.5, 3.3, 4.8, 6.6 and 9.8 feet, or you may choose such depths as will give only oscillations of a definite number of degrees. The latter system, however, cannot be introduced until the oscillations are determined by the former; and besides from year to year the oscillations at definite depths will not always be the same, because they depend upon the temperature of the outside air, I should therefore give preference to the former system. For the wants of civil life, as, for instance, Agriculture, it is necessary to have depths than about 10 fathoms.

For the wants of civil life, as, for instance, Agriculture, it seems that greater depths than about 10 feet are hardly wanted in our latitudes, as according to the observations of the last eight years, frost in Germany seldom goes deeper than 3 feet. In higher latitudes greater depths will have to be chosen, and besides, if possible, observations in greater depths might seem to be desirable in stations of the first order, although there too very often the water in the soil will soon set a limit.

Moreover, a great deal depends on the nature of the soil, and especially on the site of observation; as, for instance, whether the thermometers are always in the shade or exposed to the sun. In the garden of this Observatory I have taken the same nature of soil (first 2 feet garden earth, then about 7 feet yellow sand, and then loam), in two different places, and plunged in each a set of earth thermometers, of which one was always in the shade, the other exposed to the sun's rays for the greatest part of the day, and for the last few months have obtained the following results. (The shaded set is marked with A, the other with B:—

Depths in Feet.		0'3		0'8		1'6		2'5		3'3		4'8		6'6		9'8	
Months 1873.		A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
April	43°45	47°88	43°41	46°80	44°46	46°33	44°46	46°15	44°56	45°79	44°38	44°31	44°46	43°66	44°24	44°13	
May	48°13	53°96	47°41	51°64	47°88	51°08	47°84	50°32	47°80	48°81	47°01	48°00	47°23	47°19	46°40	46°76	
June	57°34	64°51	50°84	61°95	56°52	60°94	55°36	58°32	54°18	57°20	52°34	53°64	51°40	51°94	49°21	50°00	
July	62°17	69°87	61°95	67°28	61°84	65°95	61°02	63°36	59°76	63°24	57°92	58°50	56°48	56°59	53°17	53°92	
August	62°80	69°69	62°31	66°52	62°49	65°37	63°28	63°75	61°05	62°89	60°04	60°15	58°86	59°00	55°90	56°41	

These figures show, as would be

These figures show, as would be supposed, that the sun raises the temperature in the earth to a very considerable depth, but how great this influence is, and how much in the above figures is to be referred to special local influences, cannot be proved until the observations have embraced a longer period.

XI.

DESCRIPTION of a SIMPLE WIND-GAUGE which can be fitted on any Prof. Wild.
wind vane. By H. WILD.

REPORT to the SECOND SUB-COMMITTEE appointed to discuss Questions 7-9 Wind gauge.
of the Programme.

In the year 1861 I introduced at the Meteorological Stations of the Canton Berne a *wind vane with a simple wind-gauge*,* which has worked admirably there, and was introduced later to the other meteorological stations in Switzerland, as well as those in the Grand Duchy of Baden. I was afraid that this apparatus would not be suited to stand the severe winter of the North, and so I did not introduce it at the Russian stations until an instrument of that kind had acted for at least two years, without the least disturbance, at the Central Observatory in St. Petersburg. Since that time we have not received a single complaint from any of our stations which have received the new apparatus.

The *wind-vane* consists of an iron pipe with a steel cap on its upper end, which rests on the steel point of an iron rod, passing through the pipe and therefore turning with great ease round this point. On its lower end the pipe carries on one side the vane, consisting of two plates of sheet iron, inclined at the angle of 20° to each other; and on the other side a rod with a counterpoise of lead; on the upper end of the pipe the *wind-gauge* is fixed. This is composed of a horizontal bar, fastened to the pipe by means of a ring, and serves to hold a rectangular plate of tin. The latter is held at its upper edge, which is somewhat thickened by the points of two screws inserted in the bar which serves as a horizontal axis of rotation for it, and when it turns about them it moves along an arc attached to the same bar; four points attached to this arc serve to determine the angle of deviation of the tin plate, when it, after having first been arranged by the wind at right angles to the wind vane, is disturbed from its vertical position of rest. The plate is 1 foot long and 6 inches wide, and weighs 9 ozs. Originally the points were placed in such positions that the plate, when lifted to them, made the angles of 15° , 40° , 63° , and 76° with the vertical, and this gave, in accordance with the usual estimation of the wind's force, Light, Moderate, Strong, and Stormy winds. This scale of 4, or strictly speaking of 5 parts, has, just as the scale of 10 lately adopted by us, and as all other wind scales in use, so much that is optional that it cannot be satisfactory, and prevents any comparison with the existing wind-force scales. Since at the Meteorological Conference at Leipzig metres per second were recommended as a general measure for wind velocity, it seemed to me desirable to replace all scales of wind-force by one expressed in this absolute measure, so that a very simple instrument might at least give the Force or the Velocity of the wind by approximate measurements according to this measure. For this purpose the above wind-gauge seemed quite suitable. We only have to find out to what angles winds above the velocity of 1, 2, 3, &c. metres per second will lift the plate. Unfortunately the present state of aerodynamics will not allow us to determine these angles theoretically; they can therefore only be determined empirically.

