April 4, 1939. P. BAKKER 2,153,291

ELECTROMAGNETIC RELAY

Filed May 14, 1936 2 Sheets-Sheet 1

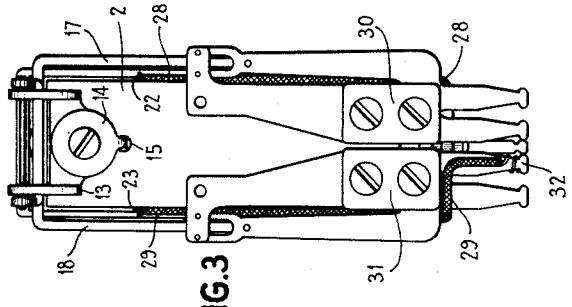


FIG.3

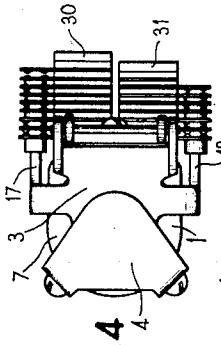


FIG.4

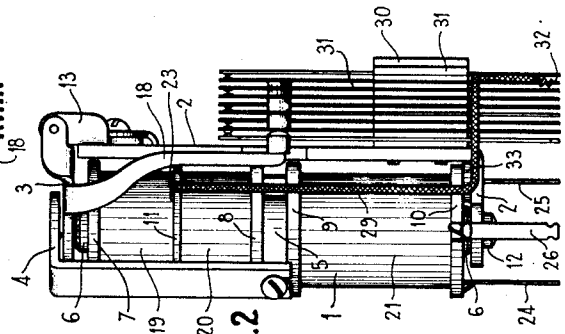


FIG.2

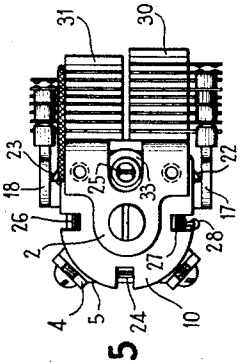


FIG.5

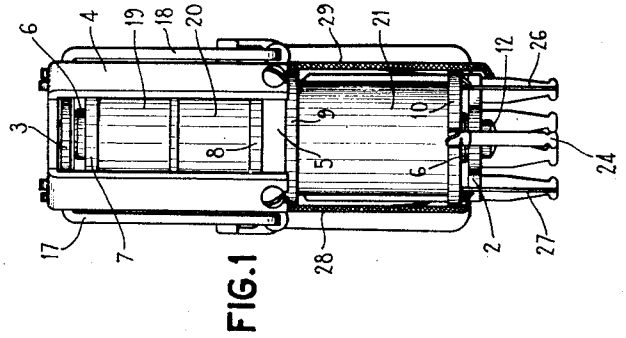


FIG.1

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April 4, 1939. P. BAKKER 2,153,291

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Filed May 14, 1936 2 Sheets-Sheet 2

FIG. 6

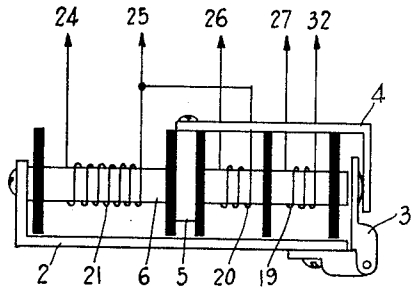


FIG. 7

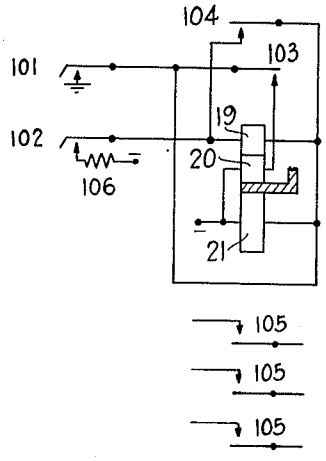
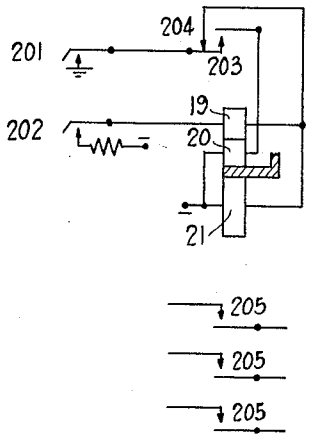


FIG. 8



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Patented Apr. 4, 1939 2,153,291

UNITED STATES PATENT OFFICE

2,153,291

ELECTROMAGNETIC RELAY

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Application May 14, 1936, Serial No. 79,637

7 Claims. (Cl. 175—320)

The present invention relates to electro-magnetic relays, and has for its object the production of a new and improved electro-magnetic relay which is reliable in operation and which will actuate and maintain actuated a relatively large number of contact springs.

