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ELECTROMAGNETIC RESPONSIVE DEVICE

Filed Jan. 2. 1924

4 Sheets-Sheet 1



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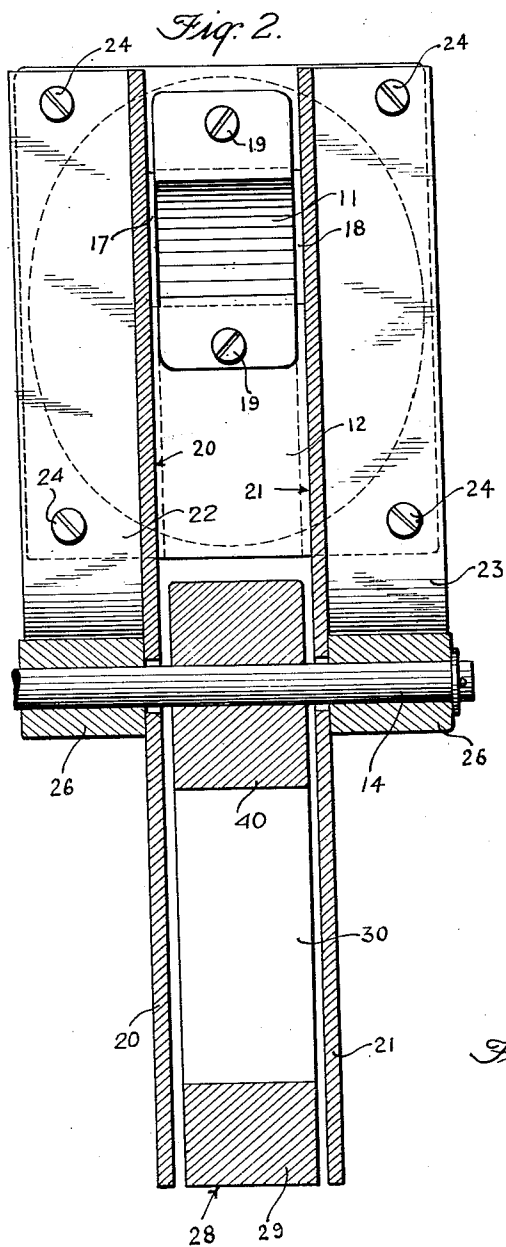
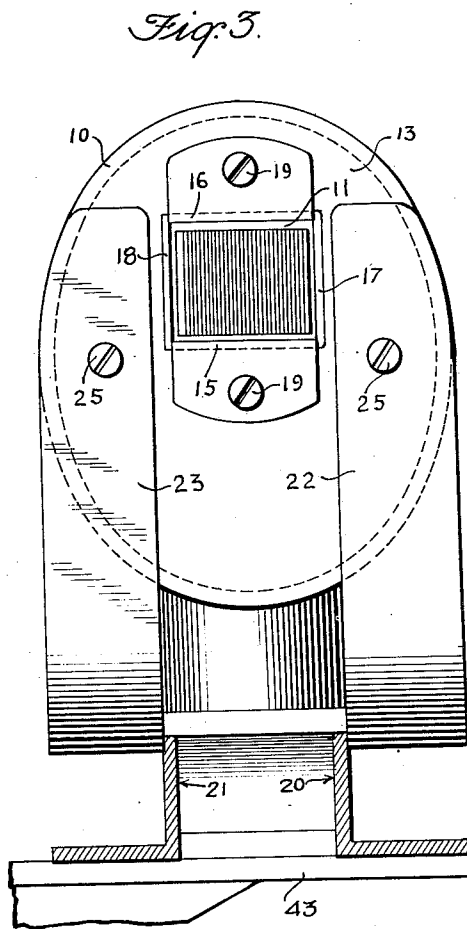
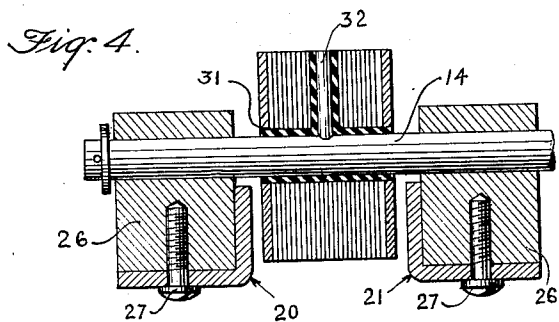
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Fig. 5.

