

May 29, 1945.

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2,377,244

ELECTROMAGNET AND RELAY

Filed June 18, 1942

2 Sheets-Sheet 1

Fig. 1.

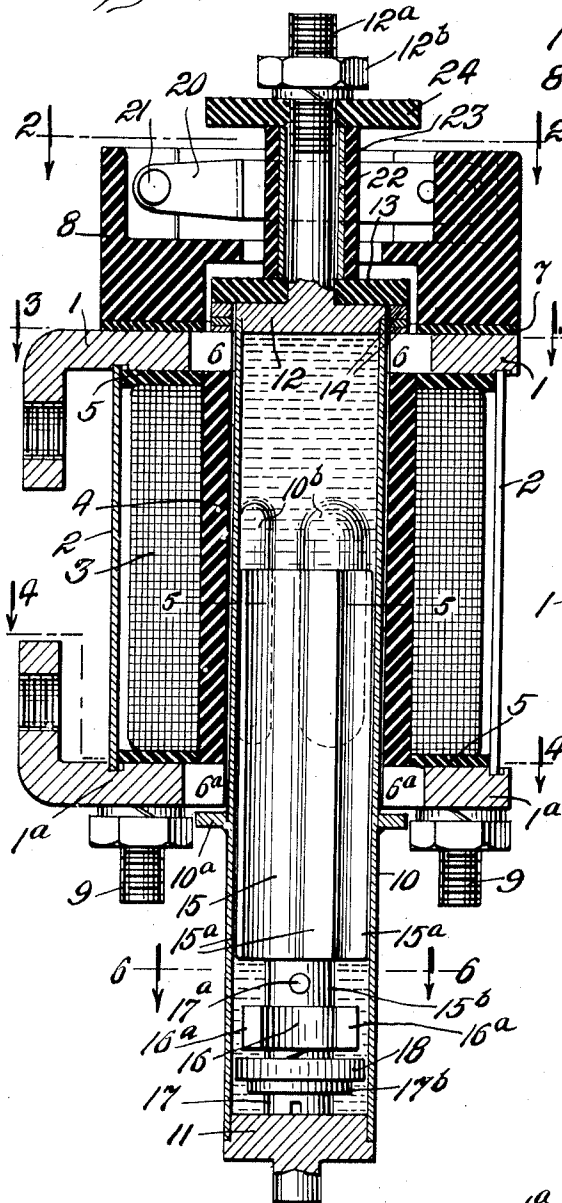


Fig. 2.

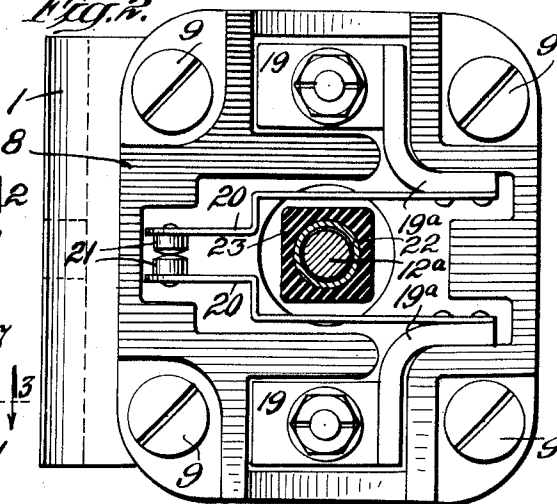


Fig. 3.

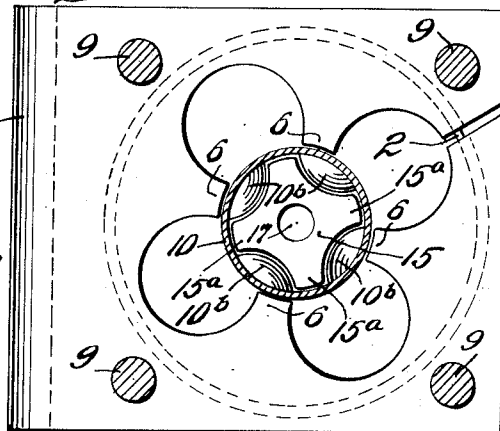


Fig. 4.

