L. D. J. A. DUNOYER.

ELECTROMAGNETIC COMPASS.

APPLICATION FILED MAR. 5, 1907.

989,134.

Patented Apr. 11, 1911.

3 SHEETS—SHEET 1.

Fig. 1.

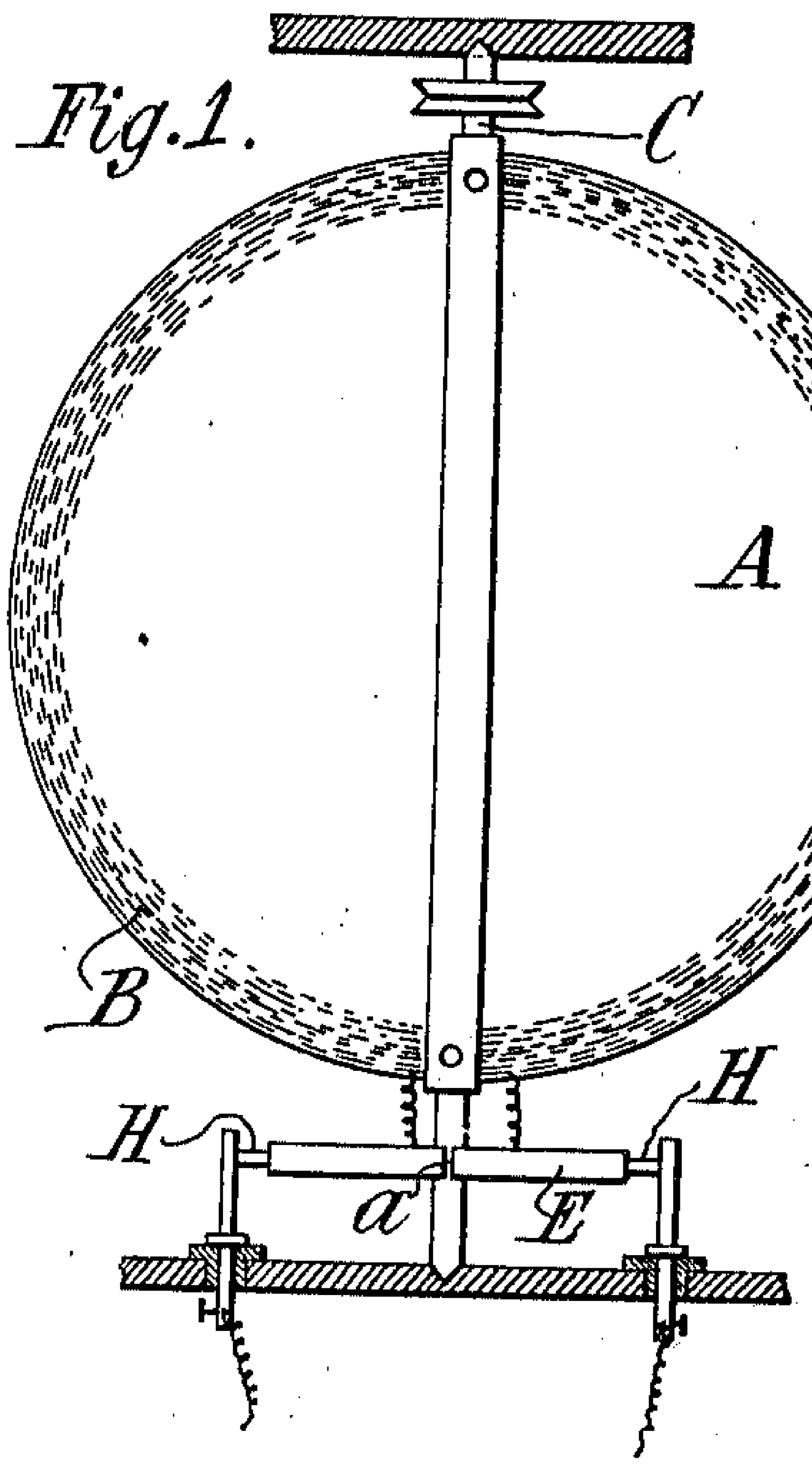


Fig. 2.