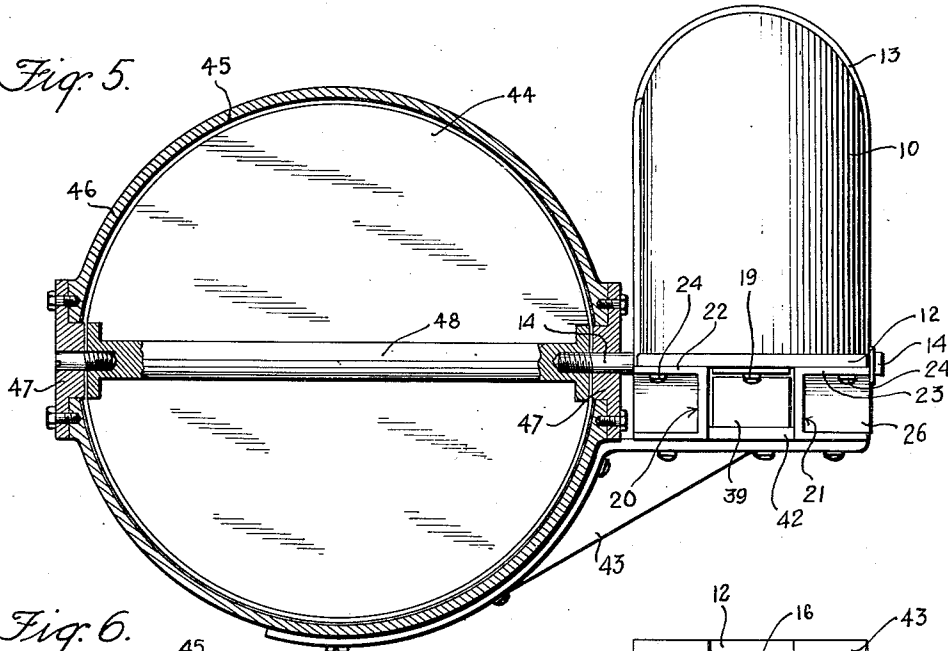
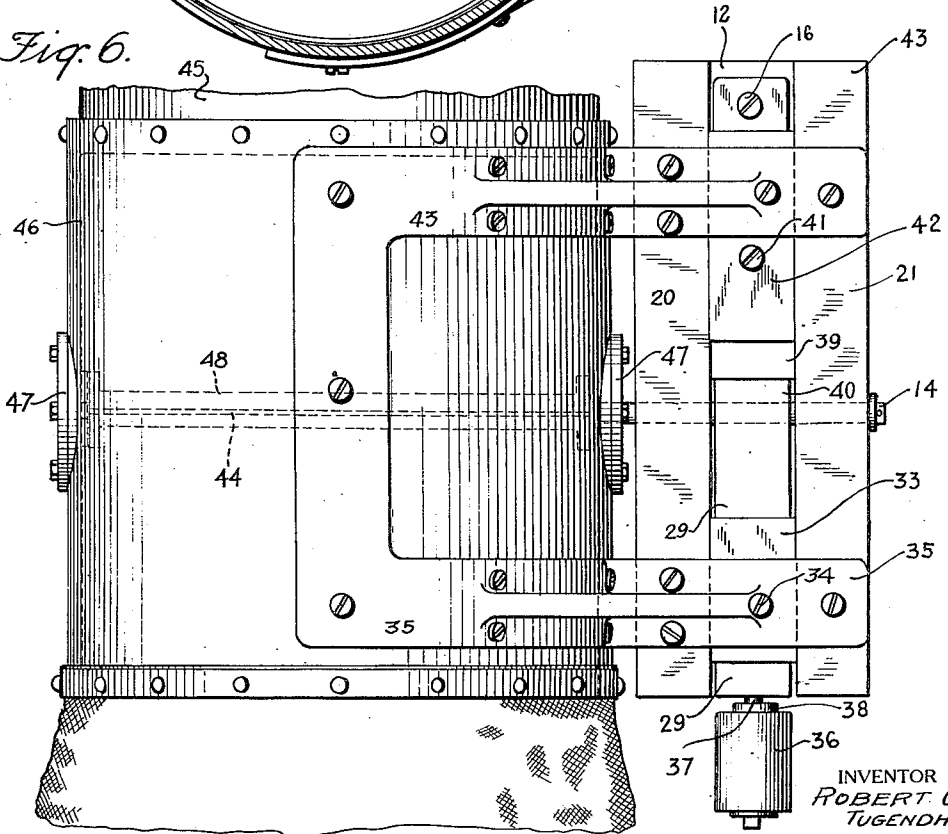


Fig. 6.



