PROGRAMME OF WORK OF AN INTERNATIONAL POLAR EXPEDITION

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[This programme was written in May 1877 for discussion by the International Meteorological Congress due to meet in Rome in September that year, and which political events caused to be adjourned to the following year]*[1]

Translated from the French by Colin Summerhayes, Executive Director, Scientific Committee on Antarctic Research, Cambridge, October 2007.

** [1] Translators note: This is a verbatim translation of the note on the front page of the article; in fact the meeting was eventually held in Rome in April 1879. It is not entirely clear why, but at its end the manuscript is dated 30 September 1877; perhaps this reflects the fact that it was written in May for presentation at a September meeting.*

The enterprise that we propose to achieve has for its goal to undertake scientific exploration and, contrary to what most expeditions have done before, to make geographic discovery a secondary goal; this will therefore be the first step towards a systematic study of the regions of the terrestrial poles and towards the detailed observation of the phenomena particular to these regions, phenomena of which serious investigation is of the highest importance from the perspective of a large number of problems concerning the physics of the globe.

The goal of the expedition is to make, in the Arctic and Antarctic, or around those regions, and at as many stations as it may be possible to establish, synchronous observations following a programme decided upon in concert, so as, on the one hand, on proceeding through comparison, to deduce from observations collected at different points, independent of the particularities that characterise the different years of observation, the general laws governing the phenomena under study, and on the other hand, to calculate what chance there may be of penetrating further into the interior of these unknown regions.

To that end, each of the States participating in the work is obliged to equip at its own expense and to send an expedition to one of the places designated at the end of this programme. It will be up to each of the interested parties to decide in what measure they wish to prolong their expedition, as well as to determine the questions to address aside from those that will be fixed.

The investigations made in concert will only address the phenomena of meteorology, terrestrial magnetism, the aurora borealis, and the realm of ice.

At each station, observations must be continued throughout a whole year, commencing 1 September 18xx and finishing 31 August 18yy.

The meteorological observations must be made in conformity with the resolutions of the permanent International Committee, and will apply to atmospheric pressure, the temperature and humidity of the air, the direction and force of winds, the state of the sky and its degree of cloud cover, and to condensation.

Atmospheric pressure will be noted by means of a mercury barometer, by preference that of Fortin. One could use an aneroid barometer for intermediate readings, but in that case it will be necessary to calibrate it against the Fortin instrument each time it is used.

Air temperature will be observed by means of an alcohol thermometer that must be suspended from a convenient point 50 metres at least from the edge of the station, and sheltered from the direct influence of condensation and the sun. Corrections to the thermometers must be effected in place, by means of standard (type) thermometers.

Every day the minimum reading will be taken. Humidity will be measured either by a psychrometer or by a hygrometer. Wind direction will be observed in relation to the16 principal compass directions. The direction of high altitude winds will be measured from observations of the movement of clouds.

Wind strength will be measured using the Wild anemometer. However, as it is likely that this instrument will give erroneous readings during frequent flurries of snow, in that case it will be necessary to estimate wind strength according to the Beaufort Scale (0-12).

The state of the sky will be recorded following the method of Howard, on a scale of 0-10, where 0 = clear.

As condensation [*translator's note – from the context, this may be taken to mean 'precipitation'*] cannot be measured exactly during blizzards, observations should indicate simply the duration, in adding 'light', 'medium', 'strong' etc. It will be necessary to note times when blizzards have prevented noting whether or not there was any real condensation [*precipitation*].

All measurements must be noted in metric terms; temperatures in degrees Centigrade.

Where circumstances permit, measurements should be made once a day of the temperature, density and salinity of the water.

It is presumed that all the stations will be established close to a coast. As one of the main goals of the expedition is to study the connection between the displacement of ice and the principal motors of that displacement, the winds and currents, it will be necessary to observe regularly the state and movement of the ice. There is reason to believe that the study of the distribution of ice in relation to the predominant winds and to periods of storms, if made at a large number of points as close as possible to the poles, will allow establishment of a theory of the movement of ice in Arctic regions, and thus enable us to find out more about the best ways of penetrating further poleward.

