Oct. 1, 1940. H. LIST 2,216,620

ELECTROMAGNETIC DEVICE

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Fig. 1

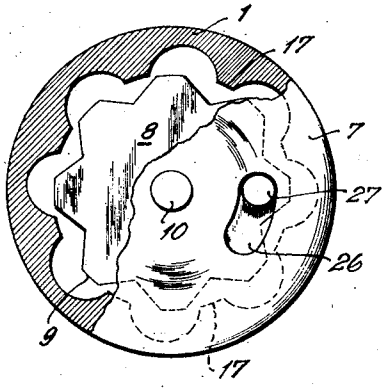


Fig. 4

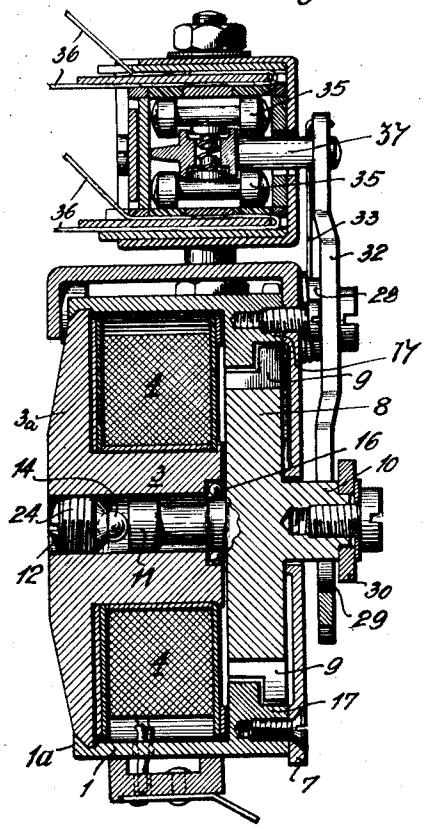


Fig. 2

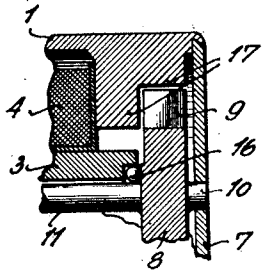


Fig. 3

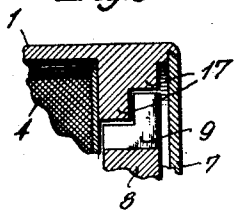
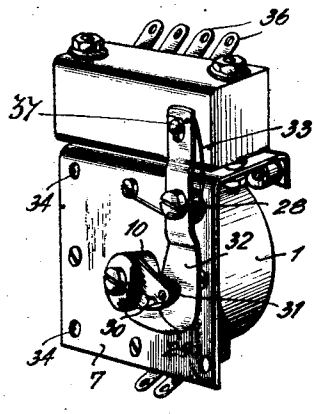


Fig. 5



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Fig. 6

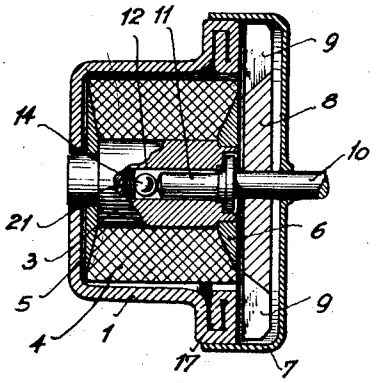


Fig. 7

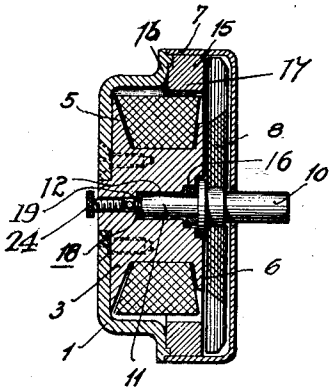
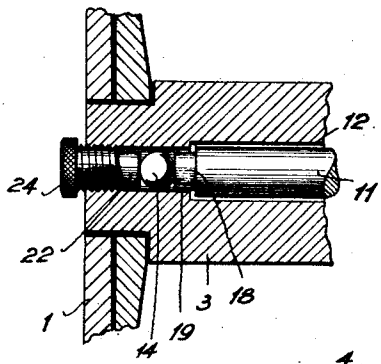


