

May 6, 1958

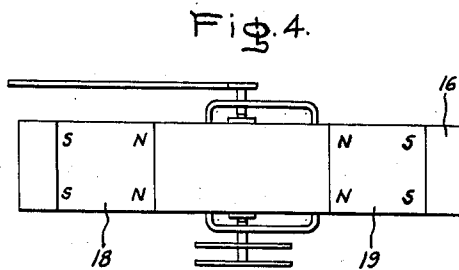
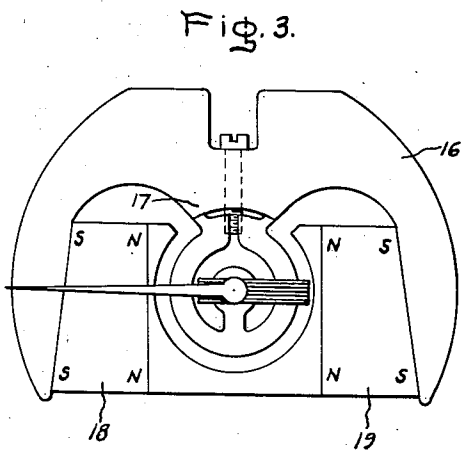
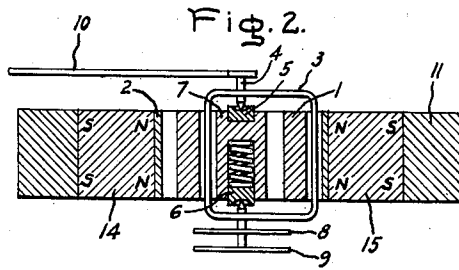
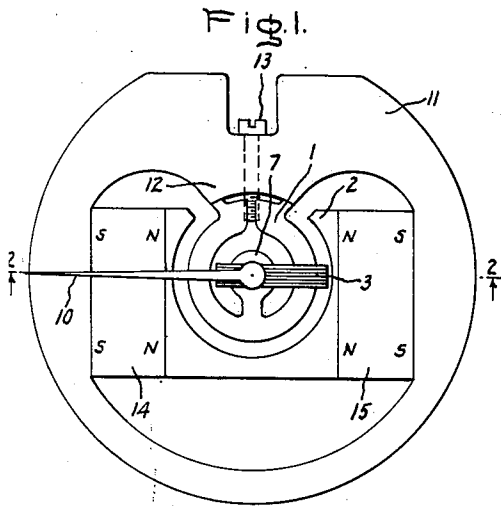
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LONG SCALE ELECTRICAL INSTRUMENTS

Filed May 26, 1953

2 Sheets-Sheet 1



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Fig. 5.

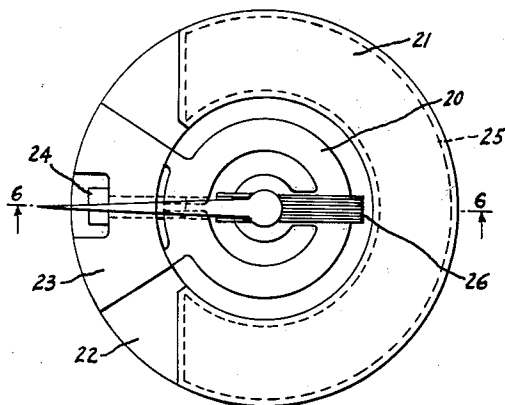


Fig. 6.

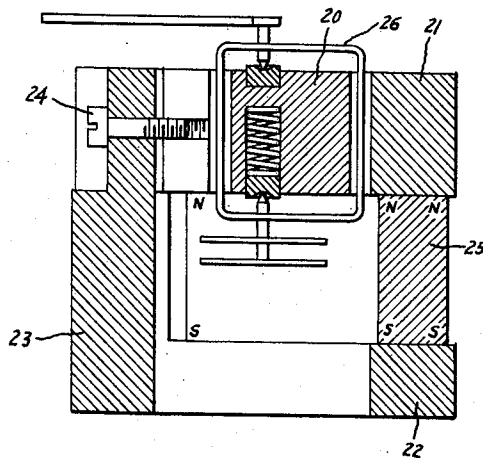


Fig. 7.

