DESCRIPTION OF THE PORTABLE MAGNETOMETER OF THE ORDNANCE SURVEY BUILT BY THE CAMBRIDGE INSTRUMENT CO., LTD.

(Extract from a pamphlet issued by the ORDNANCE SURVEY, Southampton, 1930.)

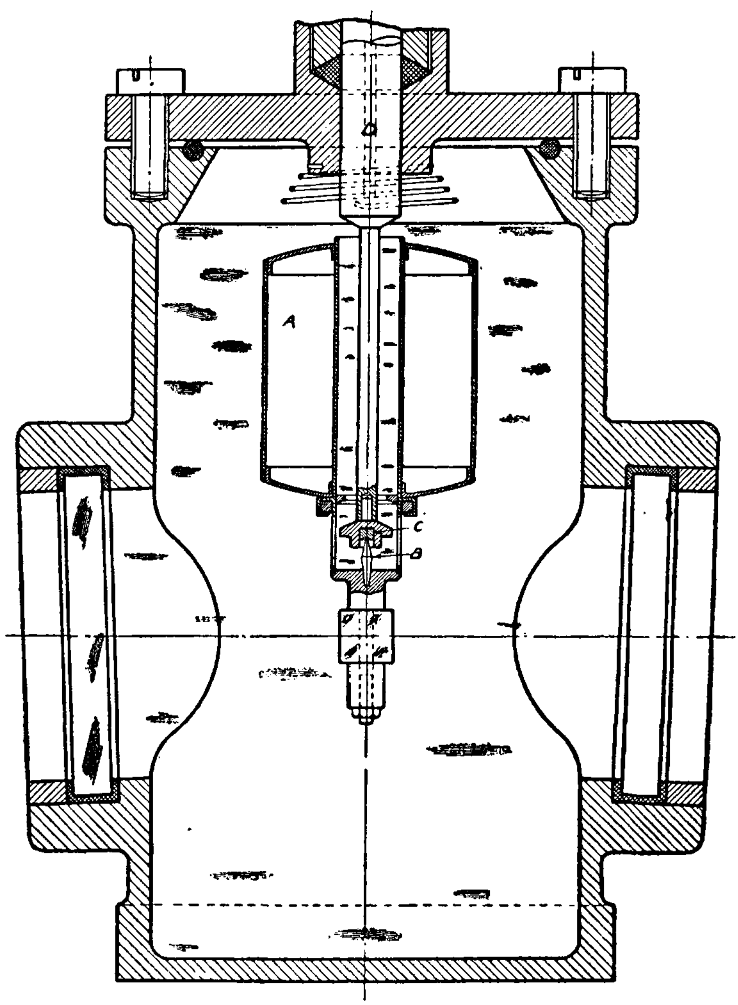
Prior to 1915, it was customary to measure the horizontal component of the earth's magnetic field in absolute units by the method devised by GAUSS, and various instruments — such as the KEW Magnetometer — were designed for this purpose. It is found, however, that these instruments are not suitable for rapid and accurate magnetic survey work because a determination cannot be made in much less than an hour, so that if the earth's field is changing rapidly during that period, only an average value is obtained, which is not necessarily related to the ordinary average value of the magnetic force during that period. Moreover, even if special precautions are taken, and the necessary corrections made, an accuracy to 1 γ (0.00001 c. g. s. magnetic unit) can hardly be claimed. In the field work of a survey where the conditions are not controllable, and vary from place to place, the average error may become appreciable.

Changes in the values of the magnetic elements from place to place can, however, be measured to a considerably higher degree of accuracy than the absolute values themselves, and, by comparing these with the absolute values obtained at the base station, the whole state of the region surveyed is known In 1915, G.-W. WALKER undertook a magnetic resurvey of the British Isles, and designed for this purpose a portable variometer for measuring variations in the horizontal component of the earth's magnetic force at different places, rather than the absolute values of this force (G. WALKER "*A Portable Variometer for Magnetic Surveying.*" Proc. Roy. Soc. A. Vol. 92, 1916). The apparatus consisted of a small magnet suspended by quartz fibre, the other end of which could be twisted by means of a torsion head until the magnet took up a position nearly at right angles to the magnetic meridian. When thus suspended, the angular movement of the magnet relative to the torsion head was proportional to the change of horizontal force, after application of a temperature correction. Provided that the instrument was set up in approximately the same position with reference to the magnetic meridian, and that the magnetic moment of the magnet system had not changed in the interval which elapsed between the determinations, the relative values of the horizontal force at the different places could be obtained. In practice the times of vibration of the magnet system at the various places in the region surveyed were compared with the time of vibration of the same magnet system at the base station, viz.:- The Royal Observatory, Greenwich. This comparison method was very promising and it appeared as though it would materially reduce the time required to take a complete magnetic survey. The instrument was, however, only made as an accessory to the KEW Unifilar Magnetometer.