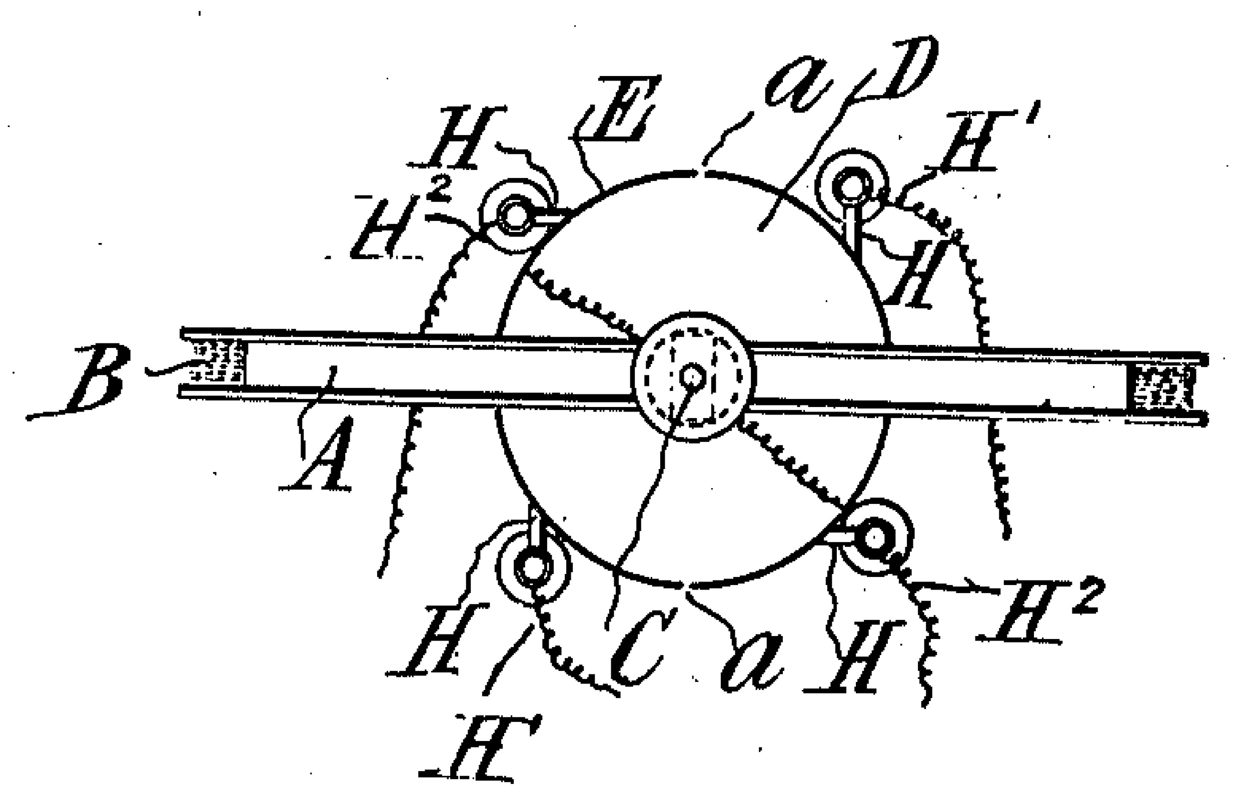


Fig. 3.

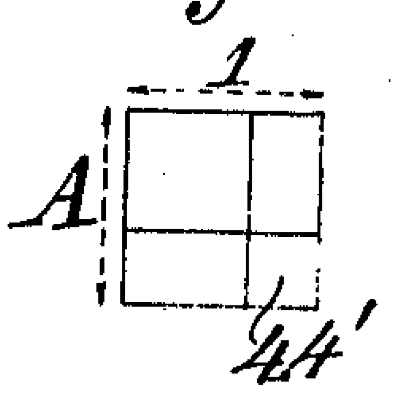
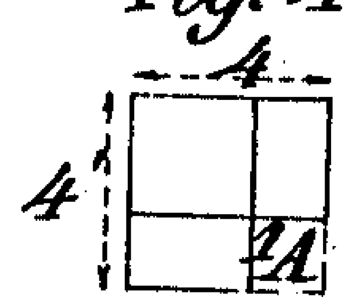


Fig. 4.