General description

It has been chosen to illustrate the invention as applied to a relay of the general type disclosed in Patent 1,673,884 granted June 19, 1928, to Harold C. Pye. The Pye relay has been widely used in automatic telephone systems and in similar systems employing testing and switching relays when a relay is required which is fast to operate and which will at the same time actuate a number of contact springs. In many circumstances under which this relay is used, the line or operating winding of the relay is of necessity removed from the circuit upon the operation of the relay, leaving only the polarizing winding energized to maintain the relay actuated until such time as it is desired to permit the relay to restore. It has been often found, however, that the polarizing winding of the relay does not afford sufficient energization of the relay to maintain it operated after the operating winding has been removed from the circuit in the event that the relay is carrying an excessively heavy spring load, such as may obtain when a large number of spring contacts are arranged to be actuated by the relay and the contact springs are somewhat heavily tensioned, or are stamped from relatively thick material. This difficulty may be partially overcome in practice by giving each relay a special adjustment under current after assembly, but such procedure is somewhat costly in a manufacturing operation; moreover, the desired contact pressure or the operating speed must often be sacrificed somewhat in order to enable the relay to remain operated from the polarizing winding alone.

Attempts have been made to overcome the difficulty by increasing the magnetizing power of the polarizing winding by the well-known process of winding it with wire of a larger diameter, but a new difficulty is then experienced in that the relay tends to operate from the polarizing winding alone before the operating winding is energized. This tendency results largely from saturation of the armature at its point of contact with the polarizing yoke serving as a backstop. Also energization of the polarizing winding beyond a critical value results in excessive power consumption and consequent inability of the winding to dissipate heat at a rate sufficient to prevent damage to the winding insulation when the relay is energized for a considerable time.

Other attempts have been made to overcome the non-holding difficulty by connecting the operating winding in the holding circuit when the operating circuit is opened, so as to cause the operating winding to aid the polarizing winding in holding the relay operated. This procedure, although successful, is somewhat involved in that it often requires switching both terminals of the operating winding from one circuit to the other, which switching operation must be performed through make-before-break contacts in order to avoid momentarily interrupting the holding circuit. Several additional contact springs are thus required, still further loading the relay.

The non-holding tendency is greater when, with a heavy spring load, the stroke or armature travel distance is reduced in order to favor speedy operation, for then the polarizing yoke is adjusted to cause the armature in its restored position to stand close to the end of the core. Therefore, the armature does not move very far from the polarizing yoke upon operating, and a large amount of flux is shunted from the armature end of the core to the armature by way of the yoke. The shunted flux, not only fails to assist in maintaining the armature attracted against the spring load, but also operates to apply an additional restoring urge to the armature.

By the present invention, the difficulties above discussed are remedied by placing a third or holding winding on the relay around that portion of the core which lies between its intermediate pole shoe and the armature, around which portion the operating winding is also wound. It has been found that a winding placed on this portion of the core is more efficient in maintaining the relay operated than is one on the heel end, because magnetic energy generated in this portion of the core is not so subject to leakage diversion (principally through the polarizing yoke).

In addition to the main object previously set forth, it is an object of the invention to provide suitable circuits incorporating the new three-winding relay. Two typical circuit arrangements are disclosed. In one, the third winding and the polarizing winding are energized together to hold the relay operated after operation thereof responsive to current-flow in the operating winding, while, in the other typical circuit arrangement, current-flow is discontinued through the polarizing winding and through the operating winding after the relay is operated, and the holding of the relay is accomplished solely by the current flow

through the third or holding winding. A further disclosure employing the elementary circuits shown herein or variations of them in a telephone system is made in the United States patent application of Voss and Crocker, 40,686, September 16, 1935.

Description of drawings

Referring now to the accompanying drawings comprising Figs. 1–6, Figs. 1–5 show related views in orthographic projection of the Pye relay modified in accordance with the present invention, Fig. 6 is a schematic drawing of the improved relay, and Figs. 7 and 8 show two typical circuit arrangements employed in the use of the relay.

