

April 30, 1940.

A. Z. MAMPLE

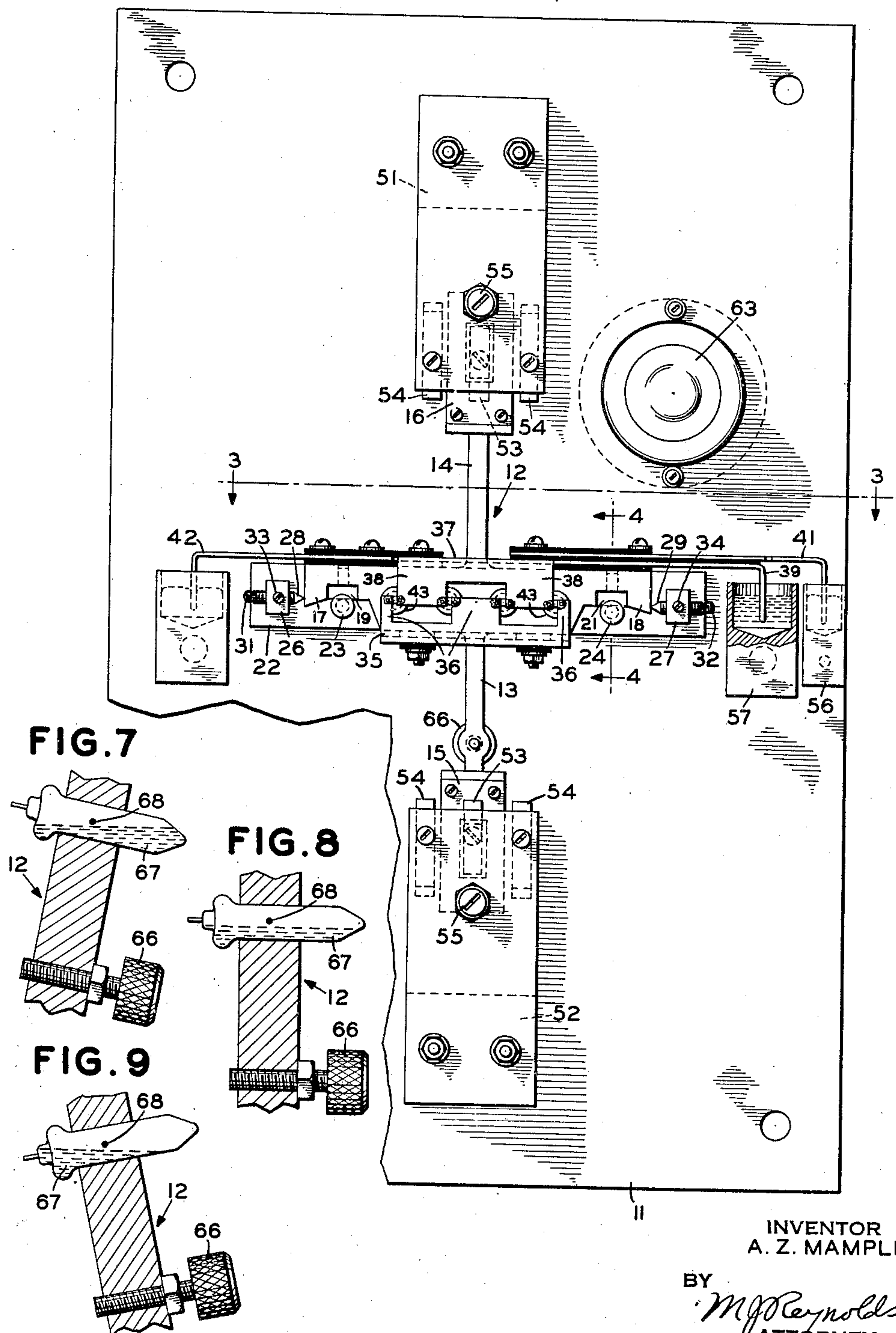
2,198,781