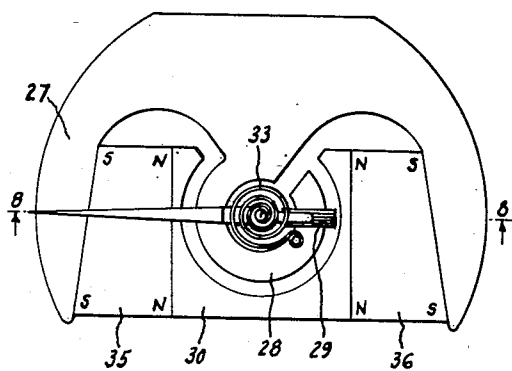
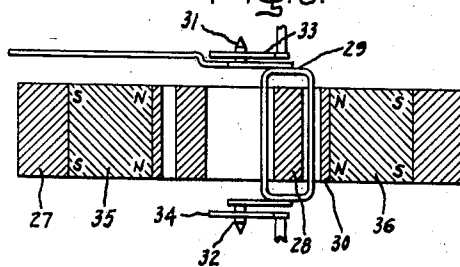


Fig. 8.



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LONG SCALE ELECTRICAL INSTRUMENTS

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Application May 26, 1953, Serial No. 357,615

4 Claims. (Cl. 324-150)

My invention relates to improvements in long-scale electrical instruments, and its chief object is to provide instruments having greater sensitivity and much lower manufacturing cost than those previously available. Other objects and advantages will appear as the description proceeds.

Briefly stated, in accordance with one aspect of my invention, I provide improved instruments having permanent magnets which are magnetized in a single straight-line direction. This makes practical the use of oriented permanent magnet materials having a preferred direction of magnetization, which, when magnetized in their preferred direction, possess exceptionally high values of coercive force and residual magnetism. Consequently, high values at magnetic flux density are obtained at low cost, and these high flux densities give greater sensitivity and improve other characteristics of the instruments. Furthermore, magnetizing the magnets and adjusting their strength for calibration purposes are facilitated by straight-line magnetization, which reduces manufacturing costs. An even greater cost reduction results from the fact that my improved instruments do not require permanent magnets having complex shapes or precise dimensions, which would necessitate costly grinding operations, since the common high-strength permanent magnet materials generally cannot be machined by standard metal-working tools. Instead, my improved instruments comprise pole pieces and a yoke which are preferably precision moulded of powdered iron, whereby precise shapes and dimensions are obtained at low cost. My invention has reduced the manufacturing cost of the magnet and pole piece structure of one type instrument to one-third the previous cost, and at the same time has improved the sensitivity and other characteristics of the instrument.

My invention will be better understood from the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims. To improve the clarity of the drawings and description, certain conventional parts, such as the instrument case, calibrated scale, and electrical terminals, have been omitted, since it is believed that those skilled in the art will have no difficulty in supplying such parts. In the drawings,

Fig. 1 is a plan view of an electrical instrument mechanism embodying principles of my invention,

Fig. 2 is a section taken generally along the line 2-2 of Fig. 1,

Fig. 3 is a plan view of another electrical instrument mechanism embodying principles of my invention,

Fig. 4 is an end view of the mechanism shown in Fig. 3,

Fig. 5 is a plan view of still another electrical instrument mechanism embodying principles of my invention,

Fig. 6 is a section taken generally along the line 6-6 of Fig. 5,

Fig. 7 is a plan view of still another electrical instrument mechanism embodying principles of my invention, and

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Fig. 8 is a section taken generally along the line 8-8 of Fig. 7.