Fig. 9



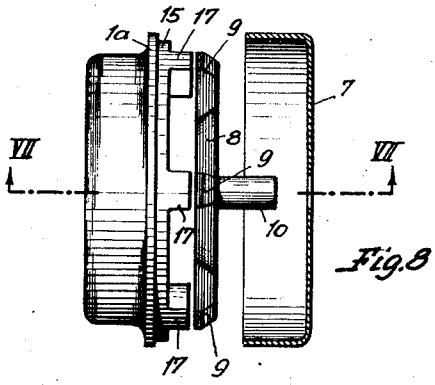


Fig. 8

Fig. 10

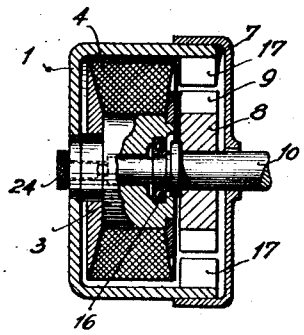


Fig. 11

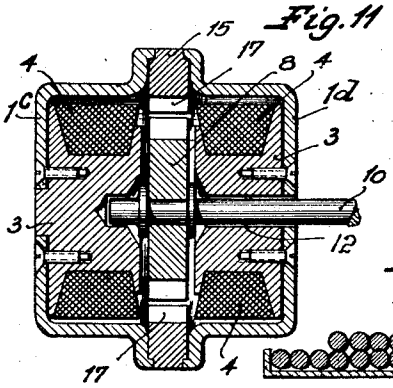


Fig. 12

Fig. 13.

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UNITED STATES PATENT OFFICE

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ELECTROMAGNETIC DEVICE

Heinrich List, Berlin-Lichterfelde, Germany

Application April 5, 1938, Serial No. 200,066
In Germany December 30, 1936

8 Claims. (Cl. 175—336)

This invention relates to an electromagnetic device of which the armature is turnable to-and-fro.

An object of the invention is to make certain improvements in such an electromagnetic device whereby the capacity thereof for transmitting power will be increased without adding to its size and weight.

Another object is to provide in such a device a stator of pot formation, with an axial core on which the field winding is put and which preferably extends from the base of the pot-form stator in the manner of a yarn-bobbin.

Another object is to provide in such a device an armature of disc-like formation mounted to turn to-and-fro in the stator, the stator and the armature to be respectively provided with toothlike pole-projections and to be so dimensioned that their flux-conducting portions are of equal or nearly equal cross-sectional areas.

Another object is to provide a construction of such a device in which the last-mentioned cross-sectional areas are sufficiently large to ensure that the stator and armature will not reach their magnetic saturation limit in the operation of the device. By virtue of such a construction, undesirable straying of the magnetic flux from the said flux-conducting portions will be materially reduced or avoided.

Yet another object is to reduce or avoid straying of the flux from the field winding by making the cross-sectional form of the winding circular or square or varying only slightly from circular or square. Such a cross-sectional form is desirable because the peripheral or external surface is small in relation to the cross-sectional area. Theoretically, a circular cross-section is the ideal, but in practice it will usually be found that a square, or nearly square, cross-section is the nearest available approximation to the ideal.

Various other objects of the invention will be apparent from the following specification and claims.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a sectional elevation illustrating one form of the toothlike pole-projections.

Figs. 2 and 3 are fragmentary sections illustrating modified forms of pole-projections.

Fig. 4 is a section of an electromagnetic device in combination with a multi-contact relay which is actuated by the device, and Fig. 5 is a corresponding perspective view drawn to a smaller scale.

Figs. 6 and 7 are sections of modified constructions of the electromagnetic device, Fig. 7 being a section on the plane indicated by the line VII—VII of Fig. 8, which is an elevation of the main body of the electromagnetic device and a section of a cover-plate shown removed.

Fig. 9 illustrates a constructional detail to a large scale.

