THE MAGNETIC SURVEY OF THE UNITED STATES

Extract from an article of

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(Extract from *The Military Engineer*, Vol. XXX, N° 169, Washington, January-February, 1938, page 13).

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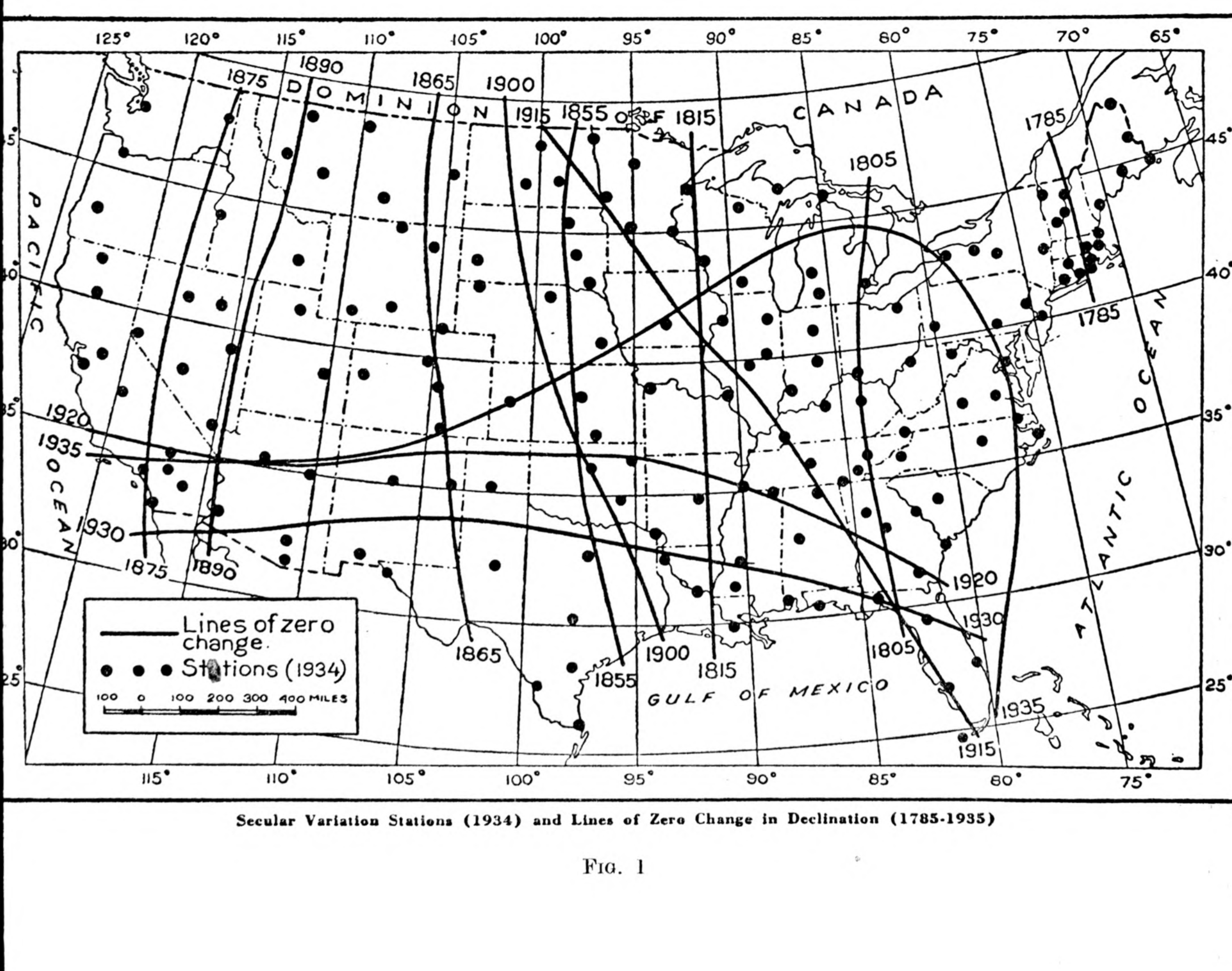
MAGNETIC CHANGES.

Secular variation. Many of the uses of terrestrial magnetism require knowledge of the various changes. Secular variation continues to be the most perplexing phenomenon. In the case of declination in the United States, there has been erratic change during the period 1900-1929 and again beginning in 1933 and not yet ended. This can best be seen from the behavior of the line of no change, which is of course one of the lines of equal change, from the earliest times to the present and it is evident that it is impossible to predict changes for more than a year or two at most.