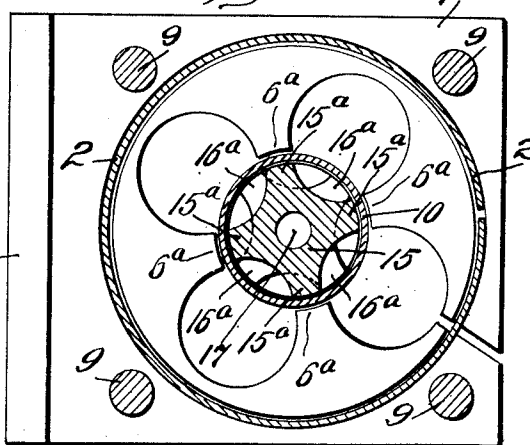


Fig. 5.

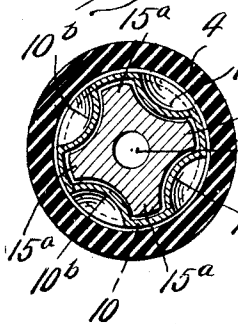
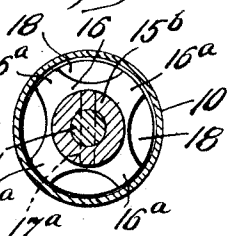


Fig. 6.



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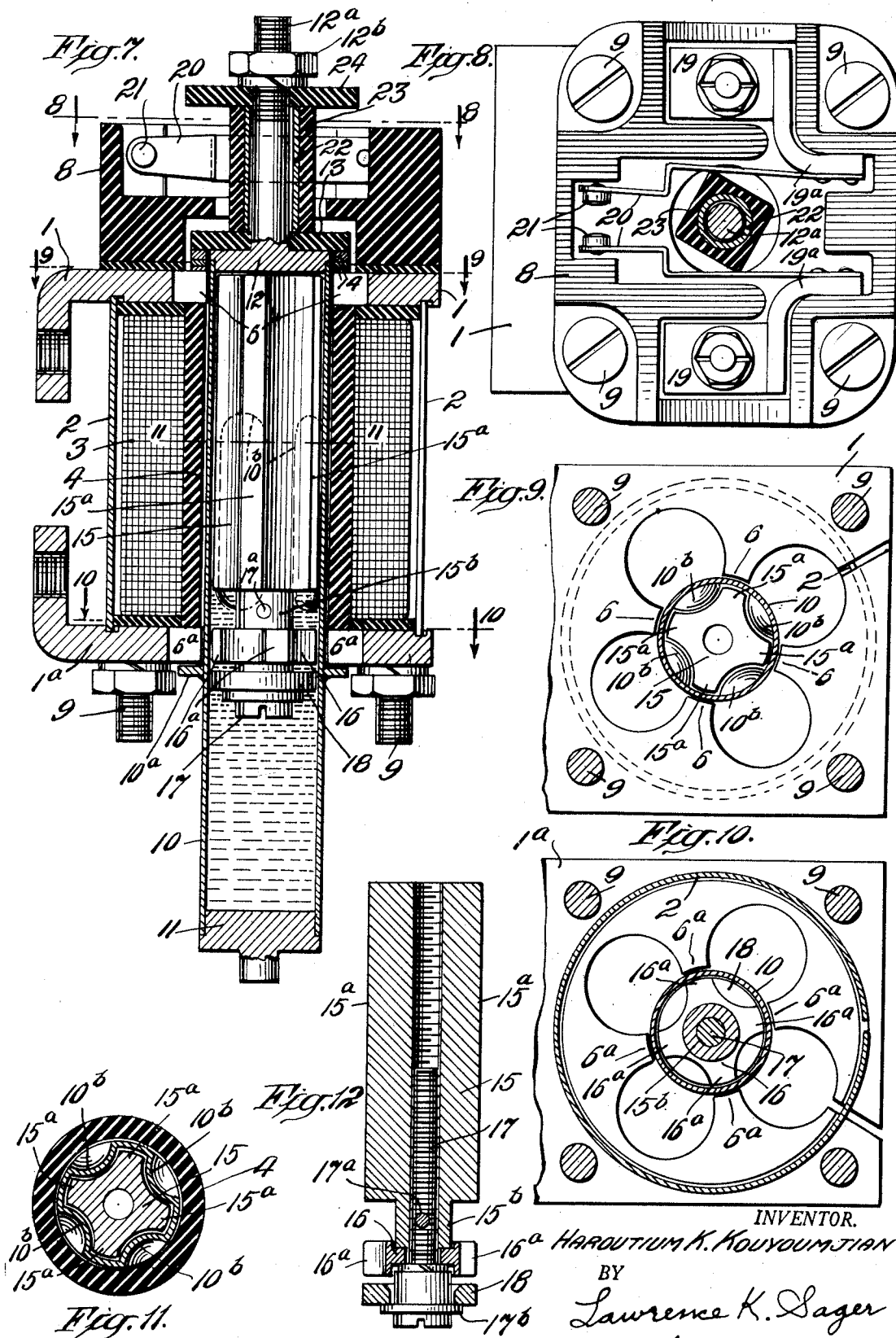
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2 Sheets-Sheet 2