Observations of the temperature and humidity of the winds, combined with the wind direction, if made in concert at different points, will provide important results for the study of the distribution of ice.

However, useful results will only be obtained if the stations are placed close to an open coast where the movement of ice is not too influenced by local conditions. It will be necessary daily to observe the position and the drift of ice, preferably form a high point. In stations where tides can be observed it will be necessary to erect a tide gauge.

Magnetic observations will include absolute determinations (*translator's note: meaning determination of the magnitude of the magnetic field strength*) and determinations of the variation of the three main elements (*translator's note: inclination, declination and horizontal intensity*). The measurements of absolute magnetism are intended to serve as a check on the state of the instruments for magnetic variation, in that each reading of variation constitutes an absolute value. To this end it will be necessary by means of often repeated measurements of absolute magnetism to determine the absolute values of the zero of the scale, as well as the changes that occur. [*Translator's note: this is presumably to eliminate instrumental drift*]

To achieve that goal, the absolute magnetic observations must always be accompanied by readings made on the instruments measuring magnetic variation. In countries where the perturbations of the needle are incessant, it will not suffice to proceed with an approximate synchronicity; on the contrary, each reading of the instrument for absolute magnetism must coincide rigorously with one of the corresponding instrument of variation, and the needles of both must to the extend possible be endowed with equal mobility.

Now, this simultaneity can only be achieved if the place which serves for absolute determinations is quite close to that which shelters the instruments of variation, enabling the observers to communicate by voice.

As perturbations often persist for some days, thus preventing measurements of absolute magnetism, the intervals separating the taking of these measurements cannot be fixed. Given that the changes that the compasses experience are always strongest at the start, the instruments should be verified more frequently during the early periods following their installation.

On average, absolute determinations of the three elements must be made every 8 days, so as to note the changes that may have been produced in the position of the zero of the instruments.

The instruments used for the absolute observations for a comprehensive station comprise:
A compass needle of declination;
A compass (dip) needle of inclination; and
A "single wire" (unifilaire) instrument *(translator's note: for horizontal intensity).*

The needles of these instruments must be as light as possible, given that heavy needles oscillate under the influence of tine magnetic perturbations. The suspension wires must be reduced to their extreme limit of resistance.

The compass of declination must be graduated to give the minute of arc and to allow easy evaluation of tenths. By preference instruments should be used in which the needle is suspended in a way that minimises the possible effects of torsion.

The "single-wire" (unifilare) instrument must be provided with three deviating magnets, which must be placed at different distances.

The compass of inclination must be furnished with three needles. It is sufficient that it gives the minutes of arc.

At the beginning and end of the observation period, the instruments must be examined and their constants determined in an observatory.

The instruments of variation must be made in such a way as to show immediately the changes produced by either torsion or the magnetism of the needles.

To this end two instruments will be needed for the observation of the variations in each of the three elements. So that the methods of observation can be checked against one another, a "single wire" (unifilare) and a "double wire" (bifilaire) instrument should be used for horizontal intensity.

Every day at a time closest to noon, a synchronous reading must be made of these two instruments.

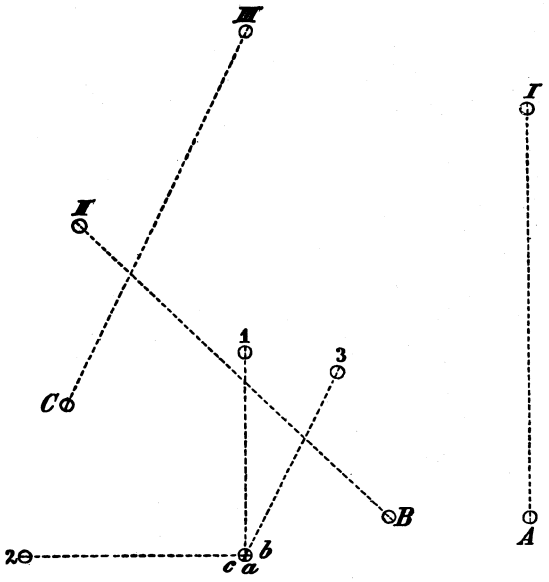
All the instruments of variation must have a small travelling telescope (lunette) on a fixed graduated scale, allowing the reading by mirror [*Translator's note: of changes in the positions of the needles*]. The scales must be of sufficient size to enable readings to be made on an arc of 10 degrees in both directions.

