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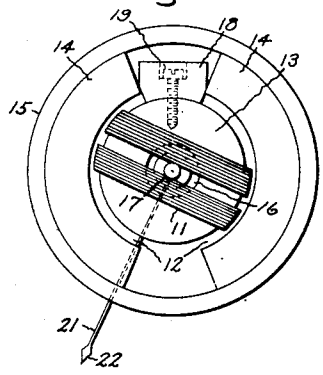
N.S (339) 1/2

March 8, 1938. R. M. ROWELL 2,110,680

ELECTRICAL INSTRUMENT

Filed July 8, 1936

Fig. 1.



compensating element having a negative temperature coefficient of resistance

Fig. 2.

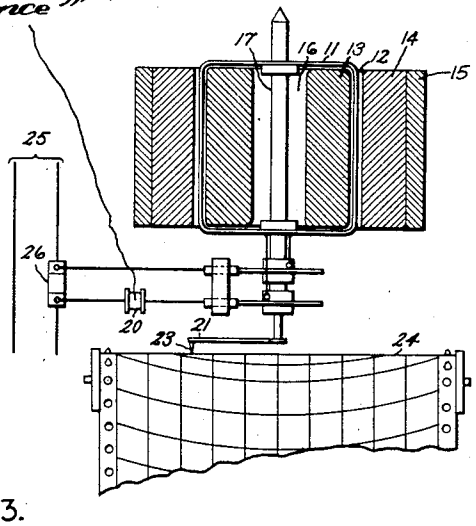
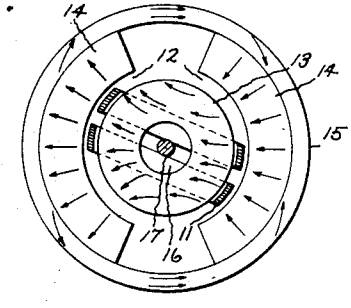


Fig. 3.



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Patented Mar. 8, 1938 2,110,680

UNITED STATES PATENT OFFICE

2,110,680

ELECTRICAL INSTRUMENT

Ralph M. Rowell, Lynn, Mass., assignor to General Electric Company, a corporation of New York

Application July 8, 1936, Serial No. 89,611

4 Claims. (Cl. 171—95)

My invention relates to electrical instruments and dynamo-electric devices and concerns particularly devices employing magnetic fields produced by permanent magnets.

An object of my invention is the production of electrical devices having relatively high torque and the production of instruments having high sensitivity.

A more specific object of my invention is the production of pen-driving mechanisms for recording instruments which, while compact, light in weight, and substantially independent of temperature effects, are capable of producing ample torque for moving the pen even when connected in circuits in which very low voltage is available.

Other objects and advantages of my invention will become apparent as the description proceeds.

In accordance with my invention in its preferred form, in order to obtain a very strong flux, I utilize a construction which is both unusually compact and permits the greater part of the magnetic field structure to be permanently magnetized. I provide a pair of radially magnetized annular segments with their inner circular surfaces serving as pole faces and, between these pole faces, I provide a transversely magnetized cylindrical core. An air gap is left between the core and pole faces for a current-conducting winding encircling the core with an axis of rotation substantially coinciding with the axis of the core. The outer cylindrical surfaces of the annular segments are joined by an annulus which may be of soft iron or other relatively permeable magnetic material. I have also found the use of a permanent magnet core to be very advantageous in an instrument otherwise of the conventional d'Arsonval type with a U-shaped field magnet.

The invention will be understood more readily from the following detailed description when considered in connection with the accompanying drawing and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. In the drawing, Fig. 1 is a plan view of an electric-indicating or recording instrument forming an embodiment of my invention; Fig. 2 is a front elevation of a recording instrument showing the magnetic field structure of the apparatus of Fig. 1 in section and showing the electrical circuit diagram of the apparatus; and Fig. 3 is a schematic diagram of the apparatus of Fig. 1 showing the approximate path of the magnetic flux. Like reference characters are utilized in the drawing throughout to designate like parts.

Referring now more in detail to the drawing, the instrument illustrated is of the direct-current permanent-magnet type with a current-conducting coil or winding 11 movable in an air gap 12 formed in a magnetic field structure consisting of a core 13, annular segments 14, and an annulus or ring 15 surrounding the segments 14. The annular segments 14 and the core 13 are spaced to leave the air gap 12 for the coil 11. If desired, an opening 16 may extend through the center of the core 13 to permit utilizing a through shaft 17 for support of the winding 11. The shaft 17, the core 13, the annular segments 14, and the surrounding ring 15 are all substantially coaxial. The shaft 17 is mounted in suitable pivot bearings, not shown, to provide the winding 11 with a pivotal mounting, making its axis of rotation substantially coaxial with the axis of the field structure and permitting the current-conducting winding 11 to deflect in the air gap 12. To secure the core 13, a suitable nonmagnetic bracket 18 may be provided having screws 19 threaded into the core 13. It will be understood that the bracket 18 is carried by a stationary portion of the apparatus not shown. The annular segments 14 and the ring 15 may be fastened together in any suitable manner, for example, the entire assembly may be die cast together.