REVERSE CURRENT SWITCH

Filed Sept. 11, 1937

2 Sheets-Sheet 1

FIG. 1



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FIG. 3

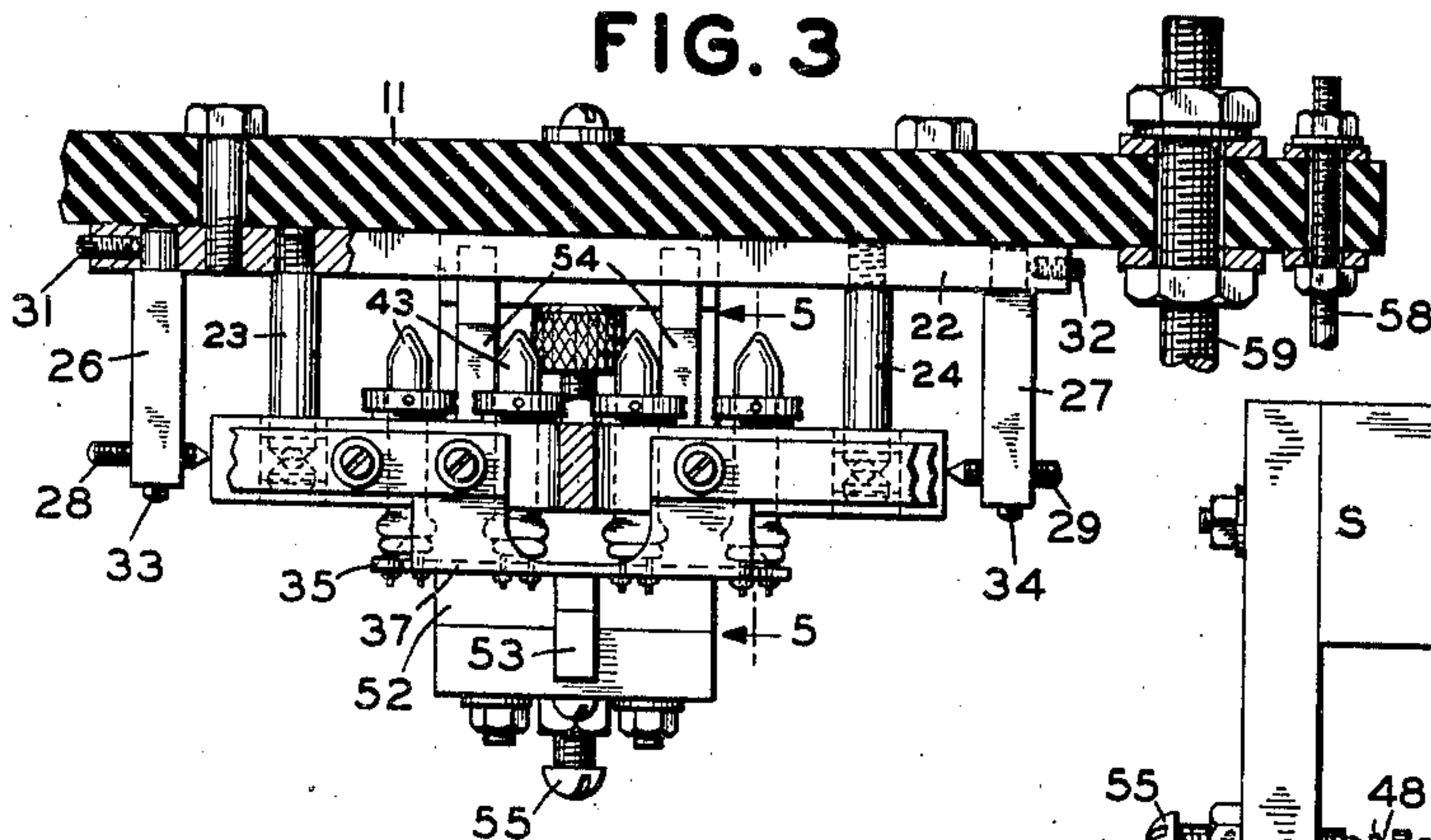


FIG. 2