One of the systems must be arranged so that lunettes are found on the same axis or are quite close to one another so that the observer can see both without having to leave his seat for the successive readings. It is by means of this system, to which the "double wire" (bifilaire) instrument belongs, that the hourly observations will be made.

For the second system the lenses will be distributed in such a way that three observers can observe the three elements synchronously, so as to determine exactly the variations in total intensity.

If the distance between the mirrors of the needles and the scales is 1 metre in the first system [*Translator's note: with the "double-wire" (bifilaire) system*] and 2 metres in the second system [*Translator's note: with the "single-wire" (unifilaire) system*], the two systems can easily be installed in an observatory of 3 metres by 3.5 metres, without much

influencing one another. The sketch enclosed shows the interior plan for an observation of this type.



I, II and III and 1, 2, and 3 mark the instruments of declination, horizontal intensity and inclination. A, B, C and a, b, c are the bases on which the lenses are installed.

An observatory of this type can be made of planks. Thick walls of snow, which are easy to build, offer sufficient shelter during periods of extreme cold, and protect the instruments against sudden changes in temperature, as long as the openings are protected by narrow snow corridors. It is more difficult in summer to guard against the effects of melting snow and sunlight. In that case a double layer of waterproof canvas can be used. Where possible the bases must be made of masonry. Wooden bases must be solidly entrenched in the ground.

The constants of the instruments of variation must be rigorously determined in place both before beginning the series of observations as well as after they are completed. Careful consideration must be given to the rigorous determination of the value corresponding to each division of the scale.

If there is reason to believe that there has been a change in the constants caused by some modification or other, it will be necessary to determine the constants anew. But the regular observations must never be interrupted by the simultaneous dismantling of the two instruments measuring the same magnetic element.

All the calculations relative to these observations must be made in place so that the observer can be assured of their exactness and can repeat them as needed.

Before beginning observations of vertical intensity, the bars of induction must be suspended for at least 8 days in their normal position.

The deviating magnets of the “single wire” (unifilaire) instrument can be compensated so as to avoid having to make corrections for changes in temperature.

To observe the aurora borealis, a small telescope (lunette) will be needed, fixed to one mechanism for horizontal movements (azimuth) and another for vertical movements, allowing a reading in both directions to around half a degree. Instruments with higher precision will be needed where it is necessary to determine the parallax.

As of all the phenomena to be measured the changes in terrestrial magnetism are those which take place most rapidly, the simultaneity of observations is an essential condition for all that touches on this domain.

For all previous magnetic observations the time of Gottingen has been adopted. Consequently all stations should use Gottingen time. Each station will use the same time of day for its observations, on the hour.

Where there are persistent perturbations, isolated readings made from hour to hour, even though made over long periods, will not suffice to determine the hourly, daily or monthly magnetic character of the observing site. Under these circumstances the frequency of observations must be increased.

Ten observations per hour for each of the three elements should suffice. So as to ensure a rigorous synchronicity, it is stipulated that the observations will be made in the following order, following Gottingen time (D = Declination; H = Horizontal Intensity; I = Inclination; m = minutes; s = seconds):

	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s
D	56		57		58		59		60		61		62		63		64		65	
H	56	10	57	10	58	10	59	10	60	10	61	10	62	10	63	10	64	10	65	10
I	56	20	57	20	58	20	59	20	60	20	61	20	62	20	63	20	64	20	65	20

That is to say one must read each of these instruments for a period of 10 minutes, from minute to minute, to know:

On the minute – the declination;
Ten seconds later – the horizontal intensity;
Ten seconds later again – the inclination.

Before and after each observation, at 52 minutes and 69 minutes one would also note the form and position of the aurora borealis.

