# DEPARTMENT OF COMMERCE AND LABOR. DIRECTIONS FOR MAGNETIC MEASUREMENTS

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Department of Commerce and Labor. Directions for Magnetic Measurements by Daniel L. Hazard



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# DEPARTMENT OF COMMERCE AND LABOR. DIRECTIONS FOR MAGNETIC MEASUREMENTS

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O. H. TITTMANN, SUPERINTENDENT



# DIRECTIONS

FOR

# MAGNETIC MEASUREMENTS

BY

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# DIRECTIONS FOR MAGNETIC MEASUREMENTS.

## PREFACE.

Although the principles involved in the measurements of the earth's magnetism have not changed since the publication of the third edition of "Directions for Magnetic Observations with Portable Instruments,"* the methods of observing and the instruments used have received so many modifications as the result of accumulated experience that a new presentation of the subject has been needed for some time to facilitate the field work and to secure uniformity. In addition it is important that the principles involved should be explained in more detail than was done in the above-mentioned publication, so that the observer may have a better understanding of what he is doing and why he is doing it without being obliged to refer to other publications. Moreover, with the establishment of five magnetic observatories and the inauguration of magnetic observations on board the vessels of the Survey, the need has arisen for printed directions for making the observations required in those two branches of the magnetic work of the Survey. The endeavor will be made to present the subject-matter in such form that an observer familiar with the use of instruments of precision but without experience in magnetic work may be able to make in a satisfactory manner the various observations incident to the determination of the magnetic elements without other assistance than that to be obtained from these directions.

In the preparation of this paper the following publications have been consulted:

Principal Facts of the Earth's Magnetism, by L. A. Bauer. Washington, Government Printing Office, 1909. (Reprinted from U. S. Magnetic Declination Tables, 1902.)

Theory of Magnetic Measurements, by F. E. Nipher. New York, 1886.

Spherical and Practical Astronomy, by Wm. Chauvenet. Philadelphia, 1887.

Traité de Magnétisme Terrestre, by E. Mascart. Paris, 1900.

Erdmagnetismus, Erdstrom und Polarlicht, by Dr. A. Nippoldt, jr. Leipzig, 1903.

*Appendix No. 8, C. & G. S. Report for 1881. Gov't Printing Office, 1882.

Handbuch des Erdmagnetismus, by J. Lamont. Berlin, 1849.

Ableitung des Ausdrucks für die Ablenkung eines Magnetnadel durch einen Magnet, by Dr. Börgen. Hamburg, 1891.

Collimator Magnets and the Determination of the Earth's Horizontal Force, by Charles Chree. Proceedings Roy. Soc. London, No. 419, 1899.

The Law of Action between Magnets, by Charles Chree. London, Edinburgh, and Dublin, Phil. Magazine, August, 1904.

La Section Magnétique de l'observatoire de l'Ebre, by E. Merveille, S. J. Barcelone, 1908.

Elementary Practical Physics, by Stewart and Gee. London, 1887.

Elements of the Mathematical Theory of Electricity and Magnetism, by J. J. Thomson, Cambridge, England, 1897.

A Treatise on Magnetism and Electricity, by Andrew Gray. London, 1898.

A Physical Treatise on Electricity and Magnetism, by J. E. H. Gordon. New York, 1880.

Practical Problems and the Compensation of the Compass, by Diehl and Southerland. Washington, Government Printing Office, 1898.

Admiralty Manual for the Deviation of the Compass, by Evans and Smith. London, 1901.

The subject will be treated under the following general headings:

I. Theory of magnetic measurements, including some of the more important facts about the earth's magnetism and the methods employed for determining instrumental constants.

II. Directions for absolute observations on land.

III. Directions for observations at sea.

IV. Directions for operating a magnetic observatory.

# THEORY OF MAGNETIC MEASUREMENTS.

## THE EARTH'S MAGNETISM.

### INTRODUCTION.

Whether the earth is a great magnet or simply acts as a magnet as the result of electric currents flowing about it, it is surrounded by a magnetic field, and the measurements of the earth's magnetism at any place consist in determining the direction and intensity of that field.

A magnet suspended in such a way as to be free to turn about its center of gravity would take a position with its magnetic axis tangent to the lines of force of the earth's magnetic field. As it is practically impossible to suspend a magnet in that way, it is usual to determine the direction of the earth's magnetic field by means of two magnets, one constrained to rotate in a horizontal plane and the other in a vertical plane.

### MAGNETIC ELEMENTS.

*The magnetic meridian* at any place is the vertical plane defined by the direction of the lines of force at that place.

*The magnetic declination, D,* is the angle between the astronomic meridian and the magnetic meridian and is considered East or West according as the magnetic meridian is east or west of true North. Declination is often called *variation of the compass* or simply *variation.*

The *dip* or *inclination, I,* is the angle which the lines of force make with the horizontal plane.

Instead of measuring the *total intensity, F,* of the earth's magnetic field, it is usually more convenient to measure its *horizontal component, H.* These three quantities, *declination, dip,* and *horizontal intensity,* are usually spoken of as the *magnetic elements* and from them the total intensity and its components in the three coordinate planes may be computed by means of the simple formulas:

$$F = H \sec I \qquad Y = H \sin D$$
$$X = H \cos D \qquad Z = H \tan I$$

$X$ and $Y$ being the components in the horizontal plane, $X$ directed north (+) or south (−) and $Y$ directed east (+) or west (−), and $Z$ being the component directed vertically downward.