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3 SHEETS—SHEET 2.

Fig. 5

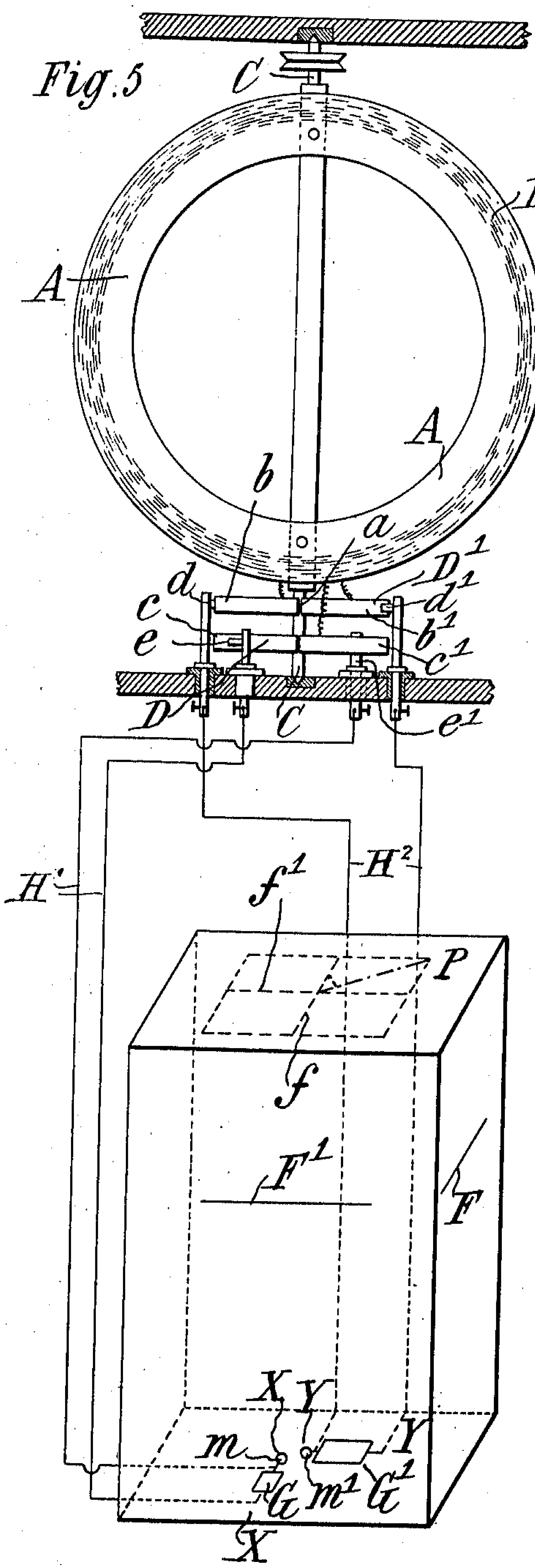


Fig. 6.

