PRELIMINARY NOTE ON AN "INTERNATIONAL MAGNETIC STANDARD."

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The intercomparisons of magnetic instruments made by the various investigators during the past fifteen to twenty years have served to call attention to the discrepancies existing between the determination of the magnetic elements by various observatory and magnetic survey instruments. These discrepancies frequently exceed the errors of observation. At the recent meeting of the International Meteorological Conference held at Innsbruck in 1905, renewed consideration was given this important matter by its Committee on Terrestrial Magnetism.

The extensive magnetic operations of the Carnegie Institution of Washington have necessitated giving the adoption of an "International Standard" correct to within at least the allowable error of field observations early consideration. In the course of the work thus far executed, comparisons have been obtained between the following magnetic observatories: Cheltenham (Maryland), Toronto-Agincourt (Canada), Baldwin (Kansas), Mexico (Mexico), Havana (Cuba), Sitka (Alaska), Honolulu (Hawaii), Apia (Samoa), Tokio (Japan), Zi-ka-wei (China), Hongkong (China), Christchurch (New Zealand), Sydney and Melbourne (Australia). Further comparisons will be obtained in 1908-9 in Europe, Africa and Asia in the course of magnetic work to be executed during this period.

Combining all the comparisons made up to date by various investigators and organizations, for which the data are at present on hand, it would appear possible to come to some preliminary decision as to the approximate corrections of some of the observatory standards upon an "International Standard." For example, tabulating the results of the horizontal intensity comparisons made since 1897, it is found that the Potsdam standard invariably is *low* on Kew, Parc St. Maur, Pawlowsk, Rome, and Pola, by amounts varying from 5 γ (.0002H) to 45 γ (.0025H).¹ On the average, of the observatories named, the values of horizontal intensity, H , observed with the Potsdam Standard would require to be

¹ It is not correct to assume that the intensity correction of a magnetometer, expressed in absolute units, will remain the same with change of magnetic field, the amount of the correction depending, in fact, upon the absolute value of the intensity at the place of observation. From whatever source the correction arises, it can be expressed, with close approximation, by a simple ratio change, i. e., a factor multiplied into the first power of the value of the intensity, only in certain extreme cases will a second term involving the second power of the intensity enter in appreciably.

increased by about 21γ ($.001H$). It would likewise appear that the Potsdam instrument might give too large west declinations (or too small east declinations) by about $\frac{1}{2}'$ or $\frac{3}{4}'$ on an "International Standard."

The Cheltenham Standard, to which all the magnetometers of the Coast and Geodetic Survey and of the Carnegie Institution have been referred in the past, would appear to give too *large* value of H by about $0.001H$ on an "International Standard." This is shown not only by the comparisons referred to in the previous paragraphs, but also by the intercomparisons of the instruments in the United States alone, as well as by the comparisons made in 1904 by Dr. Linke¹ between Cheltenham and Potsdam, and comparisons made with his instrument at Apia by the "Galilee" in 1906. About sixteen magnetometers of the most varied design and make, belonging partly to the Coast Survey and partly to the Carnegie Institution, for each of which all the various constants have been completely determined so as to make each instrument an *absolute* or *independent* one have been compared, at various times during the past years with the large Wild-Edelmann magnetometer used as standard at the Cheltenham Observatory. Frequent checks upon the results of these comparisons have been obtained by intercomparisons of the various individual instruments in the field or at the observatories to which they were assigned. Almost invariably it has been found that the correction for the horizontal intensity determinations made with these sixteen instruments is positive on Cheltenham, so that in turn the Cheltenham standard would give horizontal intensities too high on the average of the sixteen independent magnetometers by about $0.001H$.

Kew appears to come very close to an "International Standard." It may also be recalled that Watson's revised determination of the value of the horizontal intensity in international units agreed practically with that derived from the Kew magnetometer.²

Judging from Linke's result of the comparisons between Potsdam and Cheltenham, it would seem that the "International Standard" is, moreover, about midway between these two observatories. *I have decided for the present at least, as a matter of convenience, to accept the Cheltenham H standard diminished by $0.001H$ as the provisional International Standard for the Carnegie Institution work.* It is believed that this will be found correct on an "Absolute International Standard" to within $\pm 0.0005H$, or one two-thousandth part.