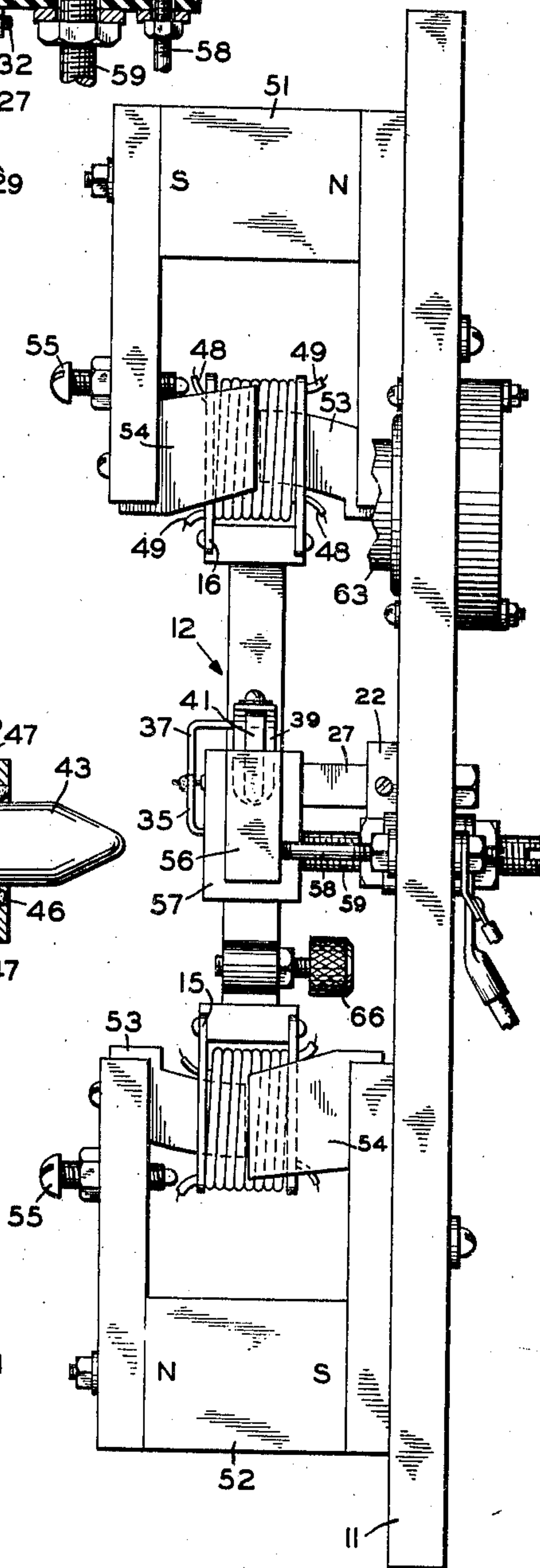


FIG. 4

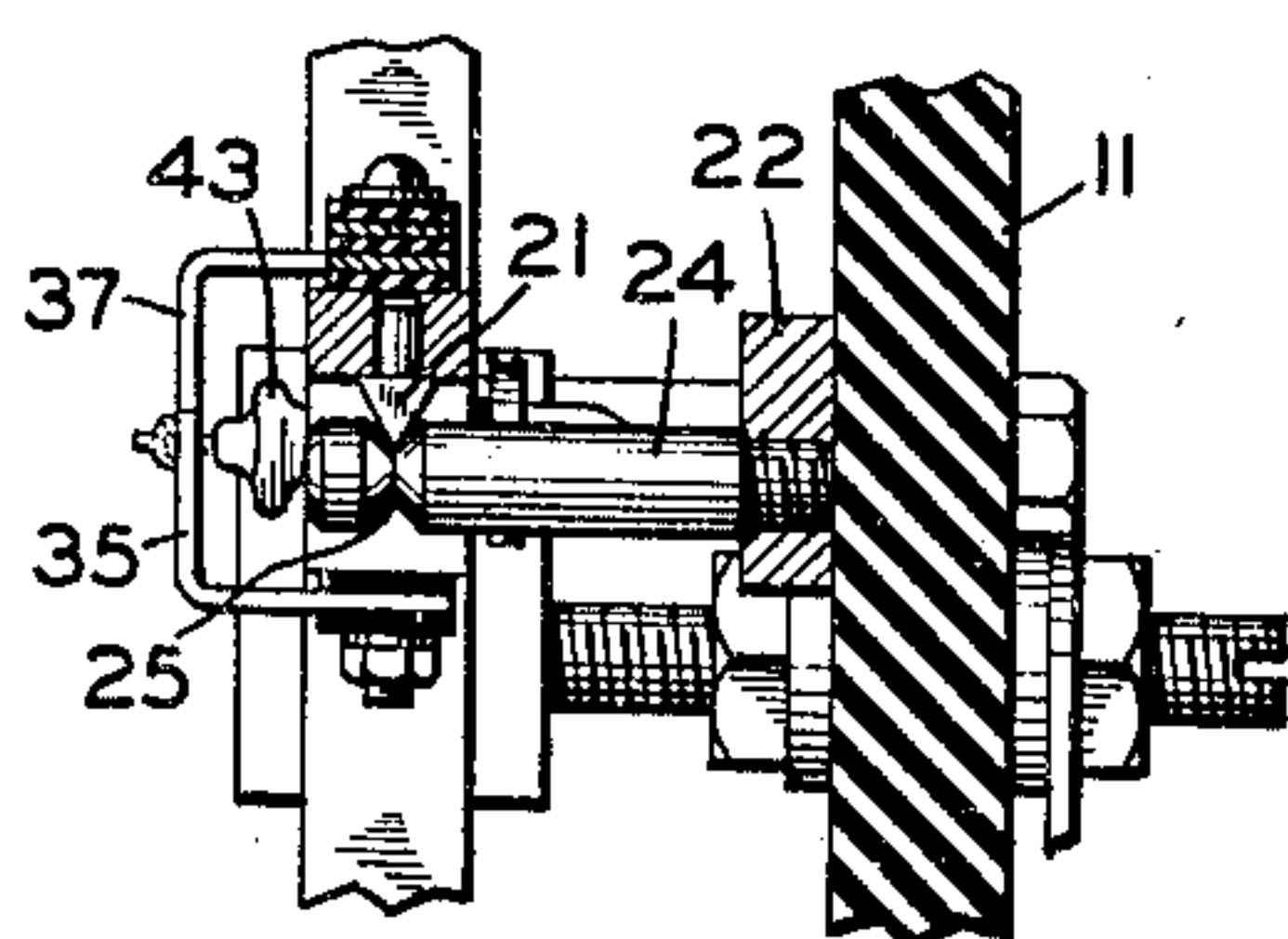