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ELECTROMAGNET AND RELAY

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Application June 18, 1942, Serial No. 447,531

11 Claims. (Cl. 175—341)

This invention relates to an improved form of electromagnet applicable to various uses and to an improved form of relay for opening or closing a control circuit or for actuating any element. The present embodiment shows the invention applied to a time delay relay responsive to an overload controlling current.

The main object of the invention is to provide an electromagnet or relay which will not be objectionably affected by shocks or jars in its controlling action and in general this is accomplished by imposing upon the movable magnetic element a compound movement for securing the controlling action and which cannot be imposed upon the movable element by shocks or jars. Another object is to provide a structure which is compact in size and which may be conveniently manufactured and assembled. Another object is to provide a structure which will be durable and dependable under long continued use. Another object is to avoid instantaneous response of the relay under extremely high values of the controlling current for the purpose of always providing at least some time interval in its action so that other devices of the control system in which it may be used will have time to function before the relay attains its final attracted position. Other objects and advantages will be understood from the following description and accompanying drawings which illustrate one embodiment of the invention.

Fig. 1 is a vertical section showing the invention applied to a time delay relay; Fig. 2 is a section on the line 2—2 of Fig. 1; Fig. 3 is a section on the line 3—3 of Fig. 1; Fig. 4 is a section on the line 4—4 of Fig. 1; Fig. 5 is a section on the line 5—5 of Fig. 1; Fig. 6 is a section on the line 6—6 of Fig. 1; Fig. 7 is a vertical section showing the movable parts in their attracted position; Fig. 8 is a section on the line 8—8 of Fig. 7; Fig. 9 is a section on the line 9—9 of Fig. 7; Fig. 10 is a section on the line 10—10 of Fig. 7; Fig. 11 is a section on the line 11—11 of Fig. 7; and Fig. 12 is a vertical section showing the assembly of the magnetic element.

Referring to Fig. 1 the magnet is provided with upper and lower end plates 1, 1a forming the main frame and are shown provided with rearwardly and inwardly projecting extensions for supporting the device on a panel. Between the end plates extends a tube 2 of magnetic material, such as iron or steel, and this may be formed from sheet metal with a small space left between the meeting edges of the tube as shown in Fig. 4 for reducing the effects of induced eddy currents. This tube forms a magnetic path between the end plates of the frame. A control winding or coil 3 is located within the tube and is shown wound upon a tube 4 of insulating material, the coil being spaced from the end plates by intervening washers or disks 5 of insulating material.

The upper magnetic end plate 1 is shown provided with inwardly extending poles 6, four being shown as indicated in Fig. 3, the spaces between the poles being shown of circular form. The poles 6 are shown displaced from vertical and horizontal lines by an angle of about 15° in a clockwise direction. The lower end plate is similar in form to the upper end plate except that the poles 6a of the lower end plate, as shown in Fig. 4, are displaced about 15° from vertical and horizontal lines in a counter-clockwise direction. It follows that the poles of the lower end plate are positioned angularly about 30° from those of the upper end plate in a counter-clockwise direction about the central axis of the magnet for the purpose later explained. Instead of making this displacement 30°, it may be made a lesser amount or a greater amount to suit particular requirements.