As soon as the Observatory got last autumn one of Combes' apparatus for testing anemometers I directed one of the assistants of the Observatory, M. Dohrandt, to carry out the empirical graduation of the above-named wind-gauge therewith. I reserve it for M. Dohrandt to give the complete account of his numerous series of observations with this and other instruments, especially Robinson's, and shall only give the final results at which he arrived for the instrument which is now in question.

Under the hypothesis that the plate is 9 ozs. in weight, 1 foot high, and 6 inches

* H. Wild, Report on the Meteorological Operations in the Canton Berne in the year 1861. Mittheilungen der Natur-forschenden Gesellschaft in Bern für 1862, p. 221.

Suppl. XI. wide, the following are the angles in which it is raised by the following
Prof. Wild. winds :—
Wind gauge.

Wind-velocity in Metres per Second.	Lifting Angle of the Plate.	Wind-velocity in Metres per Second.	Lifting Angle of the Plate.
1	2.0	7	52.6
2	7.0	8	62.0
3	14.0	9	66.3
4	22.8	10	69.9
5	32.7	12	74.2
6	42.3	14	77.0

The apparatus has only been accurately tested up to 10 metres per second; the two last figures are graphically interpolated.

If we insert on the graduated arc a point at the place corresponding to the angle of each of the even numbers for velocity (excepting 12) and so, on the whole, have 6 points, it is very easy, even when the vane is placed on a mast 33 feet high, to read the position of the plate, on an average to within 5° accurately, and so to determine the individual metres per second of the velocity of the wind. According to M. Dohrandt's experience, it is to be recommended not only to take the mean position of the oscillating plate, but during about 5 minutes to observe the two extreme positions of it; as the mean of the latter gives much more easily and certainly the true mean velocity at the time of observation.

In making the plate, care should be taken that the above dimensions should be preserved as accurately as possible, but small variations in the weight even of + 300 grains have only produced slight alterations in the angles of deviation. The pipe which stands before the plate, and so is first struck by the wind, and keeps something off from the plate, has in our instruments a diameter of 0.7 in.

The usual designations of the winds would, therefore, correspond in the following way to the measured velocities :—

Usual Designation of the Wind.	Velocity of the Wind.		
	Metres. Per Second.	Kilometres. Per Hour.	English Miles. Per Hour.
Very light breeze	1	3.6	2.2
Light	2	7.2	4.4
Gentle	3	11	6.7
Moderate	4	14	9
Moderately fresh	5	18	11
Fresh	6	22	13
Very fresh	7	25	16
Moderately strong	8	29	18
Strong	9	32	20
Very strong	10	36	22
Rather violent	12	43	27
Violent	14	50	31
Very violent	16	57	36
Moderate storm	18	65	40
Storm	20	72	45
Heavy storm	23	83	51
Moderate hurricane	26	94	58
Hurricane	30	108	67
Violent Hurricane	35	126	79

Our wind gauge would, therefore, only enable us to measure the Force or Velocity as far as "violent wind." For stronger winds we must estimate the

degree of force according to the distance the plate passes beyond the last point. If we have to measure greater velocities, a second instrument with a heavier plate of the same area may be used, but for such, an empirical graduation will meet with not unimportant difficulties.

XII.

REPORT on the INSPECTION of the SCOTTISH METEOROLOGICAL STATIONS, by ALEXANDER BUCHAN.

Suppl. XII.

Mr. Buchan.
Inspection.

The instruments I take with me on inspecting stations, are :—

- A Board of Trade Barometer.
- An Aneroid Barometer.
- A Standard Thermometer.
- A Rain Gauge testing apparatus, and
- A Compass.

On arriving at the station I hang the barometer and aneroid side by side with the barometer at the station; then collect all the thermometers and place them along with the standard thermometer in a basin of water, selecting if possible a room where there is no fire.

After some time has been allowed to elapse the comparison of the different instruments is made.

1. Barometer.

The Board of Trade Barometer and Aneroid are compared with the Standard Barometer in the Society's office before and after the visit of inspection.

The Aneroid is taken as a check on the Board of Trade Barometer, since it is found that, however great be the care taken, air does sometimes, though doubtless rarely, get into the tube of the barometer in the transit; and the aneroid enables me to know whether this has occurred before or after the inspection of the station barometer.

The following readings are taken :—

	Own reading.	Observer's reading.
Board of Trade barometer	-	-
Aneroid	-	-
Station barometer	-	-

It is seen if the observer can set his barometer (ivory point, &c.) and the vernier, and read off correctly. The liability of such errors of observation occurring at: 1.000 inch, 0.500 inch, or 0.050 inch, either too high or too low, is pointed out to the observers, and how they are likely to happen.

If any air be in the tube of the barometer, I expel it, unless it be a Board of Trade barometer, in which case it must be sent to an optician.