The instrument illustrated in the attached photograph has recently been designed by Dr F.-E. SMITH for the accurate comparison of the horizontal component of the earth's magnetic force at two stations. Knowing the force in absolute units at one of the stations (the base station) and making corrections for any magnetic disturbances which may have arisen (and for which it is possible to correct by means of recording magnetographs), the horizontal force at the subsidiary station is determined in absolute values. The instrument is, to all intents and purposes, a sine galvanometer — an instrument described in the text book but rarely used in the laboratory. In the new magnetometer a known current is used and the Horizontal Magnetic Force to be measured is inversely proportional to the cosine of the angle between meridian and the normal to the coil. The success of the instrument is primarily due to the accuracy with which an electric current can now be measured. A portable standard cell can be relied upon to give its normal voltage to within one part in twenty thousand, and when the cell is used with a potentiometer and sensitive galvanometer the current can be measured to the same order of accuracy. Accordingly the value of H can be measured under Observatory conditions to the same accuracy, viz.:- to 1 γ.

The first instrument made on this principle was constructed at the request of Sir A. SCHUSTER at the National Physical Laboratory and was designed for absolute measurements. In this case the coils were constructed in such a way that it was possible to determine in absolute measure by calculation the magnetic field given by the current and hence to measure directly the intensity of the earth's field.

The new instrument is similar in construction, its constant being determined by comparisons at a base station. In the instrument illustrated a known current (usually about 0.1 ampere) is passed through the coils and the small angle through which the axis of the coils has to be turned out of the meridian in order to obtain auto-collimation is measured on an azimuth circle; the coils are then turned so that their axis passes over to the other side of the meridian and the system is deflected through an equal angle in the opposite direction. The mean of the deflections is taken as the angular deflection corresponding to the particular value of the magnetising current at the station where the observation is made.



The method of construction is as follows:-

Two cobalt steel magnets (1.5 × 1.5 × 12 $^m/_m$ in length) are mounted horizontally side by side on the underside of an annular float which is immersed in petrol contained in a gunmetal chamber. The float is centralised in position in the chamber by means of a jewel and sapphire pivot in the manner shown in the diagram, in which *A* is the float, *B* the pivot and *C* the jewel, the latter being mounted on the spindle *D* which projects through the centre of the float chamber.

The moving system carries an optically-plane mirror of platinised quartz 6 m/m square (a cube platinised on four sides) which is mounted with its surface vertical and in a plane parallel to the axes of the magnets. This mirror is viewed by a horizontal telescope mounted on the instrument and sighted through a worked glass window in the gunmetal chamber. The upper part of the field of the telescope is occupied by a cross line illuminated by light from the sky reflected on to it by a prism. The image of the cross-wire is reflected by the mirror on to a micrometer scale (20 divisions per m/m) fixed in the focal plane of the telescope and is viewed through a RAMSDEN eyepiece. A deflection of 20 seconds of arc can be measured in this way. The magnetic coils and the telescope are mounted on a casting which rotates over a lower casting on which is mounted the azimuth circle. This circle, which is of silver and 25 centimetres in diameter, is divided to 15 minutes; by means of verniers and microscopes readings may be taken to 20 seconds of arc. Levelling screws and a sensitive level are fitted. The magnetising coils have a mean diameter of 40 centimetres and are mounted 20 centimetres apart The windings on each coil consist of forty turns of 24 s. w. g. copper wire. The coils are connected in series so as to produce axial fields in the same direction. A current of approximately 0.1 ampere is generally employed, which can be measured to an accuracy of 5 microamperes by means of a potentiometer. All the parts of the apparatus are of non-magnetic materials and the connections to the potentiometer are made by concentric cable. A complete determination — including the time taken to level the instrument, to determine the magnetic meridian, and to obtain the two sets of readings — can be made in about 10 minutes. Measurements may be made with an error not exceeding 1 γ.