U. S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, Secretary

COAST AND GEODETIC SURVEY
R. S. PATTON, Director

Special Publication No. 213

# USES OF MAGNETIC STATIONS

CONTENTS



## 1. THE COMPASS AND EARLY SURVEYS OF THE UNITED STATES

The magnetic work of the United States Coast and Geodetic Survey, initiated as one of the essential operations in the preparation of nautical charts of coastal waters, has been extended to cover the interior of the country to meet the needs of the land surveyor. Practically all of the early land surveys of the United States were made by compass and, in recording deeds, the boundaries were defined by compass bearings. In many localities and for certain types of surveying the compass is still used. In recent years the compass has come into use as an aid in aerial navigation and is indispensable in blind flying when other aids to navigation fail.

It is recognized that the compass is not an instrument of precision. Hence results of great accuracy are not to be expected in compass surveys, and the use of a compass as a surveying instrument should be avoided where circumstances permit. However, it has the advantage of speed and simplicity and is useful for the retracing of old lines of surveys originally established by compass and for surveys where great accuracy is not required, particularly in wooded areas.

There are comparatively few places where the compass needle points to the true north. Moreover, the direction of the needle is constantly changing. For the above reasons it is essential that those who wish to use the compass should have correct information concerning the nature and extent of these changes.

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# National Oceanic and Atmospheric Administration

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## 2. DEFINITIONS

(a) **Magnetic declination.**—The angle between the true (geographical) north and magnetic north (direction of the compass needle) is known as the magnetic declination, magnetic variation, or simply "variation" at the point at which the observations are made. The magnetic declination is different for different places and changes continuously with respect to time. In the northeastern part of the State of Maine the magnetic declination is almost 23° west, while in the northwestern part of the State of Washington it is more than 24° east. Since no law or formula has been deduced which can be used for accurate estimation of the value of the magnetic declination at places where no observations have been made, it can be found accurately only by observation. The best estimate of the declination at a given point, in the absence of actual observations at that point, may be obtained from an isogonic chart which delineates the general trends of the lines of equal magnetic declination. The value thus obtained is the normal (undisturbed) declination for the general vicinity. Such magnetic charts are included and described in some of the publications listed below.

(b) **Secular and annual change.**—At any particular site the average value of the magnetic declination for 1 year may differ from that for the next. In general, the change progresses in one direction for many years and is known as the *secular change.* The amount of secular change in 1 year is known as the *annual change.*

(c) **Diurnal variation.**—There is usually a systematic departure of the declination from its daily mean value, which occurs day after day, the amount of departure depending upon the time of day, the magnetic latitude and other factors. This systematic, daily departure from the mean value for the day is called *diurnal variation.* During the night hours the declination usually differs very little from the average for the whole day of 24 hours. However, about sunrise an easterly motion of the north end of the needle sets in, the extreme easterly position being reached about 8 to 9 a. m. This is followed by a change to westerly motion of the north end, the extreme westerly position being reached about 1 to 2 p. m. By 6 p. m. it is usually back again to the average position.

While the diurnal variation may ordinarily be neglected in the class of work done with a compass, yet, where greater accuracy is required, it should be given consideration. The difference in declination between morning and afternoon frequently amounts to 10 minutes or more in any part of the continental United States. This would amount to about 15 feet in running a line 1 mile in length.

(d) **Magnetic storms.**—Frequently there are irregular fluctuations of the declination superimposed upon the diurnal and secular variations. These are known as *magnetic storms.* These storms vary in character and intensity and may last for several days.

(e) **Local disturbance.**—The declination at a certain place may differ considerably from that at another place in the immediate vicinity. Differences as great as several degrees have been noted in small areas or by slight differences in height of the compass above the surface of the ground. Such local disturbances are said to be *natural* if caused by the presence of magnetic material in the geological formation at the site. They are said to be *artificial* if caused

by the works of man such as pipe lines, steel structures, etc. The presence of local disturbance may be detected quite readily by observing the compass bearing of a line at two or more points on that line. If the compass bearings of the line are the same at the different points the area is probably free of local disturbance. Areas of excessive local disturbance are found in northern Delaware, parts of Arkansas, Minnesota, Iowa, and in regions where basaltic lava formations are at or near the surface such as prevail in parts of Idaho, Oregon, and in the Hawaiian Islands.

(f) **Compass correction.**—The angle between the observed direction of the needle of a given compass and that indicated by a perfect compass at the same site is known as the *compass correction* or *index correction.* This correction for any compass may be determined by observing at one of the Coast and Geodetic Survey field magnetic stations described below, where the magnetic declination has been determined by an instrument of precision.

### 3. COMPASS SURVEYS

Since the direction of the compass needle is constantly changing and since different compasses may not agree to the required accuracy, it is desirable to provide means for referring the compass bearings to a true meridian in every compass survey. The best method is to determine the true bearings of one of the lines of a survey by observations of Polaris or of the sun. As a rule, however, this is not feasible for every survey. For this reason, it is important to maintain a true meridian line in the field of operations where the surveyor may determine, at any time, the value of the magnetic declination with the compass which is being used for the particular survey. The value of the declination so obtained may be recorded with the survey made at the time. When, in later years, another surveyor wishes to retrace the lines of the survey, he may redetermine the magnetic declination at the same station on the same meridian line and the difference between the old and the new values of the declination is the correction to be applied to the compass bearings of the earlier survey.