One would then proceed immediately to meteorological measurements, in the following order: temperatures; humidity; winds; clouds; atmospheric pressure.

Aside from these regular observations of magnetic variation, it will be important for three observers to make rigorously synchronous readings of the three elements, so as to obtain precise data on the total intensity. By this means readings of the three instruments will be made every day, by three observers, from minute to minute during every hour.

The time of these observations must be advanced by one hour each day, in such a way as to return to the point of departure at the end of a 24 hour period.

As one cannot fix in advance the beginning of the session for each station, the hours of observation will be fixed as if the session had begun on the first of January at midnight [*Translator's note – it is likely that this means midnight on December 31st*].

It will be very important, concurrently with the observations of auroras and magnetic research, to study the force and direction of the telluric currents [*Translator's note – natural electric currents near the Earth's surface*] observed in lower latitudes. The best instrument for such research is the galvanometer employed by Lamont, with two conducting wires: E-W and N-S. But as neither the instruments nor the methods of observation offer sufficient accuracy, it is not possible to provide precise instructions on what should be done. It would appear desirable to recommend that this task should be done at those stations that have sufficient personnel.

So as to ensure eventually that these stations have the agreement desired, observations of the E-W readings of the galvanometers should be made at 48 minutes to the hour, and of the N-S readings as soon as possible thereafter. Besides, it is desirable that at those stations, notably during intense magnetic perturbations and during auroras, the series of magnetic and galvanometric readings should be rigorously synchronous.

Observations of atmospheric electricity are desirable, but it is up to each station to decide whether or not to make them.

The aurora borealis must be observed as to their form, intensity and position. They will be classified as follows:

1. Iridescent arcs or arches moving regularly with their summits nearly on the N-S magnetic meridian, and most often with their two extremities reaching the horizon;
2. Irregular streamers, ordinarily entirely enclosed within a limited elongated area; they almost always have the appearance of a flame like pennant that folds with the wind and is made either from some luminous material or of closely spaced vertical rays tied together in some luminous background;

3. Beams or thin long streaks directed from the magnetic zenith to the horizon; they are separated from each other by dark spaces, and most often grouped in a fan that covers much of the sky and has the magnetic zenith at the centre;
4. Crowns (corona borealis) – these are produced by the perspective, when one of the streamers or an arch passes the magnetic zenith. They comprise either a succession of beams or rays darting more or less to the horizon, or an undulatory movement of the light around the magnetic zenith.
5. Sheets, patches, or haze: vague gleams or auroral mists.

In relation to the movement of the light one may distinguish:

(a) waves: luminous waves that move along the length of the streamers and arcs;
(b) flashes: short rays that are both large and intense, which jump very fast from the zenith to the horizon or vice versa, and are only seen normally when one of the streamers begins to change into a corona, or while a corona is appearing.

The intensity of the phenomena can only be measured roughly, as the moon and clouds introduce errors into such measurements. However, as it is likely that much the same errors may be present at each station, measurements should be made as follows:

Printed characters visible through a tube at a given distance by the light of the full moon will be designated by the number 6; those visible at the same distance under a clear starry sky [*Translator's note – presumably with no moon*] will be designated by the number 1. Intermediate numbers will express the visibility of corresponding characters in between.

To determine the position of stations relative to the most frequent zone of auroras, the direction of the horizon must be noted for each observation. The position must be indicated by the magnetic azimuth and not by the true azimuth. One must measure the precise centre of concentration of the beams, the azimuth and height of the arches and of their bases, the direction of movement, the width of streamers and arches at different heights, and the positions of the centres of corona.

In those cases where stations have sufficient personnel, one or more observers must be sent to spend some time 20 to 20 km from the station in the direction of the north or south magnetic pole so as to determine the parallax in a rigorous and synchronous manner. For these observations to succeed it will be necessary to measure, at predetermined times, the height of the phenomena in the direction of the great circle passing through the two points. These observations require instruments of greater precision than those normally used for observing aurora.

The best time for making such observations is October and November, when the temperature is not so low as to require special preparation.

