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PROGRESS OF WORK IN TERRESTRIAL MAGNETISM

OF THE

U. S. COAST AND GEODETIC SURVEY

July 1, 1927, to June 30, 1930

Report to the Section of Terrestrial Magnetism and Electricity
of the International Geodetic and Geophysical Union
International Research Council

BY

DANIEL L. HAZARD
Assistant Chief, Division of Terrestrial Magnetism and Seismology

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PROGRESS OF WORK IN TERRESTRIAL MAGNETISM OF THE UNITED STATES COAST AND GEODETIC SURVEY, JULY 1, 1927, TO JUNE 30, 1930

By D. L. HAZARD, *Assistant Chief, Division of Terrestrial Magnetism and Seismology*

INTRODUCTION

The field of the United States Coast and Geodetic Survey is continually broadening. Airway mapping has recently been added to its functions and compass data are now supplied to the navigator of the air as well as to the navigator of the seas. Engineers using magnetic methods in geophysical prospecting and investigators of radio transmission are more and more making use of the results of the magnetic work of the bureau. The officers in charge of the work are keeping in close touch with the progress in their own and allied fields by participation in the work of the American Geophysical Union and other scientific organizations and by close cooperation with the department of terrestrial magnetism of the Carnegie Institution of Washington, the Naval Research Laboratory, and other Government bureaus, so that they are prepared to take advantage of the latest developments in methods and instruments and make the most advantageous use of the facilities at their disposal.

MAGNETIC SURVEYS

In the continental part of the United States the work of the past three years has been devoted primarily to the occupation of repeat stations for the determination of the change of the three magnetic elements with lapse of time. Observations for this purpose have been made at 110 stations scattered over the country. Additional information on the secular change was derived from observations at 80 places where replacement of lost stations was made at the request of local surveyors.

The use of a small motor truck as means of transportation has made it possible to carry on this work much more efficiently and has permitted the inspection of old stations along the route of travel without serious delay in the observing program. With the completion of the present season's work the secular change data needed for the preparation of an isogonic chart of the United States for 1930 will be available.

In connection with hydrographic and topographic resurveys of portions of the coast, mainly on the Pacific side, determinations of

the magnetic declination have been made at intervals of about 10 miles.

In Alaska complete observations have been made at 15 repeat stations, 5 along the coast and 10 in the interior. Observations were secured also at six new stations in the interior. In connection with general surveying operations, declination observations have been made at numerous triangulation stations along the coast in order to develop the irregularities of distribution known to exist, particularly in southeastern Alaska.

In Hawaii observations were secured on Nihoa and Necker Islands, where large local disturbances were found, and on French Frigate Shoals.

In the Philippine Islands declination observations were made at numerous triangulation stations, mainly in the Sulu Archipelago and along the East Coast of Luzon.

MAGNETIC OBSERVATORIES

The five magnetic observatories have been in continuous operation throughout the three years. The declination and horizontal intensity variometers have shown satisfactory stability, as a rule, so that it has been possible to use the direct scaling method in the tabulation of hourly values. For vertical intensity the changes of adjustment and consequent changes of scale value have been too frequent in some cases to justify the use of that method.

A considerable number of the changes of adjustment have resulted from the manipulation of the deflector and deflection bar in scale value determinations. These have been eliminated by the use of a larger deflector mounted at a greater distance and entirely detached from the variometer. Suitable supports are attached to the wall of the building so that the deflector may readily be placed in position north (or south) of and at the same distance from each of the three variometers. Deflections are made at one distance only. With the exception of Cheltenham the supports are outside the variation room and provision is made for cutting off the light from the variometers from the outside, so that it is not necessary for the observer to enter the room during the scale value observations.

The Cheltenham (Md.) observatory has served as the base station for the standardization of instruments and as a place for experiments and tests in connection with the modification of old instruments and the development of new ones. Its records are being used extensively by those engaged in the study of variations in radio reception and for other purposes.

At the San Juan (P. R.) observatory much trouble has been experienced in protecting the variation instruments from the disturbing effects of excessive humidity. With the discontinuance of the use of the deflection bars for scale value determinations it has become possible to inclose the variometers and pier in a housing very nearly air-tight. This should make it possible to keep the humidity inside the housing within reasonable limits with the use of only a limited amount of calcium chloride. The severe hurricane of September 13, 1928, completely destroyed the office building, but fortunately neither the absolute nor variation buildings suffered material damage, and there was only a brief interruption in the

operation of the observatory. A new reinforced concrete office building has now been erected, which should withstand the severest storms. Provision has been made for the installation of a seismograph in the basement of this building.

At the Tucson (Ariz.) observatory a building was erected in the summer of 1929 for observations of atmospheric electricity, and instruments for the photographic registration of conductivity and potential gradient were provided through the cooperation of the department of terrestrial magnetism of the Carnegie Institution of Washington. These have been in successful operation since October, 1929. This observatory supplies prompt notice of the occurrence of magnetic disturbances to a score or more of engineers using magnetic methods in prospecting for oil in the southern part of the country. Remodeled H and Z variometers compensated for temperature have been installed at Tucson in place of the ones which had been in operation since the establishment of the observatory.