Referring now particularly to Figs. 1–5, Figs. 1–3 show a front view, a side view, and a rear view, respectively, of the improved relay; Fig. 4 shows a top view; and Fig. 5 shows a bottom view of the relay.

Structurally, the relay shown in Figs. 1–5 is composed essentially of the coil assembly 1, the heel piece 2, armature 3, and the polarizing yoke 4. Armature 3 is provided with spring-actuating arms 17 and 18, each of which actuates one of the spring assemblies 30 and 31, secured to heel piece 2 as indicated, the contact springs in assemblies 30 and 31 being insulated from each other.

The coil assembly 1 includes the central magnetic core 6, over which core spool-heads 7—10 are forced. The intermediate pole shoe 5 is a piece of magnetic material having a hole therein through which the core 6 is passed, and it is provided with suitable tapped holes to enable the polarizing yoke 4 to be adjustably mounted therein. The polarizing winding 21, suitably provided with a protective covering, is wound in the winding space lying between spool heads 9 and 10. The ends of the polarizing winding are secured to terminals 24 and 25, carried by spool head 10.

Holding winding 20 and operating winding 19 are wound in the winding space between spool heads 7 and 8, being separated from each other by the winding separator 11. The ends of the windings 20 are secured to terminals 25 and 26 in spool head 10, terminal 25 serving as a common terminal for one end of each of the windings 20 and 21. The leads from winding 20 pass through holes in the rear corners of spool heads 8 and 10 and thence to the base of terminals 25 and 26 beneath the covering of winding 21.

Terminals 22 and 23, as may be seen in Figures 2, 3, and 5, are fastened into the coil separator 11 to serve as terminals for the two ends of the operating winding 19. Terminal 22 is connected by means of strap wire 28 to coil terminal 27 of spool 10, as may be seen best in Figs. 1 and 3, while terminal 23 is connected by means of strap wire 29 to terminal 32 mounted in the spring assembly 31. These two strap wires, 28 and 29, are provided in order to provide terminals of the operating winding which are accessible from the terminal end of the relay, on the back side of the mounting plate (not shown) to which the relay is mounted by means of screws which pass through tapped holes in heel piece 2, as may be seen in Fig. 5.

It is to be observed that armature 3 is provided with a pair of lugs through which it is hinged to corresponding lugs on armature bracket 13 by means of a bearing pin. Armature bracket 13 is mounted on heel piece 2 by means of a mounting screw which passes through lug washer 14 and through a vertical slot (not shown) in bracket 13. A guide lug on washer 14 passes into hole 15 in heel piece 2 to prevent turning of the washer 14 as the mounting screw is tightened so as to thereby prevent twisting of the armature 3 out of its desired position upon the tightening of the mounting screw.

Method of operation

Referring now to Fig. 6, one pole of the current source is connected preferably to terminal 25, which serves as a common terminal for one end of the polarizing winding 21 and for one end of the holding winding 20, as above noted. When the relay is to be used, the other pole of the current source is connected to terminal 24, to which the other end of winding 21 is connected, thereby energizing the polarizing winding 21. Winding 19 is connected in the operating circuit through terminals 22 and 23, by way of strap wires 28 and 29, extending to coil terminal 27 and to spring-assembly terminal 32, respectively, the conductors of the operating circuit being attached to terminals 27 and 32.

With the polarizing winding 21 energized alone, the major portion of the flux produced thereby passes through the polarizing yoke 4 and by way of the back side of armature 3 to the heel piece 2 by way of which it returns to the bottom end of the magnetic core 6. In the event that a current flow is set up in the operating circuit in such a direction as to cause operating winding 19 to generate flux opposite in direction to that produced by winding 21, this additional flux passes through the core to the polarizing yoke 5, from which point it joins with the flux produced by winding 21 and passes through the yoke 4 to the armature 3, from which point it passes across the air gap existing between the armature 3 and the upper end of core 6 to the upper end of the core, completing the magnetic circuit. Armature 3 is not attracted as a result of this flux produced in the operating winding, being instead held more firmly against the polarizing yoke 4, serving as a back-stop for the armature.