FIG. 5

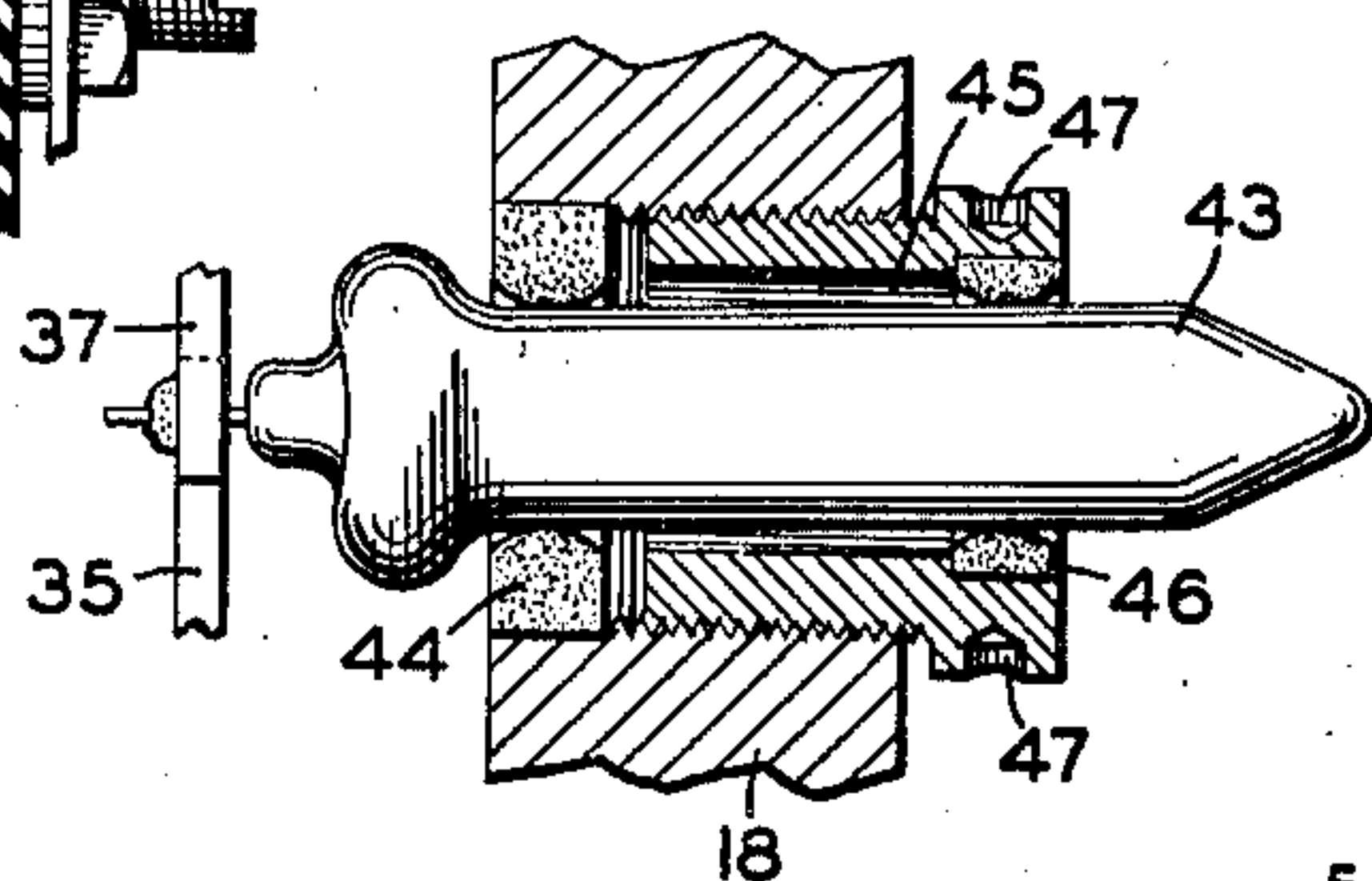
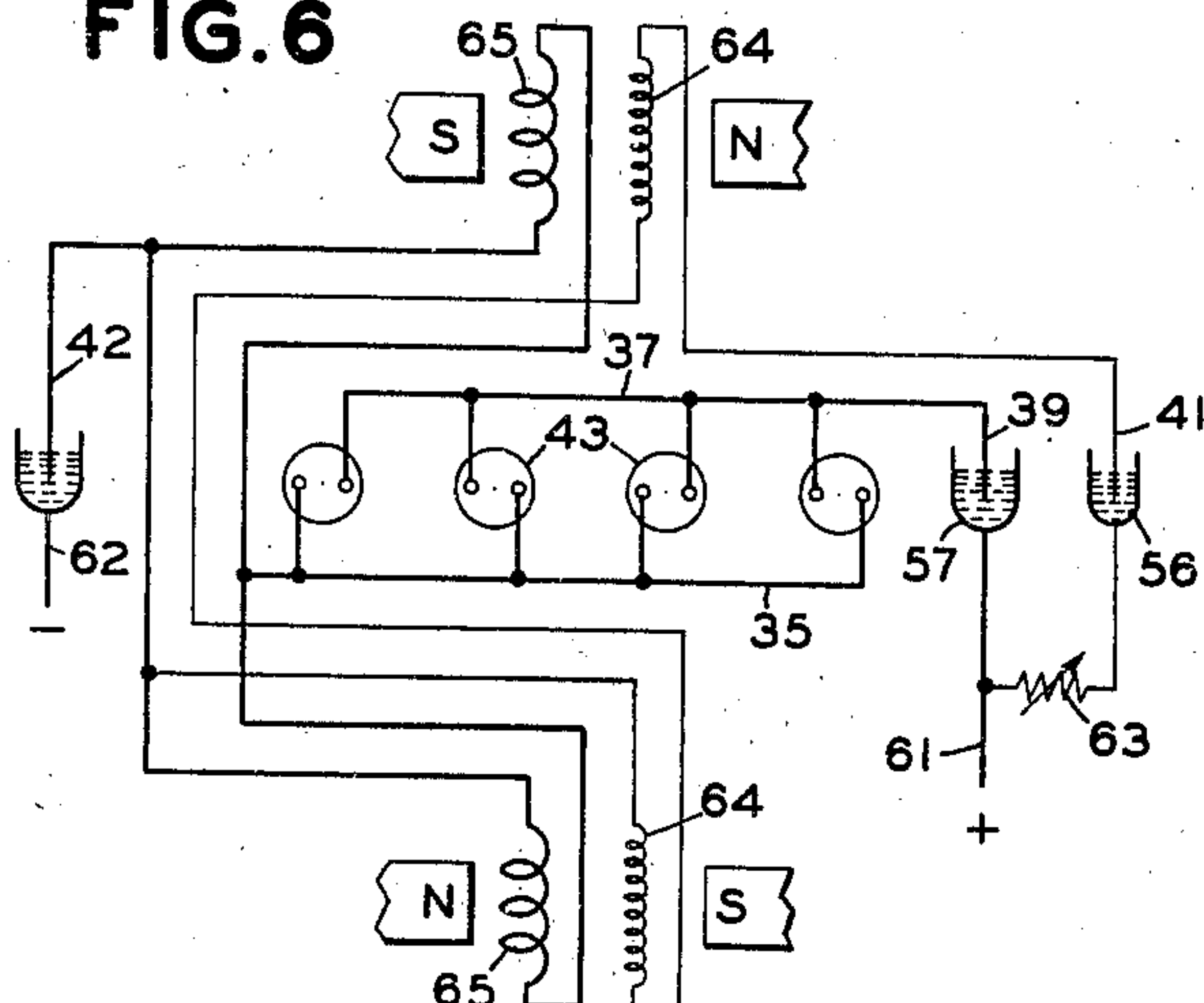