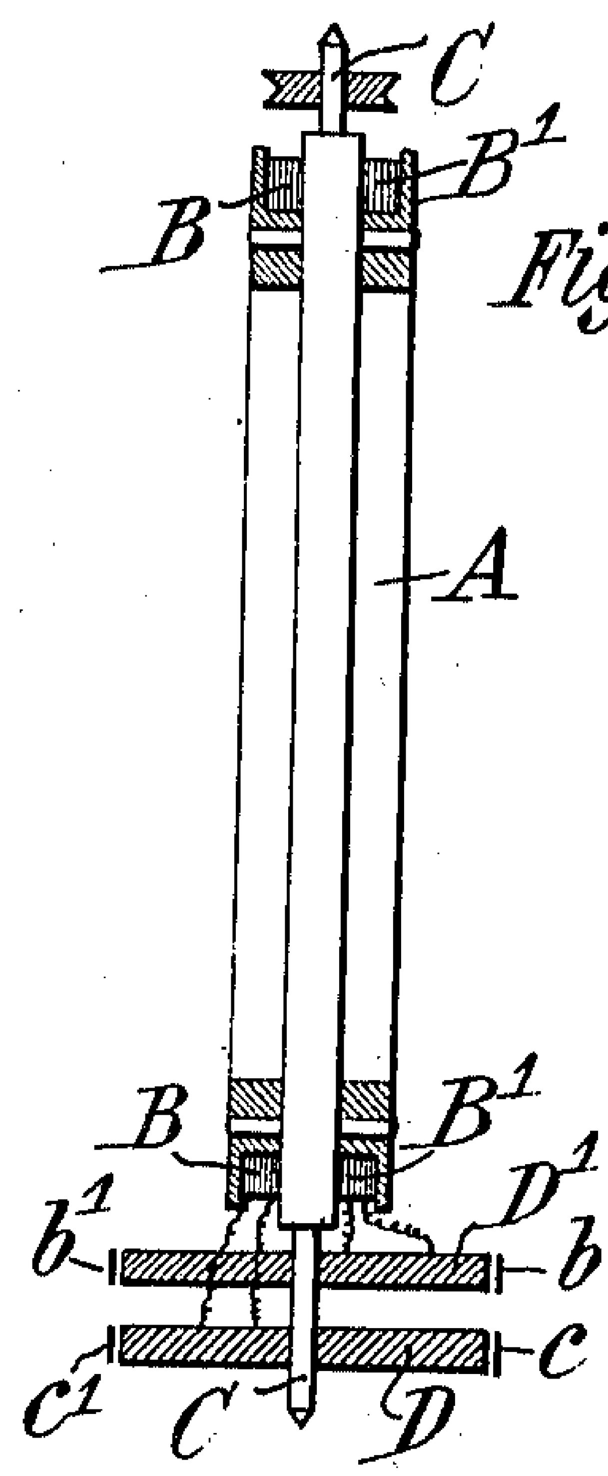


Fig. 7.

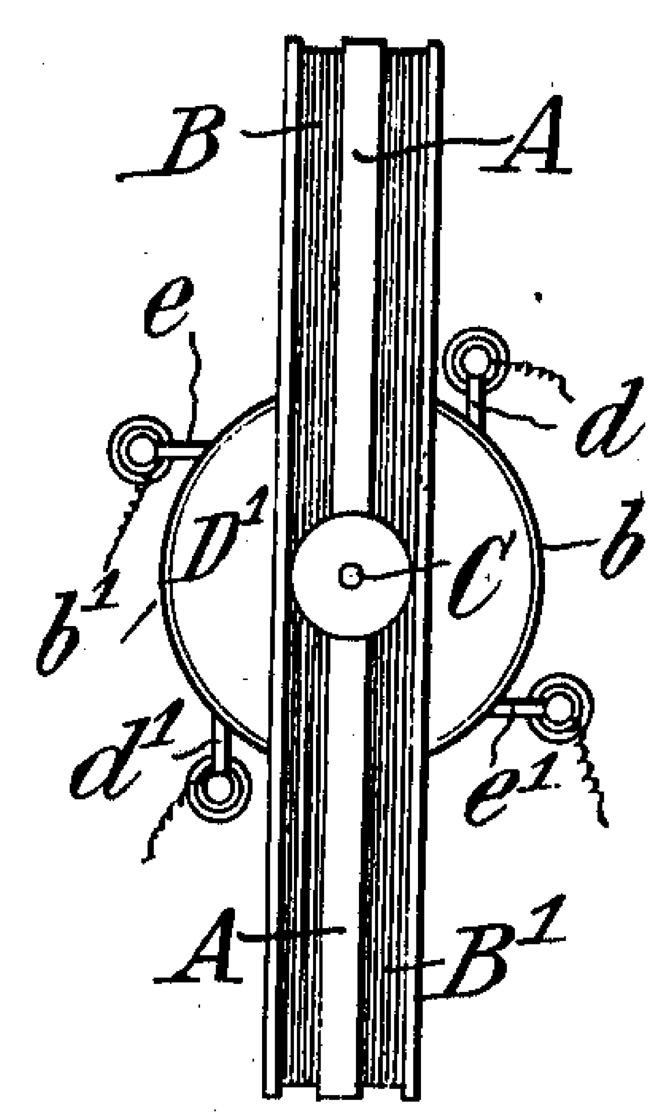
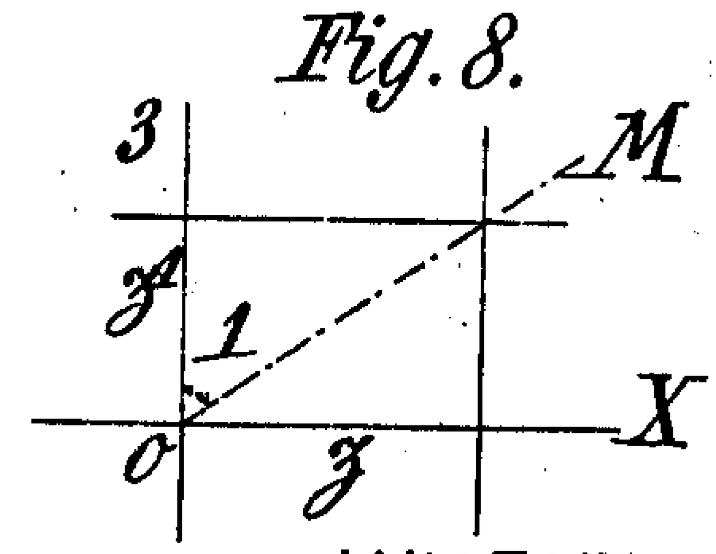


