THE DEPARTMENT OF TERRESTRIAL MAGNETISM

OF THE CARNEGIE INSTITUTION

36th. Street and Broad Branch Road, Washington, D. C.

(Reprinted from the Year Book)

THE DEPARTMENT OF TERRESTRIAL MAGNETISM was formally established under the auspices of the CARNEGIE INSTITUTION in 1904, in general accordance with a plan for an " International Magnetic Bureau ", submitted by Dr. LOUIS A. BAUER in 1902. This plan had received the support of leading investigators in terrestrial magnetism and atmospheric electricity, in U. S. A and abroad, and is published in the Institution's Year Book for 1903. The purpose of the proposed bureau was stated to be " to investigate such problems of world-wide interest as relate to the magnetic and electric conditions of the Earth and its atmosphere, not specifically the subject of inquiry of any one country, but of international concern and benefit ".

The following were designated as some of the chief problems which might be undertaken :

a) A magnetic survey of ocean areas and unexplored regions.

b) International observations of the manifold variations in the magnetic and electric conditions of the Earth, inclusive of its atmosphere.

c) Observations pertaining to terrestrial magnetism and terrestrial electricity in ocean depths and atmospheric regions.

In the plan of the bureau, reference was also made to other problems, such as the correlation of local and regional disturbances of the magnetic needle with geological and physiographic features, and the correlation of magnetic and electric disturbances with solar and allied phenomena.

The name adopted for the proposed bureau was " DEPARTMENT OF RESEARCH IN TERRESTRIAL MAGNETISM ", or, in brief, " DEPARTMENT OF TERRESTRIAL MAGNETISM ". Dr. LOUIS A. BAUER was appointed

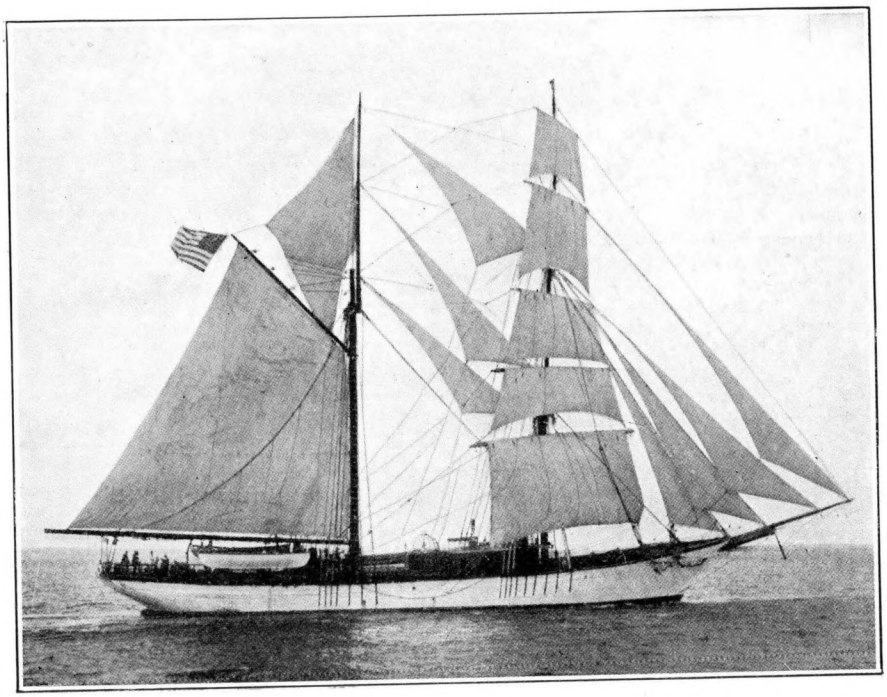
Director, and on April 1, 1904, the Department was definitely established and investigational work to a limited extent was authorized. In December 1904 more extensive operations were authorized and preparations were made for a general magnetic survey of the Earth, especially of ocean areas.

It was decided first to make a magnetic survey of the PACIFIC OCEAN, as, for that ocean particularly, magnetic data (compass direction, dip of the magnetic needle and strength of the Earth's magnetic field) were required for the correction of magnetic charts then in use by mariners and by investigators for their studies. Excepting data obtained on the voyage of the *Challenger* (1872-1876), the North Pacific Ocean in 1905 was nearly a blank as regards magnetic observations.