FIG. 6



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REVERSE CURRENT SWITCH

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5 Claims. (Cl. 200—102)

This invention relates to the protection of subterranean metallic structures against disintegration by electrolysis. More particularly, the invention has reference to an automatically operated magnetic contactor or switch which will provide the desired protection for lead sheathed cables and the like.

Accordingly, it is the primary object of the instant invention to produce a switch of the reverse current type in which is combined a high degree of sensitivity at low current values and a large current carrying capacity with the ability of giving reliable service for an indefinite period without being reconditioned or otherwise attended.

Another object of the invention is to provide a switch which is operative in response to relatively small potential differences.

Still another object is to provide a switch which is capable of conducting currents of appreciable magnitudes.

The manner in which these and other more specific objects are attained is set forth in the following description which is taken in connection with the accompanying drawings, of which:

Fig. 1 is a front elevation of the reverse current switch;

Fig. 2 is a side elevation;

Fig. 3 is a fragmentary plan view partly in section taken on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary section taken on the line 4—4 of Fig. 1 illustrating the details of one of the bearings;

Fig. 5 is a large scale sectional view of the mounting details of one of the switch members taken on the line 5—5 of Fig. 3;

Fig. 6 is a schematic wiring diagram of the switch and its connection with the circuit; and

Figs. 7, 8 and 9 illustrate three different positions of the switch.