Figs. 10 and 11 are views corresponding to Figs. 6 and 7 but illustrating further modifications.

Figs. 12 and 13 are diagrammatic sectional views illustrating forms of winding wire.

Throughout the drawings, similar or corresponding parts are denoted by the same reference numerals.

In the construction according to Fig. 1, the stator 1 and the armature 8 are each provided with eight pole-projections, hereinafter called "poles" for simplicity in referring to the drawings. The stator poles are denoted by 17 and the armature poles by 9. Each of these poles is constituted by a radially projecting portion. The number of poles employed can be chosen in accordance with the purpose to which the device is to be applied, consideration being given to the angle through which it is desired to turn the armature to-and-fro in the operation of the device. The armature would be acted upon by means for imparting to it a return force in order to restore the armature to its "non-attracted" position, but in Fig. 1 such means are not shown. The armature 8 is provided with a pin 27, offset from the armature shaft 10, which pin projects through an arcuate slot 26 formed in a cover plate 7 forming a removable part of the stator. The plate 7 should be as dust-tight as practicable. The pin 27 extends to the exterior of the device and constitutes a means whereby power can be transmitted from the armature to a part to be operated by the electromagnetic device. In such an arrangement, it is neither necessary to extend the armature-shaft 10 to the exterior of the device nor to provide for the shaft 10 a bearing in the cover plate 7, since the armature can be entirely supported by the stator core to be hereinafter described.

The armature is shown in Fig. 1 in its non-attracted position. It will be clear that, when the armature occupies its attracted position in which each pole 9 registers with a pole 17, the poles 9 practically fill or bridge the annular space between the body of the armature and the stator poles 17.

The poles according to Fig. 1 are such that the lines of force pass wholly or mainly in a

radial direction from pole to pole. If desired, the arrangement may be such that the lines of force pass not only radially but also axially—that is, in a direction substantially parallel to the axis about which the armature turns—and suitable arrangements are illustrated by Figs. 2 and 3, respectively. According to Fig. 2, the flux-passing face of each stator pole is formed like a step, and according to Fig. 3 the face of each stator pole is formed like a double step, in each instance each armature pole being stepped in counterpart to the corresponding stator pole. Such step-formed poles present a large effective surface for the radial and axial emission and reception of the magnetic flux.

In Fig. 2 there is also shown a portion of a bearing 16 which is interposed between the disc-form armature 8 and the stator core 3, only partially shown. This bearing consists of a circular thrust ball-race surrounding the armature-shaft 11, and it can be made large enough in diameter to ensure that such tilting forces to which the armature may be subjected in the operation of the device are taken up and withstood satisfactorily by the bearing. An additional bearing is provided in the cover plate 7 for the armature-shaft 10.

Referring to Fig. 4, it will be seen that the stator is made in the form of a pot, the annular wall of which consists of a ringlike yoke 1 and the base of which consists of a member 3a made in one piece with the core 3 of the stator. The core 3 and base 3a constitute a holder for a coil 4 constituting the magnet-field winding which preferably is withdrawably mounted on the core. The stator yoke 1, which bears the poles 17, has a marginal flange 1a to which the member 3a is peripherally attached. The winding 4 is square in cross-section.

In this construction, the armature-shaft consists of an integral boss 10 on the disclike armature body 8 and a journal 11 extending into and journalled in a bore 12 which axially penetrates the core 3. A thrustbearing 14 is provided to take up and withstand any axial stress to which the armature 8 may be subjected in the operation of the device; and the bearing may consist of one or more balls, although only a single ball is shown. The armature can be axially adjusted relatively to the stator through the intermediary of the ball-bearing 14 by a screw-adjustment ball-support 24 screwed into the core 3. As in the construction according to Fig. 2, a bearing 16 is provided. The bearing 16 is shown as ball-bearing, but any other form of bearing may be employed instead; for example, a sliding-face bearing.

The stator and armature are dimensionally so designed that their flux-conducting portions—namely, the core 3, the base 3a, the yoke 1, the poles 17, the poles 9 and the armature body 8—offer to the circulating flux a path whose cross-sectional area is practically constant, or nearly so. Moreover, the said cross-sectional area is sufficiently large in relation to the ampere-turns of the field winding to ensure that the stator and armature cannot reach their saturation limit in the ordinary operation of the device.