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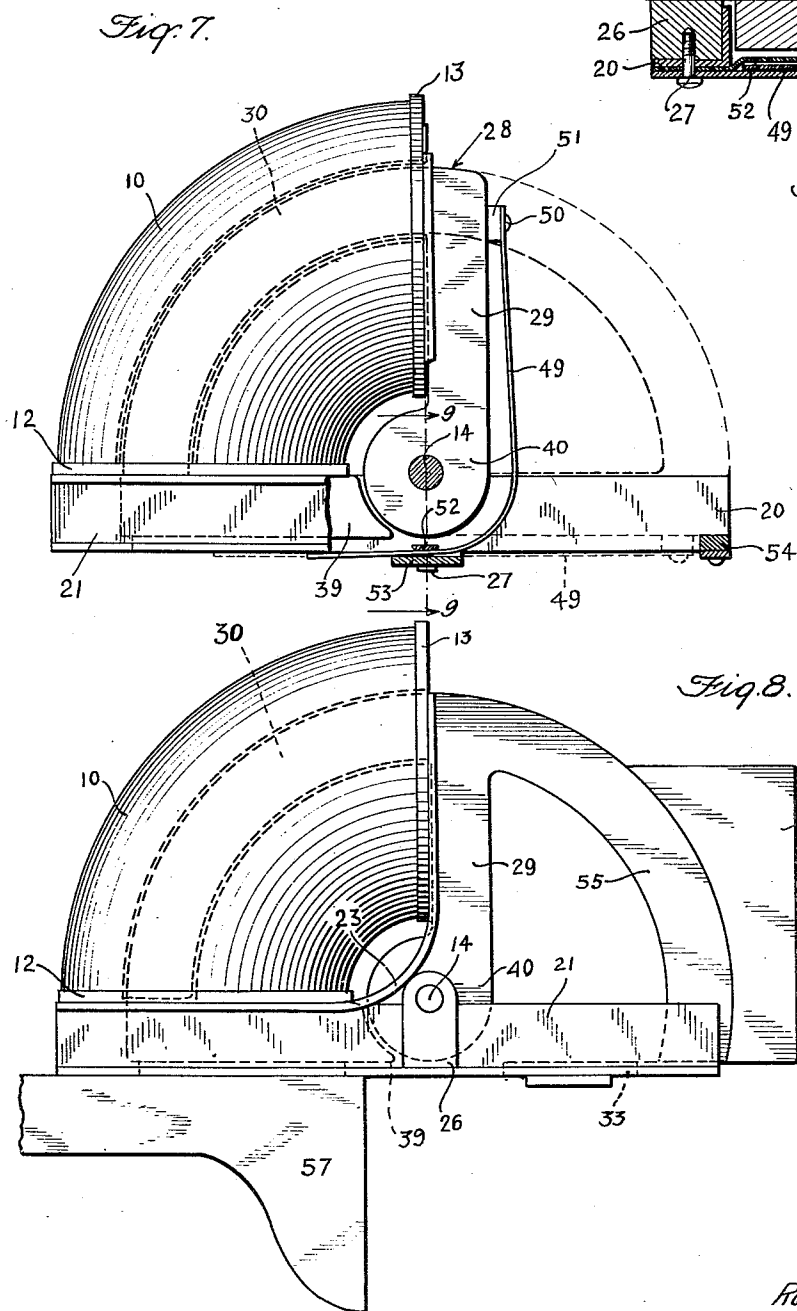
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE.

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ELECTROMAGNETIC RESPONSIVE DEVICE.

Application filed January 2, 1924. Serial No. 684,098.