Above the upper plate 1 is an insulating washer or disk 7 on which is mounted a contact head 8 of molded insulating material; and all the parts as thus far described are clamped firmly together by screw bolts 9. The heads of the bolts are located in recesses at the four corners of the contact head and extend downwardly outside of the winding and tube 2 through the upper and lower end plates, lock washers and nuts being applied at the lower ends of the bolts for holding the parts firmly together.

A tube 10 of non-magnetic material, such as brass is located within the insulating tube 4 and extends from a small distance above the upper plate 1 to a considerable distance below the plate 1a. The tube is hermetically sealed and at its lower end is a plug 11 which is brazed to the tube and a plug 12 closes the upper end of the tube, being brazed thereto, and is provided with an upwardly extending central screw threaded portion 12a. The tube is adapted to turn in opposite directions on its vertical axis through an angle of 30°, sufficient clearance for this purpose being provided between the tube and the poles of the end plates and the central insulating tube 4. The tube 10 has no appreciable vertical movement being restrained from downward movement by a washer 13 of insulating material fixed in position on the plug 12. This washer rests on a plurality of non-magnetic metal rings 14 of phosphor bronze, or other suitable material, which in turn are supported by the poles of the upper end plate. There are three such rings shown each of a different thickness from that of the others; and by removing one or more of them the relay may be adjusted to have proper clearance for permitting free rotation on these rings as bearings. The tube is restrained from upward movement by a ring 10a of non-magnetic material soldered to the outside of the tube 10 and positioned a slight distance below the poles of the lower end plate.

The magnetic plunger assembly separately shown in Fig. 12 is movable as a unit from its lowest position shown in Fig. 1 to its uppermost position shown in Fig. 7. It comprises a main magnetic element 15 which in its lowest position is shown extending from about the middle of the winding 3 to a considerable distance below the poles of the lower end plate. It is of general star-shaped form throughout its length being provided with four poles 15a which extend outwardly and are opposite the four poles of the lower end plate or of the upper end plate according to the conditions of operation. The plunger 15 is provided with a central screw threaded opening and its lower end 15b is of a reduced diameter. Below this reduced portion is another magnetic element 16 of comparatively small thickness, being of about the same thickness as the end plates of the magnet. The magnetic element 16 is of similar form to the magnetic element 15 having similar outwardly extending poles 16a.

The latter poles are displaced angularly about 30° in a counterclockwise direction about the central axis of the magnet from the poles 15a of the main portion of the plunger. The magnetic element 16 is fixed in position by the screw bolt 17 which passes upwardly through the element 16 into the threaded opening of the element 15. After the parts are secured together, a hole is threaded through the portion 15b and the screw for receiving a pin 17a for insuring the retention of the parts in place.

The head of the screw 17 is provided with a flange 17b on which is seated loosely a ring 18 of non-magnetic material, such as brass.

The tube 10 is filled with oil and then hermetically sealed. When the plunger is moved upwardly there is sufficient clearance between the rim of the ring 18 and interior surface of the tube 10 to permit slow passage of the oil from above the ring to below the ring, giving a retarded movement of the plunger and thereby imposing a time-delay action on the relay. When the plunger moves downwardly, the ring 18 is raised from its seat on the flange 17b by the action of the oil and by reason of the fact that the interior diameter of the ring is somewhat larger than the diameter of the head of the screw and by reason of the ring being chamfered on its upper interior portion, there is a free passage of the oil from below the ring to above the ring. This permits a rapid downward movement of the plunger when the winding of the relay is deenergized.

The mid-portion of the tube 10 is depressed inwardly along a portion of its length at the regions between the poles 15a of the main element 15 of the plunger. These inwardly depressed portions 10b of the tube 10 are well shown in Fig. 5. Although affording sufficient clearance between them and the plunger 15 to allow free movement of the latter in a vertical direction relatively to the tube 10, any turning movement of the plunger will be imparted to the tube 10 by reason of the coupling formed by the depressions of the tube between the poles of the plunger.