The members constituting the field structure, especially the core 13 and the annular segments 14, are composed of permanent magnet material, preferably material having a high coercive force, in order that a high degree of magnetization may be maintained and a compact construction may be used with the field members magnetized in the direction of their shorter dimensions. While my invention is not limited to the use of any particular materials, I have found that satisfactory results may be obtained by the employment of cobalt steel or an aluminum, nickel, iron alloy composed of nearly 16% aluminum and approximately 20% nickel, and, if desired, also a small percentage of cobalt.

The core 13 is magnetized transversely and the segments 14 are magnetized radially in order to send a flux across the air gap 12 radially. The direction of magnetization is represented approximately by the arrows in Fig. 3. Although the surrounding ring 15 may also be composed of permanent magnet material and may be permanently magnetized, I find that satisfactory results may be obtained by composing the member 15 of soft iron or other relatively high permeabil-

ity, low coercive force, magnetic material. The ring 15 provides a return path for the magnetic flux set up by the permanently magnetized members 13 and 14 and also serves to shield the apparatus against stray fields and any magnetic or electrical disturbances which may be taking place in the vicinity of the instrument.

It is evident that the length of the magnetic circuit of the field structure is short in comparison with the area of the magnetic pole faces.

By having a relatively short low-reluctance magnetic path and by having a very large portion of this magnetic path represented by permanent magnets, it will be seen that I am able to force a comparatively large flux across the air gap 12. In this way, a relatively large torque may be exerted on the coil 11 for a given current flowing therein. This feature is of particular value in connection with recording ammeters which are in reality millivoltmeters connected across a current shunt in which a relatively small voltage drop occurs.

In order to avoid excessive losses in the current shunts, the shunts are made with relatively low resistance, consequently, they produce a relatively low voltage drop and are capable of sending only a limited current through the instrument winding. Therefore, it is desirable to maintain the resistance of the instrument circuit at a minimum and to obtain a maximum torque from the current available by providing a high flux. High flux is obtained in the air gap by the construction explained above and the resistance of the electrical circuit is maintained at a minimum without introducing temperature error from self-heating or ambient-temperature variations by providing a highly effective temperature-compensating resistor 20 in series with the winding 11. The compensating resistor 20 may be composed of an annealed crystal of silver tellurium alloy or a disc of annealed tellurium having a resistance at average ambient temperature which is approximately one-third of the resistance of the winding 11. For example, the resistor may consist of an alloy of 15 per cent silver and 85 per cent tellurium annealed at a temperature of from about 115 to 125 degrees centigrade for about 15 hours. Such material has a negative temperature coefficient of resistance approximately three times as great as the positive temperature coefficient of resistance of copper, of which the winding 11 would ordinarily be composed.

In the apparatus shown by way of explanation, the shaft 17 for supporting the winding 11 has mounted thereon an indicating deflecting arm 21 which may carry a target 22 cooperating with a scale, not shown, and a pen 23 cooperating with a movable record chart 24 to produce a record curve. It will be apparent that current flowing in the circuit 25 will produce a potential difference in the shunt 26 to which is connected the circuit of the winding 11. This potential difference and the current flowing in the winding 11 will vary in proportion to the current flowing in the circuit 25. Accordingly, the arm 21 will deflect and the pen 23 will trace a curve on the record chart 24 representing variations of the current flowing in the circuit 25. As a result of the relatively high flux and current brought about by using my construction, it is unnecessary to employ a torque amplifier or follow-up means in order to overcome pen friction in producing the record, and the record may be produced directly on the chart 24 by the movement of the current-conducting winding 11.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

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

1. A current-responsive instrument comprising in combination, a substantially cylindrical core of relatively high coercive force material permanently magnetized transversely with the direction of magnetization at the pole faces normal to said pole faces, a pair of annular segments of relatively high coercive force material permanently magnetized radially, said segments having circular surfaces substantially coaxial with said core, the inner of said surfaces being spaced from said core to form an air gap, a current-conducting winding movable in said air gap, mounted with an axis of rotation substantially coincident with the axis of said core, and a relatively low coercive force magnetic member joining the outer circular surfaces of said annular segments and serving to complete the magnetic circuit of the permanently magnetized members.

2. A sensitive temperature-compensated recorder comprising in combination a torque-producing pen-driving mechanism and a temperature-compensation resistor, said mechanism including a current-conducting coil and a magnetic field structure cooperating with said coil, said field structure being formed with a length of magnetic circuit relatively short in comparison with the pole face area and comprising magnetic material, the greater part of which is composed of high coercive force material permanently magnetized in order to produce a high flux reacting with said coil, said temperature-compensation resistor being connected in series with said coil, having a resistance at average ambient temperature approximately one-third the resistance of said coil, and being composed of a material having a negative temperature coefficient of resistance with a numerical value approximately three times the temperature coefficient of resistance of the material composing the coil in order to maintain the resistance of the coil circuit at a minimum while compensating for temperature variations.

3. A torque-producing element comprising a magnetic core, a rotatably deflectible current-conducting coil surrounding said core in inductive relation therewith, and a pair of magnets on either side of said core with inner pole faces spaced from said core to leave air gaps for said coil, a surface of said core and said pole faces conforming in shape to the surface generated by deflection of said coil and said core and magnets being permanently magnetized along normals to said pole faces.

4. An electric measuring instrument comprising a movable coil and a magnetic circuit therefor comprising field portions within and outside said coil, both such portions including permanent magnet material magnetized with such a polarity as to produce flux in the same direction in said magnetic circuit.

RALPH M. ROWELL.