As far as the corrections to declinations observed with different in-

¹ F. LINKE. Vergleich der Messung der Horizontalintensität des Erdmagnetismus in Potsdam und Cheltenham in Jahre, 1904. Nach. Gesell. Wiss. Göttingen, 1907.

² Cf. CHREE, C.: Mr. Watson's comparison at Kew Observatory, *Terr. Mag.*, vol. VII, 1902, p. 199.

struments are concerned, the experience up to date has been that the differences between any two carefully constructed instruments are generally below 2', and that the corrections on any one standard are, in general, less than 1'. Only in a few cases, unless there is some radical defect, does the correction amount to more than 2'. *In intercomparing instruments, experience has repeatedly shown that the declination comparisons should, by all means, be included.*

The experience in the Coast and Geodetic Survey and the Carnegie Institution have been that good, modern earth-inductors of varied make will give values of the inclination agreeing within a fraction of a minute. The corrections for dip needles will receive special attention in a future paper.

In conclusion, it may not be amiss to point out a few matters which experience has shown highly desirable in intercomparison work of the highest order.

a. Every precaution should be taken to eliminate local differences in the magnetic field between stations occupied by standard and by instrument compared, either by the method of exchange of stations or by some special investigation. [It has happened that the instrument compared could not be mounted at the place of the observatory standard, and the assumption was made that for lack of *a priori* reasons to the contrary, the magnetic field at the two stations was precisely the same. More care in this matter appears essential. By previous notification to the director of the observatory to be visited, arrangements can usually be made to permit of exchange or occupation of identical stations.]

b. The observations between the instruments should be strictly simultaneous, each observer, if not following the identical method, adopting one of equal value, at least, the observations with each instrument being reduced preferably (though not necessarily in this instance) to the same basis with the aid of the observatory registrations. If simultaneous observations between two observers are not possible, then special standardizations of base lines of magnetographs before and after the comparisons by the observatory staff are required.

c. It is extremely desirable that the instrument compared be an absolute instrument with constants well determined, and that frequent controls be had in the course of the work upon those of the constants likely to suffer change in transportation.¹ The observer and observatory should reduce their observations and compare results at once, so that anything which does not appear quite right can be immediately investigated, thus avoiding needless worry and useless future correspondence. It appears unfair to an observatory, after the interruption

¹ This does not prevent the observer using his instrument, of course, also as a purely relative one, if he prefers.

in its work necessarily caused by the comparisons, not to be informed promptly of the general results. A long delay, in fact, may defeat in some measure the very object of the comparisons.

d. A really successful and valuable comparison supposes a careful individual study of the instruments compared. Thus, for example, any magnetic impurity in the materials of which the instrument is constructed will have different effects according to its orientation with respect to the magnet system. The comparisons should, therefore, include every possible relative orientation of the various parts concerned and be made in fact under the most varied conditions possible. There are, indeed, so many points to be considered, that the most successful results can be hoped for only from one who can make a specialty of this kind of work. Fortunately for the requirements of magnetic survey work the highest refinement is not demanded. For observatory work, however, careful attention is required as to the "constancy" of the observatory standards. It would be highly desirable to have two separate sets of absolute instruments, one set for regular use which is compared, say, once a month with the second or reserve set. [In some instances, because of change of constants or of instruments or for some other uninvestigated cause, the observatory observations can not be used as effectively for the determination of secular variation as good field observations.]

e. Complexities and multiplicity of instrumental parts will, in general, be found detrimental. The massing of any metal near the magnets is to be avoided. If copper dampers are used, they must be carefully tested as to freedom from magnetic impurities. [Judging from the experience had with various instrument makers, the procuring of absolutely pure brass or copper is apparently not a simple matter. The only safeguard appears to be in making the magnet house of wood and sufficiently large so that the suspended magnet will come far enough away from the metal parts. The magnetometers with brass magnet houses have been found, in general, either owing to impurities, or to damping effects, or to some other as yet undiscovered cause, to have appreciable corrections, especially to the H determinations.]

f. Dip intercomparisons are preferably to be made with approved earth-inductors, and not with dip circles, as the corrections to dip needles are known to be a function of the dip. However, the question of constancy of earth-inductor results in all magnetic latitudes requires early consideration.