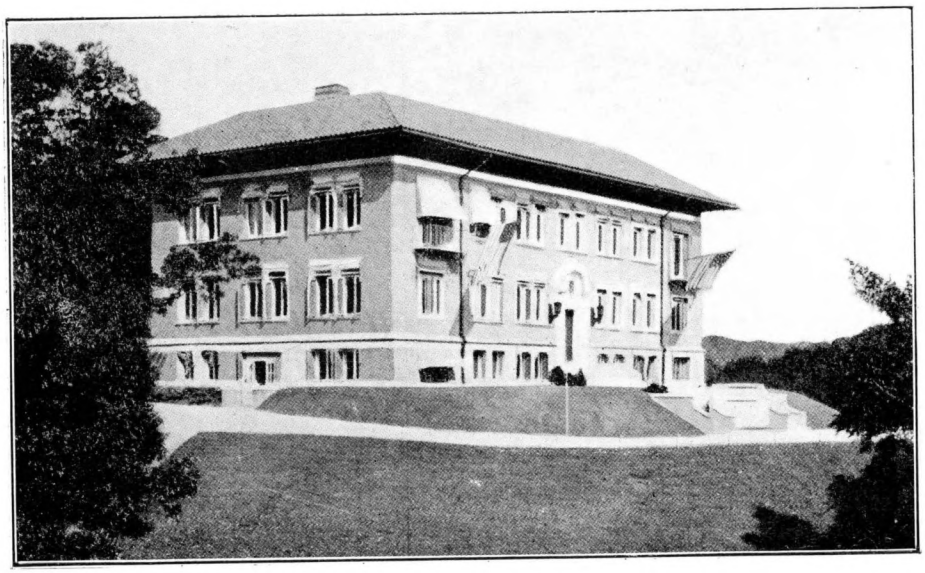
Accordingly, the brigantine *Galilee* of San Francisco, having a displacement of about 600 tons, was chartered and adapted for the purpose of magnetic observations at sea. Cruises were made in the Pacific Ocean with this vessel from August 1905 to May 1908, aggregating 63,834 nautical miles, or 73,511 statute miles, and completely crossing that ocean a number of times from the American to the Asiatic continent and from Alaska to New Zealand.

The success of the work of the *Galilee* and the importance of the errors disclosed in ocean magnetic charts led the Institution to authorize the construction of a non-magnetic ship, the *Carnegie*, specially designed for magnetic work in all the oceans. This vessel was launched at BROOKLYN, NEW YORK, June 12, 1909, and entered upon her work on August 21, 1909 ; since then she has been continuously in commission, excepting for a period of about one year, when it was necessary, on account of the Great War, to discontinue the ocean work.

The *Carnegie* is an auxiliary brigantine of 568 tons displacement. Her dimensions are : Length over all, 155 feet 6 inches ; length on load water-line, 128 feet 4 inches ; extreme breadth, 33 feet 6 inches ; mean draft, about 14 feet. Her lines are fair and easy, running in an unbroken sweep from stem to stern, and showing strength and sea-going qualities throughout. All the materials entering into her construction are non-magnetic—*i. e.*, such as not to affect a compass-needle—the fastenings and other metal parts being of bronze, copper or gun-metal. The rigging is of Manila hemp, the four anchors are of manganese bronze with 11-inch cables of 120 fathoms, the windlass for weighing the anchors is of wood and brass, and the auxiliary power plant, consisting of a gasoline engine of about 120 HP, is built almost entirely of bronze. This unique vessel carries about 10,000 square feet of canvas, under which she generally



THE CARNEGIE



Central Laboratory of the Department of Terrestrial Magnetism.
Laboratoire central du Département de magnétisme terrestre.

makes the desired average daily run of about 120 nautical miles between the required observation-points; under favorable conditions her daily run, under sail alone, has been as much as 255 nautical miles. Of special interest is the observation room, or deck-house, located on the main deck amidships, forward and aft of which are circular observatories with revolvable domes, under which the observer may completely protect the magnetic observations from wind and weather. Abaft the after observatory is a house specially built for the investigation of the electric condition of the atmosphere over the oceans.

At the end of 1921 the aggregate length of the *Carnegie*'s six cruises, August 1909 to November 1921, in 252,702 nautical miles, or 291,012 statute miles. The combined aggregate length or the nine cruises of the *Galilee* and of the *Carnegie*, August 1905 to November 1921, is 316,536 nautical miles, or 364,523 statute miles, which is about 14.5 times the Earth's circumference. The data resulting from these cruises include declination observations at 3,316 points and both inclination and horizontal-intensity observations at 2,147 points. All of the cruises have been accomplished without any serious mishap. The vessel was laid up temporarily in Washington at the close of the sixth cruise.

The ocean work, besides important researches in terrestrial magnetism and atmospheric electricity, includes auxiliary researches in atmospheric refraction, meteorology, hydrography, and geography. The Department, through its ocean work, is at present conducting the chief researches pertaining to the geographical distribution of the atmospheric-electric elements.