Fig. 8.



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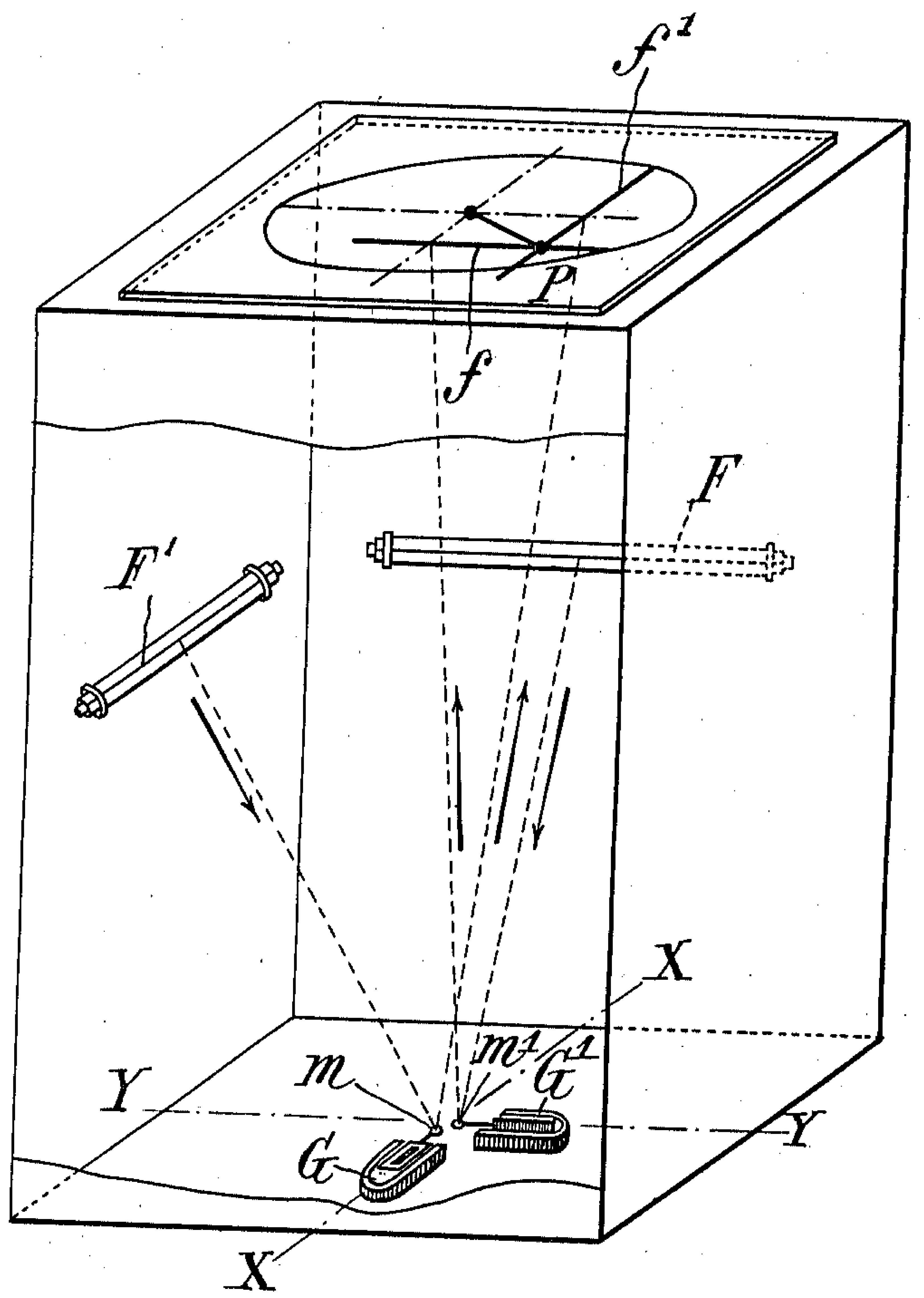
3 SHEETS—SHEET 3.