Referring now to Figs. 1 and 2 of the drawings, the instrument mechanism comprises a substantially annular inner pole piece 1 and an outer pole piece 2 having a C-shaped inner pole face which is substantially concentric with the inner pole piece. A conventional moving coil 3 is mounted so that a portion of the coil is movable along the circular air gap between the inner and outer pole pieces, as is usual in long-scale electrical instruments. Coil 3 is attached to a rotatable shaft 4 pivoted in conventional jewels 5 and 6. The jewels may be supported by a bracket 7 extending inwardly from annular pole piece 1. Electrical connections to coil 3 are made through conventional lead-in spirals 8 and 9. A pointer 10 which cooperates with a calibrated scale, not shown, moves with coil 3 and shaft 4 to display the value of current flowing through the coil. Bias torque tending to return the pointer to its zero current position may be supplied by the lead-in spirals 8 and 9 in the conventional manner.

A substantially annular yoke 11 extends circumferentially around the outer pole piece 2, but not in direct contact therewith. Yoke 11 has an inwardly extending tongue portion 12, to which the inner pole piece 1 is directly connected by suitable means such as screw 13. The pole piece 1 may have a small radial slot, as shown in Fig. 1, to facilitate insertion of the coil 3 during assembly. The thread of screw 13 may engage threaded portions of pole piece 1 on opposite sides of this radial slot.

Permanent magnets 14 and 15 are connected between yoke 11 and outer pole piece 2 as shown. Each of these magnets preferably has substantially the shape of a rectangular parallelepiped. Preferably, the two magnets are located on diametrically opposite sides of pole piece 2, as shown, and are respectively magnetized in opposite straight-line directions. In the drawings, the letters N and S respectively represent north and south poles of the magnets. The magnets 14 and 15 provide magnetic flux through pole piece 2, across the circular air gap in which a portion of coil 3 moves, through pole piece 1 and back through yoke 11. In addition to providing a return path for the magnetic flux, the annular yoke 11 provides a degree of shielding against the influence of any external magnetic fields.

Although the pole pieces 1 and 2, and the yoke 11, can be made of any suitable ferromagnetic material, such as soft iron or annealed steel, they are preferably made of precision moulded powdered iron. When so made, these parts can be shaped and dimensioned very precisely, thus providing a high quality instrument, with very low manufacturing cost. The permanent magnets 14 and 15 are preferably made of oriented permanent magnet material having extremely high coercive force and residual magnetism. For example, permanent magnet alloys of the oriented Alnico type may be used. Because of their rectangular shape, and the fact that little if any grinding is required, these permanent magnets can be made at relatively low cost. The outer pole piece 2 and the yoke 11 may be placed in a suitable jig, to hold them precisely in the desired relative position, and the permanent magnets may then be bonded between the outer pole piece and the yoke to form a permanent unitary structure. This structure is then removed from the jig, and the other parts of the instrument are assembled.

Figs. 3 and 4 show a modified form of the instrument mechanism. The instrument shown in Figs. 3 and 4 is similar to that shown in Figs. 1 and 2, except that the yoke and the permanent magnets are somewhat differently shaped. The yoke 16 is substantially C-shaped, as shown, with the tongue portion 17 extending inwardly from its

center. The permanent magnets 18 and 19 are shaped substantially like truncated wedges, as shown. This wedge-like shape of the magnet permits intimate magnetic joints while still maintaining pole piece 2 in a central position, even though the thickness of individual magnets may vary considerably. This construction increases the coil flux and maintains a uniform circular air gap with resulting advantages in instrument sensitivity and scale markings.

Figs. 5 and 6 show still another form of instrument which may be used where small radial dimensions are required. The annular inner pole piece 20 is substantially the same as the inner pole pieces shown in the preceding figures. The outer pole piece 21 is substantially C-shaped, as shown. The yoke comprises an annular portion 22 and a tongue portion 23. The annular portion 22 is coaxial with, and spaced axially apart from, the pole piece 21. The tongue 23 extends parallel to the common axis of the annular portion and the pole pieces. The inner pole piece 20 is connected directly to tongue portion 23 by suitable means, such as screw 24. A C-shaped permanent magnet 25 is connected between pole piece 21 and the annular portion 22 of the yoke, as shown. C-shaped magnet 25 is magnetized in a direction parallel to its axis, so that it provides magnetic flux through pole piece 21, across the air gap in which a portion of coil 26 moves, through pole piece 20, and back through tongue 23 and annular portion 22 of the yoke.