This invention relates to improvements in electromagnetic responsive devices, and particularly to solenoids for actuating valves, cocks, doors, shutters, and other devices which may be mounted on rotatable shafts. In order to actuate such devices by the usual solenoids having plungers which move in a straight line, it has hitherto been necessary to employ some type of linkage to translate the reciprocating movement of the plunger into rotary movement of the shaft carrying the device to be rotated.

The main object of this invention is to provide an electromagnetic responsive device for directly rotating a shaft and thus to actuate the mechanism mounted thereon without the necessity of employing any such translating linkage.

Another object is to provide a simple, compact, solenoid which will be reliable in operation, cheap to manufacture and will require little or no supervision, together with a plunger or armature mounted on a rotatable shaft in position to be drawn into the solenoid or retracted therefrom in accordance with the condition of energization of the solenoid.

Other objects will appear hereinafter.

In the drawings illustrating a preferred embodiment of the invention designed to rotate a shaft through a right angle,

Fig. 1 is a central vertical section, partly in elevation, through a solenoid and an armature rotatable about a horizontal axis;

Fig. 2 is a vertical section taken on the line 2-2 of Fig. 1,

Fig. 3 is a horizontal section taken on the line 3-3 of Fig. 1 as seen from below;

Fig. 4 is a horizontal section on the line 4-4 of Fig. 1, showing the armature mounting;

Fig. 5 is a plan view, partly in section and on a smaller scale, of a passage controlled by a butterfly valve and a solenoid to operate the valve;

Fig. 6 is a vertical elevation of the construction shown in Fig. 5;

Fig. 7 is a plan view, partly in section, of a solenoid having an armature mounted for rotation about a vertical axis, with spring means for retracting the armature.

Fig. 8 is a front elevation, of a modification in which an armature rotatable on a

horizontal axis is provided with a peripheral weighted extension to retract the armature; and

Fig. 9 is a fragmentary section on the line 9-9 of Fig. 7.

Referring to the construction shown in Figs. 1 to 6, 10 is a solenoid winding having an arcuate passage 11 between the two insulating end plates 12 and 13, whose outer surfaces lie in radial planes intersecting on the axis of the shaft 14 which passes through the center of the arc described by the arcuate passage 11. Since the purpose of this construction is to operate a butterfly valve, requiring a movement of the shaft 14 through a right angle, the solenoid extends through a quadrant. But under different conditions the solenoid might extend through a greater or a less angle according to the arc through which the shaft was to be rotated. When the solenoid is designed for operation on direct current, the arcuate passage 11 which is preferably of square or rectangular cross section is lined with four non-magnetic strips of metal such as brass, of which the opposite walls 15 and 16 are shown in Fig. 1, but when the solenoid is to be energized by alternating current, only the inner and outer walls 15 and 16 are metal while the side walls 17 and 18 are of insulating material such as fibre board. The metal lining strips lap over the plates 12 and 13 at opposite ends of the solenoid, and are held in place as by the screws 19.

The solenoid may be conveniently mounted on two channel shaped supports 20 and 21 arranged back to back (Fig. 5) in approximately parallel spaced relation, the distance between the backs of the channels being just greater than the width of the arcuate passage 11 (Figs. 2 and 3). The insulating plate 12 at the upper end of the solenoid is firmly secured as by the screws 24 to the opposite front flanges 22 and 23 of the channel supports. These front flanges are sheared away from the body of the channels about midway of their length and extend forwardly to support the plate 13 to which they are secured as by the screws 25 (Fig. 3).

The shaft 14 which is to be rotated by the solenoid is journaled in bearing blocks 26, preferably mounted on the rear flanges of

the supports, screws 27 being provided to hold them. Fixed to the shaft is an armature 28 having a radial arm 29 and a peripheral arm 30 curved about the axis of rotation of shaft 14, and of cross section to provide clearance from the arcuate passage linings when it is drawn into the arcuate passage. The length of the radial arm is such as to permit free movement of the peripheral arm 30 of the armature into the solenoid when energized. When direct current is used the armature may be made of a single piece of soft iron (Fig. 1) but when the source of power is alternating current, it is necessary to make the armature of laminated soft iron as is customary in all solenoids. In the former case, the armature is integral with or directly secured to shaft 14 in any suitable manner, but in the latter case it is desirable to insulate the armature from the shaft by a non-conducting sleeve 31 (Fig. 4), while the pin 32 which prevents relative movement between shaft 14 and the armature is also insulated from the latter. The length of the curved arm 30 of the armature is approximately equal to the length of the arcuate passage, so that in its retracted position (shown in full lines in Fig. 1) the end of the armature will be just within the arcuate passage and therefore subject to the attraction of the solenoid, while when the armature is attracted (dotted lines in Fig. 1) it does not quite protrude from the upper end of the solenoid.