Fig. 9.



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UNITED STATES PATENT OFFICE.

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ELECTROMAGNETIC COMPASS.

989,134. Specification of Letters Patent. Patented Apr. 11, 1911.

Application filed March 5, 1907. Serial No. 360,770.

To all whom it may concern:

Be it known that I, Louis Dominique Joseph Armand Dunoyer, a citizen of the Republic of France, residing in Versailles, Seine-et-Oise, France, have invented certain new and useful Improvements in Electromagnetic Compasses, of which the following is a specification.

The apparatus forming the subject matter of this invention is based on the generation of induced currents by the earth in a circuit having a rotary motion in the terrestrial magnetic field. These induced currents are sent into a galvanometer the deflection of which is measured. It is the amount of this deflection which determines the angle inclosed by the longitudinal axis of the ship with the magnetic meridian.

This apparatus will be particularly useful for obviating the disturbing effect upon the needle compass: 1. Of the masses of iron or steel surrounding the deck houses or central stations on board ship. 2. Of the considerable vibration which affects the magnetized needle in torpedo boats and motor boats. The rotary frame may in fact be placed at a spot (for instance, on a mast) where perfect compensation can be made readily and with certainty.

An apparatus embodying the invention is shown in the accompanying drawings, in Figure 1 in elevation, and in Fig. 2 in plan. Figs. 3 and 4 are diagrammatic representations of tables containing previously determined values of the coefficients of the apparatus and the angles of deviation. Figs. 5, 6, and 7 refer to a modification. Fig. 5 is an elevation showing the general arrangement of the apparatus. Fig. 6 is an axial section through the frame and the disks. Fig. 7 is a plan thereof. Fig. 8 is a diagram showing the manner in which the deviation is to be read off from the apparatus of Fig. 5. Fig. 9 is a separate view of the receiving and indicating apparatus shown diagrammatically in Fig. 5.

The device shown in Figs. 1 and 2 is composed of a, preferably circular, frame A, of insulating material or of a metallic substance in which slots are suitably made so as to prevent the generation of Foucault currents. Upon this frame is wound insulated copper wire B. The frame is capable of rotating on a vertical axle C situated in its plane and passing through its center, this motion being imparted to it by any desired means.

At right angles to the axle and rigidly fixed to it there is provided a horizontal disk D of insulating material. The circumference of the disk is covered with a metal band E cut in two places *a a* by very fine cuts situated at the ends of that diameter of the disk D which is perpendicular to the plane of the frame A. Each of the two conducting semi-peripheries thus formed, is connected to one end of the wire that is wound on the frame. On this conducting periphery there rub several pairs of brushes H H; each pair is located at the ends of one and the same diameter. These two pairs of brushes are indispensable. If greater accuracy is desired according to the sensitiveness of the galvanometer employed, other pairs of brushes may be utilized situated at the ends of the intermediate diameters. There are always two pairs situated at the ends of two diameters located at right angles to each other. Each of these pairs of brushes is connected by means of two insulated wires H′ H^2 to a suitable measuring instrument such as a galvanometer of any suitable type.