When the operating winding 19 is energized in such direction that the flux resulting therefrom coincides in direction with the flux produced by the polarizing winding 21, the net flux passing through polarizing yoke 4 is correspondingly reduced, and if the energization of the operating winding 19 is sufficient the flux passing from the upper end of core 6 across the small air gap to armature 3 is greater than the flux reaching armature 3 by way of the polarizing yoke 4, and the armature is attracted toward the core 6. As the armature 3 moves, an air gap is introduced between it and the polarizing yoke 4, while the air gap between the armature and the core is steadily reduced. As a result, by the time armature 3 has reached the core 6, the major portion of the flux generated by windings 21 and 19 passes serially through the entire core, returning by way of armature 3 and heel piece 2, and the flux passing through polarizing yoke 4 is reduced to a low value.

As has been pointed out, it is often necessary to discontinue the flow of current in the operating circuit upon the operation of the relay, which is accomplished ordinarily by contacts actuated by the movement of the armature 3. Heretofore, the only means of maintaining the relay operated following the cutting out of winding 19 is the flux generated by the polarizing winding 21. It is to be noted that, upon the cut-

ting out of the winding 19 and the flux generated by the current passing therethrough, the presence of polarizing yoke 4 constitutes a serious shunt on the flux generated in winding 21, in that whatever flux passes yoke 4 to armature 3 and returns by way of heel piece 2 works in direct opposition to the flux that traverses the entire length of core 6 and passes through armature 3 to the heel piece. With the improved structure, however, the holding winding 20 may be connected in circuit upon the operation of the relay by applying the other pole of the current source through contacts of the relay to coil terminal 26, the first pole of the current source having been connected to one terminal of winding 20 by way of coil terminal 25, as previously noted. Winding 20 may be wound so as to produce a relatively powerful flux through the portion of the core encircled thereby, which flux is driven through the upper end of core 6 to the armature 3, returning for the most part through the heel piece 2 to the lower end of core 6. Being located on the inside of the path through the polarizing yoke 4, the winding 20 is relatively efficient in holding armature 3 operated, compared to the expenditure of similar power in polarizing winding 28, due to the somewhat adverse location previously noted of winding 21 with respect to holding the relay operated.

When it is desired that the relay be restored, one pole of the current source may be disconnected from terminals 24 and 26, de-energizing both the polarizing winding 21 and the holding winding 20. Alternatively, the controlled pole of the current source may be disconnected from terminal 24 upon the operation of the relay, leaving only winding 20 energized (through terminals 26 and 25) to maintain the relay operated. Under this condition, it is merely necessary to disconnect terminal 26 to thereby deenergize winding 20 to permit the relay to restore.

Circuit operation of the improved relay

The circuit operation of the improved relay will be understood more fully upon reference to the following description of the typical circuits illustrated in Figs. 7 and 8.

Fig. 7 shows a circuit arrangement in which the improved relay is held up, when once operated, by cooperation of the holding winding and the polarizing winding. When key 101 is closed, polarizing winding 21 is energized and circuits are prepared for the energization of windings 19 and 20. The circuit for winding 19 is held open at key 102 and the circuit for winding 20 is held open at contact 103, so that the relay does not operate at this point but merely becomes polarized as hereinbefore mentioned. Now, by closing key 102 the circuit is completed for energizing the operating winding 19 in the same direction as winding 21 and the armature of the relay is immediately attracted to close contacts 103, 104 and 105. The closure of contact 103 completes the circuit to energize the holding winding 20, and the closure of contact 104 short circuits winding 19 which deenergizes; it will be seen, therefore, that the relay is now held up by windings 20 and 21 and may be released by opening key 101. It will also be observed that any associated relays, whose windings are shown as element 106 in Fig. 7, which may have been operated at the same time winding 19 was energized or alternatively, when winding 19 was short circuited, will also be released by opening key 101. The relay is prepared for subsequent operation by opening key 102 which restores the shown circuits to their original state.

In Fig. 8 a circuit arrangement is shown whereby the relay is held up, when once operated, by the holding winding alone. Key 201 is closed to energize polarizing winding 21 and to prepare circuits for the energization of windings 19 and 20. The circuit of winding 19 is held open at key 202 and the circuit of winding 20 is held open at contact 203 so that the relay does not operate. When key 202 is momentarily closed winding 19 is energized to assist winding 21 and the relay operates. In operating, contact 203 is closed to complete the circuit for the holding winding 20 which energizes, and contact 204 is opened to effect the deenergization of windings 19 and 21. The relay, now being held up by winding 20 alone, may be released by opening key 201.