The plate 13 acts as a stop to attractive movement of the armature, the inner end of radial arm 29 being recessed to clear the end of the arcuate passage lining 15 and its screw 19, as shown in Fig. 1. Retractable movement of the armature is limited by abutment of the radial arm 29 against a cushion 33 secured between the channels as by the screw 34 to one of the main brackets 35.

Where the force opposed to retraction of the armature by the apparatus actuated by shaft 14 is considerable, the weight of the armature alone may not be sufficient to insure its retraction when the solenoid is deenergized. In such cases a counterweight 36 may be mounted on the armature, a screw 37 having a lip 38 being inserted at the end of arm 29, the weight 36 being held against the lip as by the washer and pin shown.

To increase the tractive power of the solenoid by lowering the reluctance of the magnetic path, there is preferably provided a fixed secondary armature 39 consisting of the same material as the movable armature 30, a bar of soft iron for direct current operation, or a laminated bar for alternating current. The secondary armature extends from across the open upper end of the arcuate passage of the solenoid downward toward the shaft 14 into close proximity to

the radial arm 29 of the movable armature. The arm 29 has a tubular hub portion 40, and the end of the secondary armature conforms to the shape of the hub, only sufficient clearance being allowed to avoid frictional contact. When the solenoid has attracted its movable armature, its upper end is as close to the upper end of the secondary armature as is possible without causing danger of striking it, so that the two armatures cooperate to form practically a closed magnetic path for the flux caused by energization of the solenoid, thereby permitting the latter to be maintained energized with a minimum current consumption. The stationary armature 39 may be conveniently mounted between the channel supports, being held by one or more screws 41 to the insulating plate 42 which is preferably secured to the upper main bracket 43.

In Figs. 5 and 6 the apparatus is shown mounted to actuate a butterfly valve 44 in a pipe 45, representing for example the outlet of a flour hopper leading to an automatic weighing machine. When necessary the pipe may be reinforced by a jacket 46 having suitable bearings 47 in which the shaft 48 of the butterfly valve is journaled for rotation on a horizontal axis. The solenoid assembly supported on the channels 20 and 21, as described, is mounted so that armature shaft 14 will be coaxial with valve shaft 48. This may readily be accomplished by securing the channel supports to brackets 43 and 35 which are fastened to the jacket 46 as by the screws or rivets shown. Armature shaft 14 is rigidly joined to valve shaft 48 by the screw-threaded connection shown or otherwise, so that energization of the solenoid will open the valve and deenergization will close it. Obviously a change of 90° in the relative position of the valve 44 and its shaft 48 would result in maintaining the valve closed by energization of the solenoid and open when the power was cut off.

On account of limitations in space or for other reasons it may not always be convenient to mount the supporting channels in the vertical position shown in Fig. 1. In Fig. 7 there is shown a construction which may be used to rotate a shaft about a horizontal axis, the supporting channels 20 and 21 lying in a horizontal instead of a vertical plane, and the movable armature 30 entering the solenoid 10 at the top instead of the bottom. The weight of the armature does not tend to start retractile movement upon deenergization of the solenoid, and spring means are therefore provided for this purpose. In one form, a flat normally straight spring 49 is secured near the outer end of arm 29 of the armature by a screw 50, a washer 51 separating and if necessary insulating the spring from the armature. The spring extends downwardly between the non-

magnetic plates 52 and 53 which extend across the channel supports 20 and 21, and may be secured thereto by the same screws 27 which hold the bearing blocks 26. The

5 inner plate 52 is centrally offset to provide sufficient space for the free sliding of the spring between it and plate 53 during movement of the armature. To reduce friction, the bearing surface of plate 52 and the bearing
10 edge of plate 53 are curved and polished. When the armature is in its attracted position, illustrated in full lines in Fig. 7, the spring is under considerable tension, so that upon deenergization of the solenoid it
15 straightens out to the position shown in dotted lines, thereby retracting the armature. Such movement of the armature is limited by the abutment of the end of arm 29 against a cushion plate 54 secured trans-
20 versely of the channel supports 20, 21 in position to clear the end of spring 49 when in normal position.