The amount of the galvanometric deflection will indicate the magnetic deviation of the ship.

The rotary frame is to be placed in some convenient spot on the ship where the magnetic compensation of the masses of iron and steel constituting it may be effected in an efficient manner; an especially suitable spot is on a mast.

No part of the apparatus should be of iron.

To use the apparatus, the frame is caused to rotate in a uniform manner, and by means of a multipolar switch the two brushes of one and the same pair are connected to the two terminals of the galvanometer; and the deviation δ is read off the latter.

Assuming that use is made at first of the pair of brushes fixed at the ends of the diameter perpendicular to the longitudinal axis of the ship, and let α be the magnetic deviation of the ship that is to say, the angle inclosed by its axis with the magnetic meridian then we have

$$\tan. \delta = A. \sin. \alpha.$$

If now by means of the multipolar switch, use be made of the pair of brushes fixed to the ends of the diameter parallel to the axis of the ship, the deviation δ' is given by the equation:—

$$\tan.\ \delta' = A.\ \cos.\ a.$$

We have then

$$\tan.^2\ \delta + \tan.^2\ \delta' = A^2.$$

These two values thus serve to determine the coefficient A. It is only necessary to determine those two values from time to time for the purpose of determining the value of the coefficient A which varies with the longitude, the latitude and the velocity of the rotation of the frame.

In practice a table in double entry of the values of A will be prepared beforehand, by arranging the values of the horizontal component H of the earth's field in vertical columns and arranging the values N of the number of revolutions per second in horizontal lines. This table having been prepared, a second table is then prepared (see the diagram Fig. 3) showing the values of A in a vertical column at the left as indicated and those of a in a horizontal line at the top as indicated at 1. In the compartments 4 4′ of this table will be found the values of δ and of δ'. Finally a third table (see the diagram Fig. 4) contains in the left hand column 4′, the values of δ' and in the top line 4 the values of δ, and in these compartments 1^a the corresponding values of A and of a. These two last tables are in front of the eyes of the steersman. They allow of solving the following two practical problems:—

1. *To follow a given course.*—This consists in giving a at every moment. A is determined from time to time by the method hereinbefore described. The second table alone thus gives the deviation δ which the steersman must keep in the galvanometer by suitable steering.

2. *To take a given course.*—A and δ of the given course are determined; this gives a from the third table. It is necessary therefore to veer by the angles u from the magnetic deviation a at the time. The second table is then inspected along the top line to find the column corresponding to the angle $a+u$; the compartment thus found gives the deflection δ which must be imparted to the galvanometer.

With the object of obviating the two measurements of δ as hereinabove stated, and also of dispensing with the use of the two tables, the apparatus may be completed in the following manner:—It then comprises two windings on the same frame, and two pairs of half rings, these pairs being each connected to a galvanometer through the medium of suitable brushes and conductors. Upon the mirror of each galvanometer there will be reflected respectively two relatively perpendicular lines which form on a dull glass plate or other surface images whose point of intersection serves for obtaining the deviation as hereinafter described.

The apparatus consists of a frame A, preferably circular, in which are formed two parallel grooves capable of receiving two similar windings B and B′. On the pivotal axis C C of the frame there are fixed two disks D and D′ of insulating material, on the circumference of which there are arranged two half rings b b' and c c'. Two pairs of brushes d d', e e' rub on these two pairs of half rings. The brushes of the second pair are fixed at right angles to those of the first pair.

Each pair of brushes is connected respectively to a galvanometer having a horizontal axis; these two galvanometers G and G′ having their axes X X and Y Y perpendicular to each other in a horizontal plane. The mirror m of the galvanometer G forms on a dull glass plate P (or a plate of celluloid or any other analogous semi-transparent substance) an image f of a fixed wire F parallel to its axis X X. Likewise, the mirror m' of the galvanometer G′ gives an image f' of a straight line F′ parallel to its axis. If the frame A of the transmitter be caused to rotate, these images f and f' which are perpendicular to each other, will move over the dull glass plate P on which there is engraved a series of radius vectors spaced suitably apart in the form of a mariner's compass card divided into 360 degrees; each radius vector being marked with a sign such as N, N—E, &c. (all but one being omitted from Fig. 9 for the sake of clearness). The radius vector on which the crossing point of the two perpendicular images f and f' stops, indicates the magnetic deviation of the ship. In fact, if a be this magnetic deviation, the diagram (Fig. 8) show that

$$Z = A\ \sin.\ a$$
$$Z' = A\ \cos.\ a$$

the angle a being indicated at the point 1. Z and Z′ representing the displacement of the images which is proportionate to the deflection of the galvanometers, and A being a coefficient which varies with the longitude, the latitude and the velocity of the rotation of the frame.