The armature-shaft 10 extends through the cover-plate, and has secured to it, outside the plate 7, a lever arm 30. As can be seen best in Fig. 5, the arm 30 is provided with a roller 31 which engages with a curved cam surface of a lever 32 whose fulcrum bolt 28 is secured to the plate 7. The lever 32 is acted upon by a return spring 33, which serves to return the armature to its non-attracted position whenever the magnet is de-energised. The arrangement is such that the to-and-from angular motion of the armature 8, arm 30 and lever 32 is transmitted to and converted into rectilinear motion of a relay-actuating member 37.

The plate 7 is adapted to be secured to an instrument panel or wall, for which purpose the plate has screw-holes 34.

The multi-contact relay to which the electromagnetic device is applied is of such a nature that the device serves to switch-in and switch-out the contacts. An eight contact relay has been shown, involving the use of four upper terminals and four lower terminals all denoted by 36. To these terminals the outer electricity conductors (not shown) would be connected in the usual manner. The electromagnetic device and the relay are preferably mounted as a single structural unit on the plate 7. In order to minimise the power required to operate the relay, contacts or bridges consisting of rollers 35 can be employed with advantage as the means whereby current is passed between the respective terminals.

The poles 9 and 17 have been illustrated as of the same double-step form as in Fig. 3, but it is to be understood that they may have any other suitable form, for example axial or unstepped form, as illustrated by the other figures of the drawings.

To maintain the desired constancy of cross-sectional area, the core base 3a thickens on its outer face towards the centre.

Referring to Fig. 6, the pot-formed body or "pot" of the stator therein shown is of such a nature that it can be made by a stamping process or by a drawing process from a single piece, the poles 17 being formed at spaced intervals around the outer edge of the pot by a flanging operation.

To improve the magnetic conductability between the core 3 and the pot and to preserve constancy in the cross-sectional area of the magnetic circuit, discs 5 and 6 with flattish-coned inner faces are secured to the core. The cover plate 7 is slipped upon the outermost rim of the pot.

To provide for axial adjustment of the armature 8 in relation to the stator, distance pieces 21 are inserted between the thrust-ball 14 and the closed end of the bore 12.

The armature 8 also may be of such a nature that it can be made by a stamping process or by a drawing process.

Referring to Figs. 7 and 8, the armature therein shown is composed of laminae, which may be stampings. This is the preferred form of armature, and such an armature may be used with advantage in any of the other constructions herein described. There are also provided flattish-coned discs 5 and 6, but these are turned out of the same piece as the core 3, so that the core presents the appearance of an ordinary yarn or thread bobbin. The pot is provided with an out-turned flange 1b and to this flange there is attached as a separate part a crown-like ring 15 on which the poles 17 are formed. It is not necessary for the armature-shaft 11 to be a neat fit in the bore 12, because a stub 18 and bearing 19 can be provided which take up any tilting stresses to which the armature is subjected. An advantage of providing such a bearing is that the need for accurate fit between the shaft 11 and the bore 12 is avoided.

Referring to Figs. 7 and 9, the armature shaft 11 in each instance is shown provided with a stub 18 which abuts against a thrust ball 14 located in a small cavity into which the stub 18 extends and with which it forms a bearing. In Figs. 7 and 9, the said cavity is constituted by a bore 19 which is a continuation of, but smaller in size than, the main bore 12. The arrangement is such that the stub 18 serves to take up any tilting forces to which the armature and its shaft may be subjected. The friction losses of such a bearing are small.

Referring to Fig. 10, the armature 8 is located radially within the ring of poles 17 on the pot constituting the main body of the stator, and the bearing 16 is constituted as a ball-bearing. As in Figs. 4 and 9, a screw 24 is provided for axially adjusting the armature in relation to the stator.