Figs. 7 and 8 show another form of improved instrument mechanism having a simple, inexpensive construction with external pivots. The moving coil 29 has a low resistance because of its short mean length of turn, making this construction particularly useful in those applications (millivoltmeters) requiring low resistance. The substantially C-shaped yoke 27 and the substantially annular inner pole piece 28 may be moulded as a single unitary part. A portion of a coil 29 is movable along an air gap between the inner pole piece 28 and an outer pole piece 30 having a substantially C-shaped inner pole face. The moving coil is supported by pivots 31 and 32 which cooperate with conventional jewels, not shown, attached to the instrument frame. Conventional lead-in spirals are shown at 33 and 34. Permanent magnets 35 and 36, preferably shaped substantially like truncated wedges, are connected between the yoke 27 and the outer pole piece 30, as shown. This provides magnetic flux from the north poles of permanent magnets 35 and 36 through the outer pole piece 30, across the air gap to inner pole piece 28, and back through yoke 27 to the south poles of the permanent magnets.

In all the embodiments described, it will be noted that the permanent magnets are substantially straight in their direction of magnetization, and that all of the permanent magnets are magnetized in a single straight-line direction, so that the magnetic lines of flux are substantially straight and parallel as they pass through the permanent magnets. As has been explained, this makes practical the use of oriented permanent magnet materials, with consequent advantages in greater sensitivity and improved instrument characteristics.

It will be understood that my invention is not limited to the specific embodiments herein illustrated and described, and that the following claims are intended to cover all changes and modifications which do not depart from the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a long-scale electrical instrument of the moving coil type the combination of a substantially annular inner pole piece, an outer pole piece having a C-shaped inner pole face substantially concentric with said inner pole piece, a C-shaped yoke extending about a portion of said outer pole piece but not in direct contact therewith, said yoke having a tongue portion extending inwardly from its center, means connecting said inner pole piece directly to said tongue portion, and a pair of permanent magnets connected between said yoke and said outer pole piece, said magnets each having substantially the shape of a truncated wedge, said pair of magnets being respectively located on diametrically opposite sides of said outer pole piece and being respectively magnetized in opposite straight-line directions to provide magnetic flux between said pole pieces, each of said magnets having pole faces of like polarity in juxtaposition to the pole face of said outer pole piece.

2. In a long-scale electrical instrument of the moving coil type the combination of a substantially annular inner pole piece, an outer pole piece having an outer pole face and a C-shaped inner pole face substantially concentric with said inner pole piece and spaced therefrom to form an air gap, a ferromagnetic yoke member connected to said inner pole piece and having portions thereof spaced radially outwardly from portions of said outer pole piece, and a pair of wedge-shaped permanent magnets connected between said outer pole piece portions and said yoke portions, said pair of magnets being respectively located on diametrically opposite sides of said outer pole piece and being symmetrically aligned with and on diametrically opposite sides of said annular inner pole piece, said magnets being respectively magnetized in opposite straight-line directions to provide magnetic flux between said pole pieces, each of said magnets having pole faces of like polarity in juxtaposition to the outer pole face of said outer pole piece portions.

3. In a long-scale electrical instrument of the moving coil type the combination of a substantially annular inner pole piece, an outer pole piece having an outer pole face and a C-shaped inner pole face substantially concentric with said inner pole piece and spaced therefrom to form an air gap, a substantially C-shaped ferromagnetic yoke member having a centrally located inwardly extending tongue portion to which said inner pole piece is connected and having portions which are spaced from portions of said outer pole piece, and a pair of wedge-shaped permanent magnets connected between said outer pole piece portions and said yoke portions, said pair of magnets being respectively located on diametrically opposite sides of said outer pole piece and being respectively magnetized in opposite straight-line directions to provide magnetic flux between said pole pieces, each of said magnets having pole faces of like polarity in juxtaposition to the outer pole face of said outer pole piece portions.

4. The combination defined by claim 3 in which said yoke is in the form of a moulded powdered iron member and said inner pole piece is formed as an integral portion thereof.

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