From the two preceding equations, there results

$$\frac{Z}{Z'} = \tan.\alpha.$$

If O3 and OX represent the two images f and f', and OM the radius vector upon which the crossing points of said images lie, then the angle MO3 is equal to the angle a the magnetic deviation of the ship. Thus in this case, the magnetic deviation is obtained here by simply reading the same on the indicated radius vector on the plate P without the use of tables, whereas in the first arrangement the coefficient A rendered the use of tables necessary. Furthermore, by causing the dull glass plate to rotate in a suitable direction through an angle equal to the declination of the locality of observation, the geographical deviation will be obtained. Finally, the receiving apparatus, formed of two galvanometers G and G′ having a movable frame and having their axes perpendicular to each other, and having mirrors that form on a dull glass plate P the images of two wires F and F′ or two incandescent filaments at right angles to each other, may serve in all cases where it is desired to measure the proportion between the intensities of two currents, because these intensities are proportionate to Z and Z′. For this purpose it will be sufficient to graduate the radius vectors in values of tan, α.

Applicant reserves the right of modifying the dimensions or the details of this apparatus for the purpose of applying it to the measuring of the proportion between the intensities of two currents. Fig. 9 is a separate view of such apparatus. The galvanometers G and G′ are connected in any desired way with the circuits of the two currents in question, and they throw upon the plate or screen P images *f*, *f′* of a pair of lines F and F′, shifting the positions of said lines according to the intensities of the two currents, so that the point of intersection of said two lines will fall upon different radii upon the screen, according to the relative intensities of the two currents in question. This mechanism serves the same purpose whether used in connection with the other elements of the electromagnetic compass described or not.

Claims.

1. A compass for determining magnetic deviation, including in combination a coil adapted to be rotated in a magnetic field and in which induced currents are generated, a current collecting ring with gaps at diametrically opposite points, electrical connections between said coil and ring a galvanometer, and brushes connecting said coil through said ring to said galvanometer to cause the latter to indicate the intensities of said currents.

2. A compass for determining magnetic deviation, including in combination an armature frame carrying at least one winding and adapted to receive a uniform rotary motion about a vertical axis, a pair of half rings and means for connecting them for rotation with said frame, at least two pairs of brushes contacting with said half rings and located on diameters at right angles to each other, one of these diameters being adapted to be set parallel to the longitudinal axis of a ship, and the other at right angles thereto, a galvanometer, wires H′ and H² for connecting said pairs of brushes alternately with said galvanometer, and means controlled by the galvanometer for indicating the angle between the axis of the ship and the magnetic meridian.

3. A compass for finding magnetic deviations, including in combination a frame, a pair of windings carried thereon, separate pairs of half rings connected one pair to each of said windings, pairs of brushes for each of said pairs of half rings and adapted to be located on diameters one in the direction of the ship and another at right-angles thereto, galvanometers subject to simultaneous deflection, means connecting one of said galvanometers to each of said pairs of brushes, and an indicating apparatus controlled by said galvanometers for indicating the deviations of the direction of the ship.

4. An indicating apparatus including two galvanometers having mirrors rotatable on horizontal axes perpendicular to each other, two wires arranged perpendicularly to each other and reflected by the respective mirrors of the galvanometers, a screen upon which said lines are reflected and upon which the position of the intersection of the line indicates the relative positions of the mirrors, said screen being graduated in the manner of a mariner's compass.

In witness whereof, I have hereunto signed my name this 22d day of February 1907, in the presence of two subscribing witnesses.

LOUIS DOMINIQUE JOSEPH ARMAND DUNOYER.

Witnesses:

MARCEL ARMENGAUD, Jeune,

HERNANDO DE SOTO.