Referring to Fig. 11, in this construction the armature 8 is disposed between two cores 3 respectively embraced by windings 4. The exterior portions of the stator are constituted by two pot-form caps 1c and 1d between which is sandwiched the ring 15 on which are formed the poles 17. The arrangement is such that the stator constitutes a conductor for two magnetic flux circuits. Such an arrangement has a higher efficiency in as much that the armature works in a space enclosed by two magnetic fields practically not subject to loss by straying. The armature is disposed in the zone between the cores 3, and if desired ball, roller or other anti-friction bearings may be employed to support the armature-shaft in the respective cores. In this construction one is concerned wholly or mainly with radial stresses. One of the cores 3 is completely penetrated by its bore 12 to provide a passage to the exterior of the device for the armature shaft 10.

Features already described with reference to the preceding figures, more especially Figs. 4, 6 and 7 can also be applied to a two-field arrangement such as illustrated by Fig. 11.

Although it is only in Figs. 4 and 5 that a return spring 33 has been shown, it is to be understood that equivalent return means would be provided in each of the other constructions herein described and illustrated.

In the constructions according to Figs. 6 to 8, the armature 8 is axially spaced from the stator poles 17; whereas, in the constructions according to Figs. 10 and 11 the armature 8 is arranged radlaily within the ring of working poles 17. In the constructions according to Figs. 2, 3 and 4, the armature 8 is spaced both axially and radially from the stator poles 17.

In order to attain the highest efficiency, it is necessary that the winding space should be fully occupied. Figs. 12 and 13 illustrate a difference between a winding composed of circular section wire and a winding composed of square section wire. By employing wire of which the cross section is so chosen that useless air spaces are avoided, one can obtain considerably more turns of wire in comparison with what one would obtain by using circular section wire of the same cross-sectional area. Thus, one can with advantage use wire of which the cross section is of such a geometrical form that the sides of adjacent and superposed wires fully cover or register with one another.

For winding material it has been proposed heretofore, to use, inter alia, aluminium or alloys thereof as a suitable substitute for copper, the material used to be given an insulating surface or some corresponding surface modification. As will be manifest, aluminium can only be employed as a complete substitute for copper if the number of turns is proportionately increased, or if at the outset the prescribed sizes are exceeded. By using wire of the cross section indicated (for example in Fig. 13) useless air spaces such as shown in Fig. 12 between adjacent turns of the wire will be avoided and accordlingly the required extra turns of aluminium or the like can be accommodated in the same winding space, and the dimensions which would be prescribed for a winding composed for circular-section copper wire need not be exceeded. Accordingly, it is to be understood that, in any of the constructions of the electromagnetic device herein described and illustrated, the wire used for the field winding or windings may be of the cross-sectional form illustrated by Fig. 13.

I claim:

1. An electromagnetic device comprising a stator formed about a central axis and provided with an axial core, a central bore in said core, a field winding on said core, an armature constituted by a disc-like body on a shaft journalled in said bore, said armature being adapted to turn to-and-fro in the stator about said axis under electromagnetic action of the stator and the opposed action of armature-returning means, angularly spaced toothlike pole-projections on the stator, similarly angularly spaced toothlike pole-projections on the armature, said stator and armature being spaced apart axially to leave an interpole gap, an abutment in said bore, a thrust-bearing between said abutment and said shaft, said abutment being adjustable in said core to effect axial regulation of the armature in relation to the stator and therefore regulation of said gap.

2. An electromagnetic device comprising a stator formed about an axis and including an annular wall with a base and an axial core, stator poles on said wall presenting magnetic-flux conducting faces which face forwardly away from said base and a field winding upon said core and within said wall, an armature journalled for rotation about said axis and arranged in front of said stator, poles on said armature presenting magnetic-flux conducting faces which face towards said base, the faces presented by said armature and its poles being axially spaced from the faces presented by said stator and its poles, said faces being arranged in planes to which said axis is perpendicular, said stator and armature poles being adapted to interact magnetically to rotate said armature whenever said winding is energised, means for returning said armature whenever said winding is de-energised, and means for regulating the axial spacing between said stator and armature.