The complete mapping of the Earth's magnetic field requires that, while the magnetic survey of the oceans is in progress, that of the land areas likewise be vigorously conducted. Accordingly, about 130 magnetic exploratory expeditions were sent out, between 1905 and 1923, to remote and little-explored regions and to countries in which either there were no established organizations for magnetic work or in which the existing agencies, for one reason or another, welcomed the co-operation of the Department. Some of these land explorations have been very notable, for example, the complete crossing of the Desert of SAHARA; the caravan trip from PEKING to CHINESE TURKESTAN and across the HIMALAYAS to INDIA; the crossing of Central AUSTRALIA, from south coast to north coast; the successful trip over an infrequently traveled route across the desert region of northwestern AUSTRALIA; complete crossing of AFRICA in the equatorial and southern regions; canoe trips in northern regions of BRITISH NORTH AMERICA; hazardous and extensive journeys in various parts of SOUTH AMERICA, *etc.* Nearly all parts of

the Earth have been visited by these land parties, the number of points at which magnetic observations and geographical data have been obtained up to the end of 1923 being about 4,800. At about 10 per cent of these stations occupied previous to 1921 the observations have been repeated at various intervals of years in order to determine the changes in the Earth's magnetism which took place during the interims; of the 500 stations occupied in the past two years, about 400 were such repeat stations distributed over six continents. Over 1,000,000 miles have been traversed by the observers, without loss of life, though some of the routes followed were both difficult and fraught with dangers. Valuable magnetic data have also been obtained in polar regions by cooperation with various Arctic and Antarctic expeditions.

As the Earth's magnetic and electric conditions are subject to continual change, the Department cooperates with other countries in observing and recording changes at so-called "magnetic observatories". Since there are comparatively few such observatories in the Southern Hemisphere, the Department was authorized to erect its first observatories in that hemisphere. Accordingly, a magnetic observatory was built at WATHEROO, WESTERN AUSTRALIA, about 120 miles north of PERTH, which was put in operation on January 1, 1919. A similar observatory near HUANCAYO, PERU, at an elevation of about 11,000 feet and about 125 miles east of LIMA, was put in operation March 1, 1922.

Since June 1921 the Department has cooperated with the NEW ZEALAND Government in maintaining the APIA Observatory, more particularly in continuing the atmospheric-electric and associated meteorological work there and in acting in an advisory capacity as regards the magnetic work. Temporary magnetic and asmospheric-electric observatories are established from time to time for special expeditions, particularly in the Arctic regions, where difficulties of living and maintenance practically prohibit the establishment of permanent observatories, and at stations occupied for short periods to study magnetic and electric effects that may be related to natural phenomena such as eclipses. Experimental work is conducted in terrestrial electricity, at an observatory provisionally erected on the deck of the main laboratory in Washington for the study of theoretical questions and for the improvement of instruments and methods for use as the observatories of the Department. Here continuous photographic registrations of the variations in potential gradient and conductivity of the asmosphere are being made. Special experiments on the subject of magnetism in general are in progress in WASHINGTON in the non-magnetic Standardizing Magnetic Observatory and in the non-magnetic laboratory known as the Experiment Building.

The reduction of the accumulated magnetic data since 1905 to a common date is now under way for the construction of new world magnetic charts and to make a new analysis and study of the Earth's magnetic field on the basis of more complete and more accurate data than have been theretofore available. But for the Great War, these objects of a magnetic survey of the globe would have been realized earlier. Pending final publication of the accumulated data, preliminary magnetic and geographic results have been published, or supplied in manuscript, according to demands, thus meeting the immediate needs of investigators and of establishments engaged in the preparation of magnetic charts and geographical maps.

The growing needs of the Department led to the purchase of a site in 1913 near ROCK CREEK PARK, in the DISTRICT OF COLUMBIA, which, with additions acquired since, now comprises about 9 acres. A substantially built and well-equipped laboratory was completed on this site in 1914. It contains the Director's headquarters and working rooms for the staff, facilities for experimental work, library, archives, instrument shop, two subterranean constant-temperature rooms, and a deck for special work.

Since 1914, two non-magnetic, specially constructed buildings have been erected, one (the Standardizing Magnetic Observatory, erected in 1915) for the standardization of magnetic instruments, and the other (the Experiment Building, erected in 1919) for experiments, under the most favorable conditions possible, bearing on the subject of magnetism in general. Several small auxiliary buildings have also been erected.

The instruments used by the Department in the magnetic survey at the observatories and in the laboratory at Washington, have been very largely designed by members of the staff and are usually constructed in its instrument shop.

The data resulting from the investigations are published in the series entitled *Researches of the Department of Terrestrial Magnetism*, four volumes of which have been issued by the Institution. A yearly résumé of the work is contained in the annual reports, in the *Year Books of the Institution*, the first of these being for 1904.

Some 300 miscellaneous papers by members of the staff, published in journals and proceedings of learned societies, show the varied activities of the Department in the subjects of physics, geophysics, and cosmophysics and indicate the close interrelationship between these sciences.