The Sitka (Alaska) observatory has been supplied with a remodeled magnetometer in place of the one which had been in use since 1906, and advantage was taken of the exchange to secure a needed comparison between the Cheltenham, Sitka, and Tucson standards. Systematic auroral observations have been continued, but the prevalence of clouds renders Sitka a very unsatisfactory place for celestial observations. Fortunately, a grant from the Rockefeller Foundation has made possible the establishment of an auroral observing station at the Alaska Agricultural College and School of Mines at Fairbanks, an admirable site, and copies of the Sitka magnetograms are being supplied to that station for comparison purposes.

A change of magnetometers was made at the observatory near Honolulu, Hawaii, in August, 1926, and this provided an opportunity for the comparison of the standards of this observatory with those of the Tucson and Cheltenham observatories.

INSTRUMENTS

Continued attention has been given to the improvement of the instrumental equipment of the observatories, but progress has been slow because of the limited personnel available for work on instruments.

Cheltenham, Tucson, and San Juan are now equipped with H and Z variometers compensated for temperature and a remodeled Z variometer is ready for installation at Sitka. The Z variometers have received especial attention, as they have always given trouble in operation. New pivots have been provided, after tests of various kinds. Provision has been made for a reserve spot in the instrument intended for use at Sitka, as the range of Z at that station is frequently so great that the regular spot goes off the paper.

Improved suspension systems are being introduced in the H and D variometers and a more dependable means of attaching the ends of the filaments has been devised. A study has been made of quartz filaments and suitable apparatus has been devised to make easier their installation and the adjustment of the variometers. In the case of the H variometer, it is now possible to select a filament of

about the right size to give the desired sensitivity, with only a small variation of scale value with change of ordinate.

The recording magnet of the Z variometer is so different in size and shape from the deflector heretofore used for scale value determinations that it has been difficult to determine with sufficient accuracy the distribution coefficients to be used in the scale value computations. With the introduction of the method of making scale value deflections with a large deflector at a greater distance, the effect of distribution becomes negligible and at the same time the danger of disturbing the variometer in manipulating the deflection bar and the difficulty of placing the small deflector in proper position have been eliminated.

To use this method, a convenient place is selected outside the variation room (either in the corridor or outside the building) and three supports for the deflector are attached to the wall at the same elevation as the recording magnets, equidistant from them, and in the magnetic meridians through their centers. A deflector is then made of proper strength to deflect the recording magnets by suitable amounts. Specially treated cobalt steel magnets are being used. Provision is made for cutting off the light from the magnetograph lamp without entering the instrument room.

New recording boxes have been designed with direct gravity drive, so that there is less danger of the clock stopping. Instead of the shutters operated mechanically formerly in use, provision is made for widening the lamp slit once an hour by electrical connection with the minute hand of the clock, so that all of the lines on the magnetogram are widened for a few seconds once an hour. In this way the hours are marked on the curves themselves and there is not the question of allowing for possible overlap that results when there are only breaks on the base lines. Small electric lamps are used.

Extended experiments were carried out at the Cheltenham Observatory to supplement the theoretical study of the distribution coefficients of magnets made by George Hartnell, observer in charge of that observatory. The formulas derived for deflections in various positions were given practical tests as they apply to deflection observations in horizontal intensity determinations, scale value deflections and determination of induction coefficient by Lamont's method.

An apparatus was designed for recording on a chronograph the oscillations of the magnet of a magnetometer, particularly in connection with determinations of moment of inertia. At each transit of the magnet across the magnetic meridian, light from an electric lamp is reflected from the glass in the south end of the magnet to a photoelectric cell. By means of suitable amplification this actuates a relay to which is attached the chronograph pen. In this way results of great accuracy are secured.

COMPUTATIONS

The direct scaling of hourly values from the magnetograms is now the rule at all of the five observatories of the bureau. Provisional base line values and suitable scales are furnished to the officer in charge of the observatory, and with them he is enabled to tabulate directly the absolute values for each hour with the same accuracy and nearly the same rapidity as was possible when tabulating the ordi-

nates in millimeters. For the horizontal intensity variometer a single scale is provided which is so graduated as to take account of the variation of scale value with ordinate. For the vertical intensity variometer as many scales are provided as may be needed to take care of changes of scale value, no account being taken of changes less than 1 per cent. With the variometers compensated for temperature, the preparation of the results for publication involves only small corrections, constant for a day at least, resulting from the final adjustment of base line values. When the Z variometer is unstable and frequent changes of adjustment occur, the old method of reading the ordinates in millimeters is followed.

The preparation for publication of the observatory results has been retarded by lack of sufficient personnel, but the work has now been done to the point where direct scalings began and in the future will proceed much more rapidly. The results have now been published or are ready for publication for all observatories to the end of 1924.