The contact head is provided with opposite recesses for reception of two contact terminals 19 having clamping nuts and washers for connection to an external circuit controlled by the relay. The terminals are provided with inwardly and outwardly extending portions 19a on the inner sides of which are riveted the two contact arms 20. The arms extend rearwardly from the contact terminals at opposite sides of a central open-

ing and are then bent towards each other and carry the contacts 21 at their inner ends. The contact arms are of phosphor bronze or similar material forming leaf springs for normally pressing the contacts 21 together. On the upwardly extending threaded portion 12a of the plug 12 is a brass tube 22 and outside of this is a separator 23 of molded insulation. The outside shape of this separator is square and above it and the tube 22 is a disk 24 of insulating material and these parts are held in fixed position on the threaded portion of the plug 12 by a nut 12b and lock washer which are above the disk 24.

Under normal conditions when the winding of the relay is deenergized or carrying insufficient current to raise the plunger, the parts may be assumed to be in the position shown in Figs. 1 to 6. At this time the contacts 21 are in engagement and the separator 23 is in the position shown in Fig. 2 and not affecting the contact arms. The poles of the upper magnetic element 15 are then opposite the poles 6a of the lower end plate as shown in Fig. 4 and are offset counterclockwise about 30° from the poles 6 of the upper end plate. At this time the position of the magnetic element 15 is under the full influence of the poles 6a of the lower end plate and not affected materially as regards its axial position by the poles of the upper end plate. Likewise at this time the poles 16a of the lower magnetic element are offset counterclockwise from the poles 6a of the lower end plate as shown in Fig. 4.

When current is supplied to the winding 3 of the relay the path of the magnetic flux in the position of the parts shown in Figs. 1 to 6, is from the upper end plate through the tube 2 to the lower end plate and thence through its poles to the poles of the upper magnetic element 15 and from the upper end of this element to the poles of the upper end plate. When the current through the relay winding exceeds a predetermined amount, such as by the passage of an overload current therethrough, the plunger assembly will be moved upwardly within the tube 10, being retarded by the dashpot action of the oil and ring 18 within the tube in the manner already described. During the upward movement the axial position of the parts remain as described with reference to Figs. 1 to 6 until the plunger approaches the upper limit of its movement. At that time the lower end of the magnetic element 15 is leaving the influence of the poles 6a of the lower end plate and is coming within the influence of the poles 6 of the upper end plate. Likewise the poles of the magnetic element 16 are coming within the influence of the poles 6a of the lower end plate. In view of the fact that the poles 15a of the upper element are then displaced counterclockwise about 30° from the poles of the upper end plate and that the poles 16a of the lower magnetic element are displaced about 30° counterclockwise from the poles of the lower magnetic element, the strong magnetic influence between these poles results in the plunger assembly being turned about 30° in a clockwise direction at or near its fully attracted position. The poles 15a are then opposite the poles of the upper magnetic end plate and the poles 16a are then opposite the poles of the lower end plate. This turning movement imparted to the plunger assembly results in the tube 10 being similarly turned owing to the plunger 15 and the tube 10 being interlocked as regards rotary movement in the manner previously described.

This fully attracted position of the plunger and the various related parts are shown in Figs. 7 to 11. The turning of the tube and the separator 23 results in opening the contacts 21 for resultant control of the external circuit, these parts then being in the position shown in Fig. 8.

When the winding of the relay is deenergized, or its current reduced to a value insufficient to retain the plunger in its uppermost position, the latter will fall rapidly to the lower end of the tube and any current in the relay winding will cause the poles 15^a of the upper magnetic element to assume a position opposite the poles of the lower end plate. This results in turning the plunger assembly and the tube 10 in a counter-clockwise direction bringing the parts back to the relative positions shown in Figs. 1 to 6. But if the current in the relay winding is cut off entirely when the plunger is in its uppermost position, the pressure of the spring contact arms 20 against the separator 23 may, if desired, impose the same counter-clockwise movement upon the tube 10 and the plunger so that the parts will then assume the position shown in Figs. 1 to 6 when the plunger is released from its uppermost position. This permits the closure of the contacts 21 in readiness to respond to any further controlling action upon the current in the relay winding exceeding a predetermined amount.