The importance of this procedure has been recognized in several States by the passage of laws requiring the establishment of meridian lines and the testing of surveyors' compasses at regular intervals.

When a surveyor is called upon to redetermine the boundary lines of a tract of land originally surveyed by compass and can find in the vicinity a well-defined line, known to have been established with the same compass at about the same time as the lines of the tract in question, he can do no better than determine the amount of change in the compass bearing of that well-defined line and use it to obtain the present compass bearings of the boundary lines to be established. In this way the possible index errors in the two instruments as well as the uncertainty in the secular change data will be eliminated. Only in the absence of such definite information is the use of secular change data, as furnished by the Coast and Geodetic Survey in correspondence or in the form of publications, recommended.

In using such data the surveyor should bear in mind the uncertainties incident to the use of the compass and should not be surprised if, for example, the change of declination since the early part

of the nineteenth century, as given by the tables, differs by as much as 30 minutes from the value indicated by his own retracing of the old lines. Even at the present time some compasses are in error by as much as a quarter of a degree, owing to imperfections in construction, to lack of proper care, or for other reasons. Without doubt, such conditions were much worse a century ago. Moreover, while the data are intended to give the actual change in the magnetic declination, eliminating as far as possible the errors of individual instruments, they are only approximate, and the earlier portions are less reliable on account of the inferior character and limited number of observations upon which they are based.

### 4. MAGNETIC SURVEY OF THE UNITED STATES

The Coast and Geodetic Survey has made accurate magnetic observations at practically every county seat in the United States and at many other places where it has been necessary to investigate the nature and extent of local disturbances. The results of these observations furnish the basis for the construction of magnetic tables and magnetic charts described elsewhere in this publication. Practically all of the stations at county seats have been marked by stone or concrete monuments in order that they may be of value to local surveyors for testing compasses or for use as so-called repeat stations for the determination of secular change. Usually the true bearings of several prominent objects are determined at these magnetic stations and in many cases meridian lines have been established at the request of local authorities. The description of any of the magnetic field stations together with a list of true bearings of prominent objects that may have been determined at the station, may be obtained upon application to the Director of the Coast and Geodetic Survey, Washington, D. C.

### 5. MAGNETIC OBSERVATORIES

In addition to the field observations, magnetic observatories are operated at the following places: Cheltenham, Md.; Honolulu, Hawaii; San Juan, P. R.; Sitka, Alaska; and Tucson, Ariz. At all of these observatories there are produced continuous photographic records showing the fluctuations of the direction and intensity of the earth's magnetic field. These records are used primarily for the accurate determination of diurnal and secular changes in the earth's magnetism. More recently these records have become quite useful to investigators of radio transmission and of geophysical prospecting.

### 6. PUBLICATIONS

The Coast and Geodetic Survey has issued several publications containing the results of its work on terrestrial magnetism.

(a) The following, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., may be of interest to those who have occasion to use the compass or the results of compass surveys:

| | Serial No. | Price |
|---|---|---|
| The Earth's Magnetism | 313 | $0.15 |
| Magnetic Declination in Arkansas in 1935 | 601 | ------ |
| Magnetic Declination in Missouri in 1925 | 323 | .10 |
| Magnetic Declination in Texas in 1927 | 417 | .15 |
| U. S. Magnetic Tables and Magnetic Charts for 1935 | 602 | ------ |
| Magnetic Declination in Delaware, Maryland, Virginia, West Virginia, Kentucky, and Tennessee in 1925 | 457 | .20 |
| Magnetic Declination in North Carolina in 1930 | 537 | .20 |
| Magnetic Declination in Florida in 1935 | 564 | .20 |
| Magnetic Declination in California and Nevada in 1935 | 581 | .20 |
| Magnetic Declination in the United States, 1935 | 592 | .20 |
| Alaska Magnetic Tables and Magnetic Charts for 1930 | 570 | .70 |

(b) The following, in mimeographed form, have been issued. A limited number of copies are available for distribution to those to whom they would be useful, upon application to the Director of the Coast and Geodetic Survey:

Magnetic Declination in Louisiana in 1930.
Magnetic Declination in Alabama in 1935.
Magnetic Declination in Mississippi in 1935.
Magnetic Declination in Georgia in 1935.
Magnetic Declination in South Carolina in 1935.

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## PUBLICATION NOTICES

To make immediately available the results of its various activities to those interested, the Coast and Geodetic Survey maintains mailing lists of persons and firms desiring to receive notice of the issuance of charts, Coast Pilots, maps, and other publications.

Should you desire to receive such notices, you may use the form given below, checking the lists covering the subjects in which you are interested.

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A catalog of the publications issued by all bureaus of the Department of Commerce may be had upon application to the Chief, Division of Publications, Department of Commerce, Washington, D. C. It also contains a list of libraries located in various cities throughout the United States, designated by Congress as public depositories, where all publications printed by the Government for public distribution may be consulted.



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