Since January 1, 1928, the monthly observatory tabulations have included the daily ranges for the Greenwich days, at the request of the late Dr. Charles Chree. These values are to be used in studying various activity criteria, as suggested at the Prague meeting.

PUBLICATIONS

The publications of the bureau on the subject of terrestrial magnetism are given below with brief descriptions of their contents. There is appended a list of papers prepared by employees of the bureau and published elsewhere. The following additional publications are ready for the printer or in his hands:

Magnetic Observatory Results for 1923 and 1924 for Sitka, Tucson, and Vieques.

Alaska Magnetic Tables and Magnetic Charts for 1930.

Magnetic Declination in the Philippine Islands in 1925 (with an isogonic chart).

Results of Observations made by the United States Coast and Geodetic Survey in 1929.

LIST OF PUBLICATIONS

Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., in 1923 and 1924.

Same for Honolulu, Hawaii, in 1923 and 1924.

Results of Magnetic Observations by the United States Coast and Geodetic Survey in 1926. (The results of field observations during the calendar year 1926, together with descriptions of the stations occupied.)

Same for the year 1927.

Same for the year 1928.

Magnetic Declination in the United States in 1925. (This is the latest one of the series of publications issued at intervals of about five years. It contains a map showing the lines of equal magnetic declination and of equal annual change for the year 1925 and tables showing the change of declination with lapse of time since the date of the earliest reliable observations for points all over the country at intervals of 2° of latitude and longitude. This publication is issued primarily for the use of local surveyors. A similar one for 1930 may be expected in 1931.)

United States Magnetic Tables and Magnetic Charts for 1925. (This is one of a series of publications issued at intervals of about 10 years. It contains the collected results of observations of declination, dip, and horizontal intensity for the United States, together with corresponding reduced values for January

1, 1925. There is also a table giving the results of observations at repeat stations occupied between January, 1917, and December, 1928. A new discussion was made of the available secular change data back to 1845 and tables were prepared for reducing the observed values to 1925. These tables are given in the publication. Finally there are maps showing graphically the distribution of declination, dip, horizontal intensity, and vertical intensity for 1925.)

Magnetic Declination in California and Nevada in 1927.

Same in Texas in 1927.

Same in Delaware, Maryland, Virginia, West Virginia, Kentucky, and Tennessee.

(These are in continuation of the series giving for single States or groups of States all available information regarding the magnetic declination.)

Distribution Coefficients of Magnets, by George Hartnell. (A new development of the formulas representing the interaction of two magnets, one suspended and the other deflecting, and their application to the special cases usually encountered in magnetic work.)

Directions for Magnetic Measurements, by Daniel L. Hazard. (A third edition of the manual first issued in 1911, intended primarily for the use of officers of the bureau making magnetic observations, but used by the department of terrestrial magnetism of the Carnegie Institution of Washington and by observers in various other countries.)

Magnetic Surveys—Purposes, Methods, and Instruments.

Progress of Work in Terrestrial Magnetism of the United States Coast and Geodetic Survey, July 1, 1927, to June 30, 1930.

ARTICLES

The Sensitivity of Magnetic Variometers, by H. E. McComb. Terrestrial Magnetism and Atmospheric Electricity, vol. 33, No. 2.

The Relation of the Magnetic Work of the United States Coast and Geodetic Survey to Geophysical Prospecting Methods, by Daniel L. Hazard. Terrestrial Magnetism and Atmospheric Electricity, vol. 33, No. 3. Presented at annual meeting of the section of terrestrial magnetism and electricity of the American Geophysical Union, April, 1928.

A New Method of Marking Time on Magnetograms, by H. E. McComb. Terrestrial Magnetism and Atmospheric Electricity, vol. 33, No. 3.

Auroral Observations, Radio Reception, and Magnetic Conditions at the Sitka Magnetic Observatory, August, 1927, to June, 1928, by F. P. Ulrich. Terrestrial Magnetism and Atmospheric Electricity, vol. 33, No. 3.

Distribution Coefficients for Vertical Intensity Variometers, by H. E. McComb. Terrestrial Magnetism and Atmospheric Electricity, vol. 34, No. 1.

Variometer Scale Value Determinations with a Large Deflector, by A. K. Ludy. Terrestrial Magnetism and Atmospheric Electricity, vol. 34, No. 1.

Method in Oscillations, by W. N. McFarland. Terrestrial Magnetism and Atmospheric Electricity, vol. 34, No. 1.

The Variation of Magnetic Anomalies, by W. N. McFarland. Terrestrial Magnetism and Atmospheric Electricity, vol. 34, No. 2.

Induction Coefficients for Magnetometer Magnets, by H. E. McComb, Terrestrial Magnetism and Atmospheric Electricity, vol. 34, No. 3.

Terrestrial Magnetism, by Daniel L. Hazard. American Year Book for years 1927, 1928, and 1929.

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