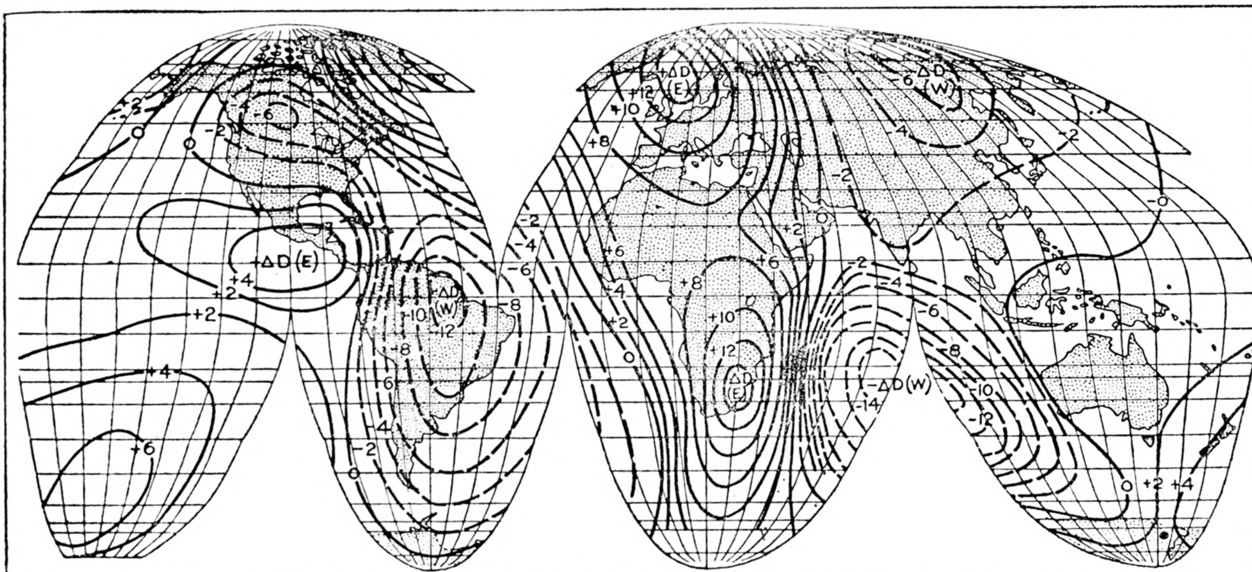
Secular Variation Stations (1934) and Lines of Zero Change in Declination (1785-1935)

Fig. 1

The changes appear to be wholly unsystematic so long as the lines are confined to a single country. For convenience the lines of equal annual change have been called isopors. Isopors in declination were drawn by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, for the earth as a whole for the period 1920-1925 and it was shown that there are focal points of maximum rate of change surrounded by the lines of equal change which are usually closed curves. The positions of the isoporic foci and the maximum amount of change continually vary and with them the entire system of isopors. About 1920 there was a focus of maximum value of 14 minutes in declination in northwest Europe which did not exist before 1900. A recent map of South Africa indicates that a maximum of 14 minutes in 1927 had been reduced to 5 minutes in 1937.

A peculiarity of these foci is that there is a tendency for the more important ones to be on land in spite of the much greater size of the ocean areas. No geological explanation has been found and, in fact, neither geologists nor magneticians have any satisfactory explanation of secular change. There is ample evidence that most of the change must be due to causes within the earth and not too near the surface, while, on the other hand, it is known that even iron loses its magnetism at about 700 degrees Fahrenheit, which corresponds to a moderate depth. Furthermore, no source of change within the crust can be conceived which would be as rapid as the shift of the isoporic foci.

The determination of secular change in an area so large as that of the United States and the regions under its juridiction, approximately 1 1/2 per cent of the entire land area of the globe, is by no means easy. The method of dealing with the problem in the continental United States will be described, since the principal difference between the practice in different regions is in the interval between observations.



Department of Terrestrial Magnetism. Carnegie Institution of Washingt

Lines of Equal Annual Changes, Approximate Epoch 1920-1925.

FIG. 2

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The results are made available in the form of maps and publications. Maps of declination have been issued at 5-year intervals, the last for January 1, 1935. For the other elements, maps have been issued for 1915, 1925 and 1935.

MAGNETIC OBSERVATORIES.

However, repeat stations alone can not give the correct rates of change, since the values change while the observations are in progress. There must be continuous observations at fixed points and for this purpose the Coast and Geodetic Survey operates five magnetic observatories, two in the continental United States, one at Cheltenham, Maryland, near Washington and the other at Tucson, Arizona. The other three are in San Juan, Puerto Rico, Sitka, Alaska, and Honolulu, Hawaii, respectively. The observatory at Cheltenham is recognized as the standardizing observatory of the United States and there is highly effective cooperation with the Carnegie Institution's Department of Terrestrial Magnetism in making this part of the work effective. The Canadian government operates two observatories, one at Agincourt near Toronto and the other at Meanook, Alberta, north of Edmonton. The Mexican government has a magnetic observatory at Teoloyucan near Mexico City.