2. Thermometers.

At every inspection the thermometers are compared with the Society's standard at least at one temperature, viz., that of the basin of water referred to above which has been in a room of a practically uniform temperature for about two hours, the object being to ascertain whether the mercurial thermometers or the others read any higher than at the previous comparison, or whether any minute portion of the spirit be lodged, unseen, at the top of the tube. It has been found that none of these points can be satisfactorily ascertained unless the thermometers be placed in a fluid of uniform temperature for a considerable time. If any of the spirit be lodged in the top of the tube, I expel it and show the observer how to do it himself.

If I have a list of the errors of the instruments, obtained by a previous comparison, or by certificate from Greenwich or Kew, I am content with the examination of the temperature at one point of the scale; but if I have no such list of errors, a comparison is made at three points, viz., at freezing, if ice can be obtained, at the temperature of the room, and at from 70° to 80°.

Suppl. XII.
Mr. Buchan.
Inspection.

The observer reads the thermometers, and goes through the process of setting the maximum and minimum thermometers, that I may see he understands this part of his work, and occasion is taken to point out the liability to error, even by the best observers, of 10° and 5° .

In reading the thermometers special attention is given to see that the underground ones are read properly; that the eye is on a level with the mercury of the thermometers.

Particular attention is paid to the state of the muslin of the wet bulb of the hygrometer, and generally that this instrument is kept in good working order.

The mode of taking the temperature of the sea by boat (or otherwise) and the place where the observations are made are carefully noted, and inquiry is made as to local currents, so as to ascertain whether any currents from heated or cooled sands are likely to affect the readings.

III. Louvre Board Box for Thermometers.

The following points are noted:—

1. Its colour outside.
2. " " inside.
3. In what direction the door opens.
4. Extent of grass plot in which it is placed.
5. The bulbs of minimum thermometer and those of dry and wet hygrometer hang at the same level, viz., 4 feet above the ground, and that the maximum thermometer is hung above the minimum thermometer.
6. Distance of bulbs of minimum thermometer, dry and wet from lower edge of louvres.
7. Fixing of box, if sufficiently firm and secure.

I am directed to give very special attention to these points with the view of securing uniformity in the observation of the important element of temperature at the society stations.

IV. Rain Gauge.

The following points are ascertained:—

1. Material it is made of and its construction.
2. Diameter; four diameters being measured.
3. Measure. If measured by a scale the scale is compared with a standard scale. If measured with a graduated glass measure showing 0.10 and 0.01 inch, these measures usually being made to 0.50 . Water is poured into the observer's measure and it is seen how many standard grains of water correspond to 0.10 , 0.20 , 0.30 , &c., inch. The graduation of the hundredths are compared with standard scale.
4. Height above ground.
5. Height above sea level and how this has been ascertained.
6. Position, if sufficiently free and open. Distance of any shrubs, trees, walls, houses, &c., from the gauge. The direction in which these obstructions to the free exposure of the gauge lie is noted, and height of these obstructions above the horizon is measured with an Altimeter.
7. Position of gauge with respect to hills, rising ground, and valleys, likely to influence the amount of the rainfall of the district where the gauge is placed.

V. Wind.

1. Direction, how taken, by vane, smoke, &c., and whether the points used by the observer be true N., S., E., and W., are ascertained by compass. The direction is entered true, not magnetical, by the observers.
2. Force, whether observer gives his estimated force, uniformly with the other observers, is sought to be ascertained by the estimated force he gives at the time of inspection. The scale adopted is 0 to 6, and it is attempted that these conform to Beaufort's scale (0-12) 1 agreeing with 2, 2 with 4, &c.

If, from the past observations of the observer, very much wind or very little wind has been reported from the station, it is inquired into whether the excess

or defect is due to the erroneous estimations of the observer, or to the fact of really a greater (or a less) force of wind prevailing at the place. Mr. Buchan.

At a good many of the stations, H. C. Anemometers are in use. I cannot however say that the working of these instruments is quite satisfactory. As we have no proper means of testing the correctness of their indications we do not know how many (if indeed any at all) of these instruments give positive results, and it is certain that nearly the whole of them are not comparable *inter se*. Inspection.

There are also a number of simple pressure anemometers at the stations, which show the maximum pressure of the wind and the pressure at the moment of observation.

VI. Clouds.

The estimation of the amount is on scale 0 to 10 from the zenith to altitude 45° .

The species is from Howard's nomenclature.

The direction of motion is estimated, in one or two cases measured by an instrument specially constructed by Mr. T. Stevenson for the purpose.

The correctness of the observer's estimation of the amount, species, and direction of motion, is ascertained.

At several stations both upper and lower clouds are observed when this can be done.

VII. Evaporometer.

The evaporation is observed at present at four stations, but there is very great difficulty in securing comparableness in the results of these instruments, and the positions in which they are placed.

VIII. Ozone.

Whether Schönbein's, Moffat's, &c., test papers are used is noted, the exact method of exposure, and observer's estimation of depth of tint.

The results of the inspection are entered on a previously prepared blank Form, the details being filled in as the inspection proceeds. The Form secures that nothing is omitted.

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This Index is only a translation from that furnished with the German edition. It is hoped that the copious cross references will in some measure supply the want of a fuller Index.

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