When the relay is utilized as an overload time-delay relay, the time delay in the responsive action is prolonged when the overloads are of moderate value but the time delay in the response is much shorter when the overload is high or excessive. And unless the overload is continued sufficiently long to result in the plunger assembly being raised to its fully attracted position, no responsive action results. Furthermore, the relay, in the particular form shown, cannot respond immediately to an excessively high overload because the upward travel of the plunger assembly requires some time interval in any event. Such action is desirable when the control is utilized in a system wherein it is desired to permit the action of other controlling devices before the overload relay can accomplish its control.

It is apparent that this improvement avoids the use of any element which by its vertical movement alone, such as a latch rod or tripping plunger element, may obtain the responsive controlling effect. Consequently the effects of shocks in a vertical direction, either up or down, or vertical components of such shocks, cannot result in improper or undesired control because the turning movement is also necessary for securing a controlling response. Also any upward movement imparted to the plunger assembly by shocks is retarded by the dashpot action and the effects of the shock would, in practically all cases, be over before the plunger had reached or closely approached its upper limit of movement; and after the passing of the shocks, the plunger will fall rapidly to its lowest position. Even if the plunger attained its uppermost position under shock and even if a small current were passing in the relay winding, no turning action of the parts and control of the external circuit would result because the design of the relay would be such that the passage of a considerable current in the relay winding would be necessary to turn the parts on their axis. If the plunger happened to be part way up in the tube due to the presence of an overload current in the relay winding, then the effect of a shock in raising the

plunger would be merely to reduce the time interval of the responsive action on the relay; and such action would not be seriously objectionable. As regards the effects of shocks in a horizontal direction, the movable unit is symmetrical about its axis and mechanically balanced with the result that such shocks or horizontal components of such shocks, would have no effect in affecting the response of the relay because any impact tending to rotate the movable unit is counteracted by equal forces on opposite sides of the axis of the rotatable unit. It follows under these considerations that this improvement is every effective in reducing the effects of shocks and jars from any direction as regards improperly affecting its responsive action.

Although one embodiment of the invention has been described, various modifications and adaptations of the invention for particular purposes may be made without departing from the scope thereof. Although this disclosure relates to the separation of the contacts of the control circuit by a time delay response of the relay, the responsive action of the relay obviously could be caused to open a circuit or to move one or more parts, according to the particular requirements. In some cases the lower magnetic element of the plunger assembly may be omitted and only one magnetic element utilized where the force for turning the plunger is sufficiently obtained by the use of one magnetic element.

I claim:

1. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other, a tube rotatable on its axis and supported by the magnet frame, and a magnetic plunger vertically movable in said tube having polar projections opposite the poles of the lower of said portions in its unattracted position and opposite the poles of the upper of said portions in its attracted position for imposing a turning movement on said tube in passing to its attracted position.

2. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other, a tube rotatably supported by the magnet frame, and a magnetic plunger vertically movable in said tube and having two magnetic elements in alignment with each other with polar projections relatively displaced correspondingly to the displacement of the poles of the magnet frame for imposing a turning movement on said tube in passing to its attracted position.

3. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other, a tube rotatably supported by the magnet frame, a magnetic plunger vertically movable in said tube and having two magnetic elements in alignment with each other with polar projections relatively displaced correspondingly to the displacement of the poles of the magnet frame for imposing a turning movement on said tube in passing to its attracted position, and means actuated by said plunger within said tube for retarding the upward movement of the plunger and for permitting rapid downward movement thereof.

4. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other, a tube rotatably

supported by the magnet frame, a magnetic plunger vertically movable in said tube and having two magnetic elements in alignment with each other with polar projections relatively displaced correspondingly to the displacement of the poles of the magnet frame for imposing a turning movement on said tube in passing to its attracted position, and means actuated by said plunger within said tube for retarding the upward movement of the plunger and for permitting rapid downward movement thereof, said tube being hermetically sealed and containing a fluid medium.

5. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other, a tube rotatable on its axis and supported by the magnet frame, a magnetic plunger vertically movable in said tube having polar projections opposite the poles of the lower of said portions in its unattracted position and opposite the poles of the upper of said portions in its attracted position for imposing a turning movement on said tube in passing to its attracted position, and means for retarding the movement of said magnetic plunger in moving to its attracted position.

6. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other about the central axis of the magnet, a winding between said portions, an element supported by the frame and turnable on its axis, and a magnetic plunger movable within said winding and engaging said element and having polar projections opposite the poles of the lower of said portions in its unattracted position and during its movement toward its attracted position and opposite the poles of the upper of said portions in its attracted position for imposing a turning movement on said element upon the magnetic plunger attaining its attracted position.

7. An electromagnet comprising a magnet frame having two polar portions one above the other and having their poles displaced angularly with reference to each other about the central axis of the magnet, a winding between said portions, a magnetic element movable within said winding and having polar projections opposite the poles of the lower of said portions and displaced from the poles of the upper of said portions when in its unattracted position and during its movement toward its attracted position, and opposite the poles of the upper of said portions and displaced from the poles of the lower of said portions when in its attracted position for imposing first an upward movement and then a rotary movement on said element in passing from its unattracted to its attracted position, and means for supporting said element in its unattracted position.

8. An electromagnet comprising a magnet frame having two polar portions spaced from each other and having their poles displaced from alignment relatively to each other angularly about the central axis of the magnet, a winding between said portions, a magnetic plunger movable within said winding and having two magnetic elements in alignment with each other with polar projections relatively displaced correspondingly to the displacement of the poles of the magnet frame, the polar projections of one of said elements being opposite the poles of one of said polar portions and displaced from the poles of

the other of said portions when in the unattracted position of the plunger and during its movement toward its attracted position, and the polar projections of the other of said elements being displaced from the poles of both of said portions when in the unattracted position and opposite the poles of one of said portions when in the attracted position of the plunger for securing first a longitudinal movement of the plunger and then a rotary movement of the plunger in passing from its unattracted to its attracted position, and means for supporting said plunger in its unattracted position.

9. An electromagnet comprising a magnet frame having a fixed pole extending therefrom, a second fixed pole extending therefrom, said second pole being spaced from said first named pole and also displaced angularly from said first named pole about the central axis of the magnet, a winding between said poles, a movable magnetic element within said winding and having a polar projection opposite the pole of said second fixed pole and displaced from said first named fixed pole when in its unattracted position and during its movement toward its attracted position, and opposite said first named fixed pole and displaced from said second fixed pole when in its attracted position for imposing first a longitudinal movement and then a rotary movement on said element in passing from its unattracted to its attracted position, and means for supporting said element in its unattracted position.

10. An electromagnet comprising a magnet frame having a fixed pole extending therefrom, a second fixed pole extending therefrom, said second pole being spaced from said first named pole and also displaced angularly from said first named pole about the central axis of the magnet, a winding between said poles, a movable magnetic element within said winding and having a polar projection opposite the pole of said second fixed pole and displaced from said first named fixed pole when in its unattracted position and during its movement toward its attracted position, and opposite said first named fixed pole and displaced from said second fixed pole when in its attracted position for imposing first a longitudinal movement and then a rotary movement on said element in passing from its unattracted to its attracted position, and means for retarding the movement of said magnetic element in moving to its attracted position and for supporting said element in its unattracted position.

11. An electromagnet comprising a magnet frame having a polar portion, a winding, a magnetic plunger movable within said winding and having two magnetic elements spaced from each other and having polar projections displaced angularly with reference to each other about the central axis of said element, the polar projections of one of said elements being opposite the poles of said polar portion when in the unattracted position of said plunger and during its movement toward its attracted position, and the polar projections of the other of said elements being displaced from the poles of said portion when in the unattracted position and opposite the poles of said portion when in the attracted position of the plunger, for securing first a longitudinal movement of the plunger and then a rotary movement of the plunger in passing from its unattracted position to its attracted position, and means for supporting the plunger in its unattracted position.

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