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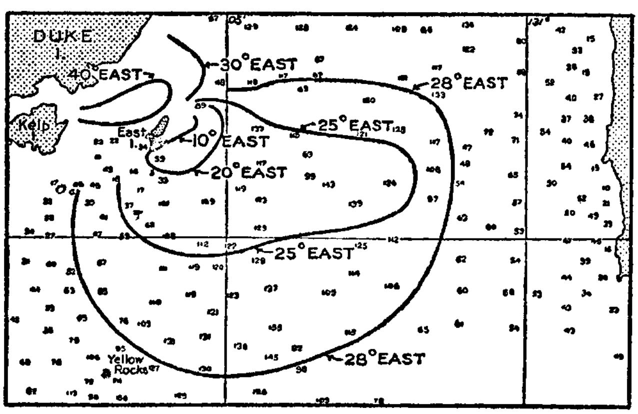
USES OF TERRESTRIAL MAGNETISM.

The earliest use, that in navigation, still continues. The gyro compass has many advantages, including that of providing automatic steering, but it is too expensive for some vessels and even the vessels which have a gyro compass must have a magnetic compass in reserve for emergency. Recent improvements in the magnetic compass, especially in England, have made it a more useful instrument.

Accordingly there is as much need as ever for correct magnetic information on the mariners charts. The problem is more difficult than on land because, unless vessels are specially built for the purpose, they have a large amount of magnetic material, and non-magnetic construction presents many difficulties in addition to the high cost of construction and operation. In oceanic areas, surveys have been made by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, using the brig *Galilee* from 1905 to 1908 and then from 1909 to 1929, the yacht *Carnegie*, the first non-magnetic vessel ever developed specially for work at sea. The Institution's surveys had covered all the oceans several times up to the date of destruction of the *Carnegie* by fire at Apia, Samoa, in 1929. The survey will eventually be resumed by the non-magnetic vessel *Research* of the British Admiralty, now under construction, which is designed after the lines of the *Carnegie.*



Area of Local Magnetic Disturbance

FIG. 3

In coastal waters, the Coast and Geodetic Survey, while it formerly made observations on its earlier vessels and was a pioneer in this field, has never had a non-magnetic vessel. Japan is building a small vessel for such waters and Estonia has for a number of years had a non-magnetic barge which is towed to any desired position in the Baltic. Accordingly, many of the magnetic data are inferred from observations along the coast and it is not certain that the distribution offshore is correctly indicated. It does not require many years for serious trouble to develop if the annual rate of change varies during a period when no observations are made. There is indication that an error of several degrees has developed in the part of the Indian Ocean between Africa and Australia since the last cruise of the *Carnegie* in this region. For the United States the problem could be solved by the construction of two small but able non-magnetic vessels, one for each coast. The Coast and Geodetic Survey Steamer *Hydrographer* has recently been successful in obtaining magnetic observations offshore in the Gulf of Mexico in a whaleboat. Observations were confined to calm sea, and motion due to the ocean swell was reduced by means of an outrigger device.

In some places there is so much magnetic material within the earth that the direction of the compass is far from normal. Where the disturbance from this cause is very great, as near local magnetic poles, several of which have been found in Alaska, navigation by compass is impossible or highly hazardous. At other places it suffices to state that over a certain area the differences may reach several degrees. Recently it has become the practice to indicate on the charts or otherwise places where ship's compass errors can not be obtained because of local disturbance.

Aviation. The use of magnetic information in aviation is different in some respects from that in ship navigation. Aviation goes on over both land and sea and often in the same flight. Much greater distances are traversed in a short time and consequently the change of declination is very rapid. The same degree of accuracy in steering as on a ship is scarcely attainable on account of the effect of the metal of the airplane, mechanical effects of the high speed and especially of changes in speed and the disturbing effect of the wind. However, it is customary to lay out compass courses to the tenth of degree and the magnetic information on the map should justify this. Steering by compass alone is probably more common in military than in civil aviation, which usually follows established routes with radio beams and other aids. However, even in civil aviation, when other methods fail, sole recourse must be had to the magnetic compass, and serious errors on maps can not be tolerated. The question has been raised as to how high in the air the effects of magnetic material within the earth may extend, but no actual observations have been made. It has become widespread practice to provide at major landing fields a compass testing platform where compass errors can be determined with little inconvenience and delay. It is customary and important to determine the value of the declination at the platform and not to take the value from the map.

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CARTE MAGNÉTIQUE DE GRÈCE

SERVICE HYDROGRAPHIQUE DE LA M.R. — JANVIER 1938