The construction just described may also be used to rotate a vertical shaft, or a shaft
25 in any position in which the armature does not automatically retract by reason of its weight when the solenoid is deenergized, the spring acting to retract the armature regardless of the direction of the shaft to be
30 rotated.

In some cases where it is necessary to employ a very heavy weight to retract the armature, the construction shown in Fig. 8 may be preferable to that shown in Fig. 1.
35 In this construction the supporting channels are horizontal and the shaft 14 is horizontal. The curved arm 30 of the armature has an extension 55 of the same cross section and preferably arcuate about the same center as arm 30, which travels freely between
40 the channel supports during movement of the armature. The supports are cut off, however, at a point within the outer periphery of extension 55, so that a weight 56
45 of any desired width may be formed integral with or secured to the extension 55 and will clear the ends of the channels. It is thus possible to provide sufficient force to retract the armature under any conditions of opera-
50 tion, and the weight may be distributed along as much of the periphery of armature extension 55 as may be desirable to avoid creating any undue stress in the armature. Retractable movement of the armature may be
55 limited by abutment of the arm 29 against a cushion plate 33 secured transversely of the channel supports, or the end of extension 55 and weight 56 may abut a portion of bracket 57 upon which the device as a whole
60 is mounted.

While a number of uses of the invention have been pointed out, and certain structures embodying it have been described, it should be understood that the invention is not to be
65 limited to the specific constructions shown

which may be modified in many respects without departing in any way from the spirit of the invention.

What I claim as new is:

1. In combination, an arcuately extending
70 solenoid having an arcuate passage there-through, a magnetic armature comprising a radial arm pivoted at the center of the solenoid and an arcuate arm adapted to enter
75 said passage and of approximately the same length as the passage, and a secondary armature of magnetic material extending radially from one end of the solenoid passage to the center thereof, the two armatures
80 cooperating to form a substantially uninterrupted magnetic path for the solenoid when energized.

2. An electromagnetic device comprising two oppositely disposed supports, an insulating plate secured therebetween, an arcuately extending solenoid lining secured at
85 one end to the plate, a solenoid wound around the lining, a second insulating plate secured at the opposite end of the lining and to said supports, and an armature pivoted
90 between said supports to rotate into said lining, said second plate serving to limit such movement of the armature.

3. An electromagnetic responsive device comprising two channel shaped supports
95 arranged back to back in spaced relation, an arcuate solenoid secured at one end to the front sides of said channels, said front sides being cut away from the remainder of the channels near their midpoint and extending
100 forwardly to support the other end of the solenoid, bearing blocks mounted on the supports, a shaft rotatable in said blocks, a radial armature fixed to the shaft between the bearings and having an arcuate extension adapted to be attracted by the solenoid
105 to rotate the shaft, and means for retracting the armature when the solenoid is deenergized.

4. An electro-magnetic responsive device
110 comprising an arcuate solenoid, a movable armature for movement into and out of said solenoid, a radially extending arm for mounting said movable armature, and an immovable armature extending from a point
115 adjacent one end of said solenoid to a point adjacent the movable arm of the movable armature and forming with the movable armature a substantially uninterrupted magnetic path for the solenoid when energized.
120

5. An electro-magnetic responsive device comprising an arcuate solenoid, a correspondingly arcuate armature adapted for movement through the arcuate solenoid, an arm associated with said solenoid and forming
125 a portion thereof, and means associated with said solenoid and with the armature thereof for establishing a substantially uninterrupted magnetic path for the solenoid
130 when it is energized.

6. An electro-magnetic responsive device comprising an arcuate solenoid, a corresponding arcuate armature for movement through said solenoid, said arcuate armature being pivotally mounted, and a stationary armature extending from a point adjacent one end of the arcuate solenoid to a point adjacent the pivotal point of the arcuate armature whereby a substantially uninterrupted magnetic path for the solenoid is provided.

Signed at Saginaw, Mich., this 18th day of December, 1923.

ROBERT G. TUGENDHAT.