It will be understood that the disclosed circuit arrangements are merely exemplary, and that the improved relay may be utilized in numerous other arrangements which will be suggested to the mind of a person versed in the art. The functions performed manually by keys in these examples will, in the automatic telephone art, ordinarily be performed at the contacts of associated relay equipment; contacts of associated relays may also, of course, be given the circuit control assigned to contacts 103, 104, 203 and 204 of these examples.

It will be understood further that the exact details of construction illustrated in Figures 1 to 5 need not be followed. For example, windings 19 and 20 may be placed on the armature end of the core 6 in the form of concentric windings instead of segregating windings as illustrated.

What is claimed is:

1. An electro-polarized relay having a core and an armature actuatable when the core is sufficiently energized, contact springs actuatable by said armature when it is attracted to the core, a polarizing winding, an operating winding, and a holding winding, all on said core, said armature being non-responsive to energization of said polarizing winding alone, but responsive to simultaneous energization of the polarizing winding and the operating winding to actuate said contact springs, and circuit connections rendered effective upon the actuation of said contact springs for energizing the holding winding in a direction to aid in holding the armature actuated.

2. In combination, an electro-polarized relay having a core and an armature attractable to said core when the core is sufficiently energized, contact springs actuatable by said armature when it is attracted by the core, a polarizing winding, an operating winding, and a holding winding, all on said core, said armature being non-responsive to energization of said polarizing winding alone to actuate said contact springs, but responsive to simultaneous energization of polarizing winding and operating winding to actuate said contact springs, circuit connections rendered effective upon the actuation of said contact springs for deenergizing said operating winding, and additional circuit connections rendered effective upon the actuation of said contact springs for energizing said holding winding in the same direction as the operating winding was energized and sufficiently to maintain the relay actuated after the operating winding is deenergized.

3. In combination, an electro-polarized relay having a core and an armature attractable to

the core when the core is sufficiently energized, contact springs actuatable by said armature when it is attracted by the core, a polarizing winding, an operating winding, and a holding winding, all on said core, said armature being non-responsive to energization of said polarizing winding alone, but responsive to simultaneous energization of the polarizing winding and the operating winding to actuate said contact springs, and circuit connections rendered effective upon the actuation of said contact springs for deenergizing said polarizing and operating windings and for energizing said holding windings to maintain the relay operated after the polarizing and operating windings have become deenergized.

4. In combination, a relay having three windings, means for first energizing the first winding in a given direction to polarize the relay, means for energizing the second winding in the same direction to operate the relay, and means for thereafter energizing the third winding in the same direction to hold the relay operated.

5. In combination, an electro-polarized relay comprising a core, a magnetic return heel piece secured to one end of the core, an armature mounted for operation in a magnetic circuit between the free end of the heel piece and the free end of the core when the core is sufficiently energized, an intermediate pole shoe of magnetic material mounted on an intermediate portion of the core, a polarizing yoke mounted on said intermediate pole shoe and being of such a configuration as to normally contact the armature and serve as a backstop therefor, a polarizing winding wound on the end of the core which lies on the side of the intermediate polarizing yoke away from the armature, and operating winding wound on said core on the end thereon lying between the armature and the intermediate pole shoe, a holding winding also wound on the portion of the core lying between the armature and the intermediate pole shoe, means for energizing the polarizing winding to polarize the relay by the passage of magnetic flux through the polarizing yoke, whereby the relay is not operated, means for energizing the operating winding in a direction to generate flux longitudinally through the core agreeing in direction with the flux generated by the polarizing winding, whereby the armature of the relay is attracted away from the back stop and in association with the free end of the core, and means responsive to the movement of said armature when it is attracted for energizing the holding winding in a direction agreeing with the energization of the operating winding.

6. In combination, an electro-polarized relay having three windings, means for energizing the first winding to polarize the relay, means for energizing the second winding to actuate the relay by the combined influence of the first and second windings, means responsive to the actuation of the relay for energizing the third winding to hold the relay operated, and for deenergizing the operating winding, and means for deenergizing the holding and polarizing windings to bring about a restoration of the relay.

7. In combination, an electro-polarized relay having three windings, means for energizing one winding to polarize the relay, means for energizing the second winding to operate the relay in conjunction with the energization of the first winding, means responsive to the energization of the relay for energizing the third winding in the same direction as the first two were energized to hold the relay operated, and means also responsive to the operation of the relay for deenergizing the polarizing and operating windings, said holding winding being effective to hold the relay operated indefinitely after the other two windings are deenergized, and means for subsequently deenergizing the holding winding to permit the relay to restore.

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