It is vital that all the observations are made simultaneously, so that the same movements, notably those of terrestrial magnetism, can be studies at all stations. As this simultaneity depends on the precision with which longitude is determined, it is necessary to measure that with the greatest possible care.

Each station must thus be equipped with a solidly installed astronomical instrument (such as a theodolite). It can be assumed that if one uses all possible occasions to make the appropriate observations [*Translator's note – of longitude*], one can, after a time, expect the [*Translator's note – scientific*] observations at all the stations to agree to within a few seconds.

The frequency of determinations of time will depend on the accuracy of the chronometers used. In no case should the uncertainty of local time exceed 3 seconds.

It can be assumed that not all stations will have at their disposal resources sufficient for making all of the observations suggested by our programme. In that case it will be necessary to reduce the number of hours of observation from 24 to 12 or even 8.

Whatever the number of hours of observation, it will always be necessary to proceed strictly according to the following instructions.

To execute over their complete range all the required observations calls for 4 observers among men trained to carry out the purely mechanical functions of taking readings.

It is up to each of the interested countries to decide on the editing and publication of the observations.

The meteorological observations will be grouped in series of 5 days, noted by hour, day and month, to be published in full, and the report of these studies will be communicated to all the interested countries.

The magnetic observations will be similarly grouped by hours, days and months and published in full. The auroral observations will be added to that report.

In previous polar expeditions the laws of magnetic perturbations have been determined by different methods and measurements, so that the results obtained by different expeditions could not be compared. So as to ensure, at the time of writing of the reports, a uniformity that will allow an exact comparison, it will be necessary in advance to establish the method by which the variations in terrestrial magnetism will be separated form those considered to be perturbations and those caused by regular variations.

First Proposal: First the hourly general averages will be extracted from all the year's observations. The amplitude of these averages (the difference between the extremes) gives the unit of measurement of the intensity of local perturbation. Every day for which the amplitude of movement of the needle does not pass this unit must be considered as a *calm day*, and it is from those days that the normal monthly averages will be determined.

All the observations which diverge by half of this unit of hourly averages in the month to which they apply must be noted as *perturbed observations*. It is from these observations that the laws of perturbations will be deduced, by distinguishing them as either *positive or negative perturbations*, and registering them by hour, day and month.

Second Proposal: It will be necessary at all times to follow the method indicated by General Sabine. Search the hourly general averages for each month and eliminate those either positive or negative that diverge more than a certain amount taken as the unit of these averages. The rest, for each month, will be used to derive new hourly averages, and the process will be repeated until the hourly averages cannot sustain further modification.

All the observations which depart from the unit adopted for these last normal hourly averages for each month will be reported as perturbations and it is from these that the laws of perturbations will be deduced in dividing them into positive and negative perturbations and in classifying them by hours, days and months.

As the unit, one will adopt half of the amplitude of the hourly general averages obtained from all of the observations. Although this unit is arbitrary, it reflects the magnetic character of the site and period of observation, and so furnishes the basis for comparison.

Third Proposal: The unit used to eliminate the observations of perturbation, so as to deduce their laws, will differ according to the local intensity of disturbance. On the one hand it is about obtaining sufficient regular observations to extract the normal hourly average, and on the other hand about obtaining a sufficient number of perturbations to be able to deduce with certainty the laws that control them.

This unit can only be fixed after the complete classification of observations, so must therefore be established by the writers of the report. It should be settled by mutual agreement.

The most favourable places for these various observations are listed below:

In the northern hemisphere:-

Spitzbergen, on the north coast;
Nova Zemlya, on the north coast;
Finmark, around North Cape;
Siberia, on the north coast near the mouth of the Lena;
New Siberia;
Point Barrow, northeast of Bering Strait (occupied by Maguire, 1852-54);
Greenland's west coast, occupied by Denmark;
Greenland's east coast around 75N latitude.

In the southern hemisphere:-

Around Cape Horn;
Kerguelen or the Macdonald Islands;
One of the groups south of the Auckland Islands.

Each of the interested countries is asked to established a station at its own costs for at least a year at one of the points suggested above, and to conform strictly to the proposed programme.

Vienna, 30 September 1877.