3. An electromagnetic device comprising a stator formed about a central axis and constituted by a pot with a disc-like base and a circular wall, a rim flange on said wall, a short heavy-section central core secured to said base and extending therefrom axially and internally of said pot, a series of angularly spaced stator poles on said flange, said poles projecting axially in front of said flange, and a field winding on said core, an armature journalled for rotation about said axis and arranged in front of said stator, poles on said armature presenting magnetic-flux conducting faces which face towards said base, said faces being arranged in a plane to which

said axis is perpendicular, said armature and its poles being axially spaced from said stator and its poles, said stator and armature poles being adapted to interact magnetically to rotate said armature whenever said winding is energised, means for returning said armature whenever said winding is deenergised, and means for regulating the axial spacing between said stator and armature.

4. An electromagnetic device comprising a stator formed about an axis and including an annular wall with an axial core, stator poles on said wall facing forwardly away from said wall and a field winding upon said core and within said wall, a shaft journalled in said core for rotation about said axis and extending forwards from said core, an armature comprising a body of disc-like formation secured to said shaft and provided with angularly spaced radially projecting armature-poles, said body and armature-poles being in front of but spaced from said core and stator-poles so as to leave a small axial air-gap, said armature-poles being attracted by said stator-poles to rotate said armature and shaft about said axis whenever said winding is energised, means for returning said armature and shaft whenever said winding is de-energised, and means for regulating the axial size of said air-gap.

5. An electromagnetic device comprising a stator formed about an axis and constituted by an annular wall, an axial core and a base interconnecting said wall and core, stator poles on said wall facing forwardly away from said base, and a field winding upon said core and within said wall, an armature journalled in said core for rotation about said axis and arranged in front of said stator, poles on said armature facing towards said base, said armature and its poles being axially spaced from said stator and its poles to leave an air-gap, said stator and armature poles being adapted to interact magnetically to rotate said armature whenever said winding is energised, means for returning said armature whenever said winding is de-energised, a thrust-ball bearing to take rearward axial thrust due to the magnetic interaction between said stator and armature, said bearing being arranged in said core and applied to said armature, and an abutment for said bearing, said abutment being screwed into said core and being adjustable axially thereof to axially displace said armature to regulate the axial size of said air-gap.

6. An electromagnetic device comprising a stator, angularly spaced poles on said stator, a field winding on said stator, an armature rotatably mounted in relation to said stator, angularly spaced poles on said armature, said armature being spaced from said stator so as to leave a small air-gap, a thrust bearing to take rearward axial thrust due to magnetic inter-action between said stator and armature, and an abutment for said bearing, said abutment being screwed into said stator and being adjustable to displace said armature to regulate the size of said air-gap.

7. An electromagnetic device comprising a stator formed about an axis and having for its components an annular wall, an axial core, a base interconnecting said wall and core, and stator poles on said wall facing forwardly away from said base, a field winding upon said core and within said wall, an armature journalled on said stator for rotation about said axis and arranged in front of said stator, poles on said armature facing towards said base, the faces of said stator and rotor poles respectively being arranged in transverse mutually parallel planes, said armature and its poles being axially spaced from the stator and its poles, said stator components and said armature all being made of magnetism-conducting material and being adapted to interact magnetically to rotate said armature whenever said winding is energised, and means for returning said armature whenever said winding is de-energised.

8. An electromagnetic device comprising a stator formed about a central axis and having for its components a pot with a disc-like base and a circular wall, a rim flange on said wall, a short heavy-section central core secured to said base and extending therefrom axially and internally of said pot and a ring of angularly spaced stator poles secured to said flange, said poles projecting axially in front of said ring, a field winding on said core, a shaft journalled in said core for rotation about said axis and extending forwards from said core, an armature having for its components a body of disc-like formation secured to said shaft and angularly spaced radially projecting armature-poles on said body, said body and armature-poles being in front of but spaced from said core and stator-poles so as to leave a small axial air-gap, said stator components and armature components being made of magnetism-conducting material and being adapted to interact to rotate said armature about said axis whenever said winding is energised, and means for returning said armature whenever said winding is de-energised.

HEINRICH LIST.