It is well known that "anodic" corrosion of a lead sheathed cable or similar structure occurs when, in the presence of an electrolyte such as soil water, moist earth, etc., a difference of potential exists between the cable sheath and the earth of such polarity to effect a flow of current away from the cable. Where this potential is invariably of the same polarity, a simple and effective remedy is available in the form of a low resistance bond between the structures. But there are innumerable instances, such as those encountered when the cable is exposed to electric railway systems, where the potential difference is continually being reversed in polarity

because of varying load conditions on the railway system.

A permanent bond between an anodic section of the cable and the negative feeder of the power system or other adjoining structure, will afford ample protection for that section in making it cathodic to the surrounding earth or electrolyte. But its purpose may be defeated at times when the current in the permanent bond reverses, causing other sections of the cable to become anodic due to the added current flowing onto the cable because of the reverse current in the bond. Thus the remedy appears to reside in a means for providing the low resistance bond only at such times as the current is flowing away from or being drained from the exposed section of the cable.

In the past, the art has taught the use of electromagnetic devices having comparatively heavy contacts so as to offer a minimum of resistance to the relatively high values of current which must be conducted. In most cases, the only available source of potential for operating a protective device is that against which the protection is sought. Since this potential is generally of a fluctuating nature and often requires as much as an hour or more to reach a value sufficient to effect the closure of the protective contacts, while the normal operating time of an electromagnetic device of this nature is measured in fractions of a second, a contact closure is obtained which, at best, is comparatively insecure. The result which follows continued operation of this type is a pitting of the contacts with the attendant increase of resistance of the bonding path. Such pitting is additive to the pitting caused by the reversals of current which occur when the current is the weakest, i. e. close to the zero line. Since the success of an entire protective system is contingent upon the unvarying functioning of each unit thereof, it is necessary that there be substantially no change in the contact resistance of the protective devices employed. Hence, to preclude such an eventuality, it is necessary that the contacts be reconditioned at frequent intervals which not only increases the cost of maintenance but also necessitates periodic replacements of the contacts.

The present invention obviates the difficulties encountered with the use of prior art devices by providing a reverse current switch which comprises a novel combination of instrumentalities whereby high sensitivity, at low current values, is combined with large current carrying capacity and positive contacting. In general, a delicately

balanced moving element which carries a plurality of mercury switches, also carries two sets of windings, one of high resistance and the other of low resistance, by which the movements of the switch are controlled in response to the magnitude and polarity of the currents applied to the windings. Also, advantage is taken of the shifting of the mass of mercury about the center of gravity of the moving element to aid in securing the desired operating characteristics of the device.

Referring to Fig. 1, there is shown the front elevation of the switch which is mounted on a vertical panel 11. The moving element 12 of the switch is assembled on a framework comprising four arms, two vertical 13 and 14 supporting at their extremities the coil spools 15 and 16, and two horizontal 17 and 18 which are fitted with two knife edge bearings 19 and 21. An auxiliary mounting block 22 is rigidly fastened to the base 11 and serves to mount a pair of studs 23 and 24 which are provided with grooves 25 adapted to engage the knife edges 19 and 21 (see Fig. 4). Two other studs 26 and 27 are mounted in the block 22 and are fitted near their outer extremities with pivots 28 and 29, the purpose of which is to prevent endwise motion of the moving element 12. Obviously, the pivot points must be in exact alignment with the knife edge bearings in order that free movement of the switch may be assured. Proper alignment is secured by suitably positioning the studs 26 and 27 in their respective mounting holes and then fixing them rigidly by means of set screws 31 and 32 (see Fig. 3). Also, the pivots 28 and 29 are adjustable to properly center the switches, being held in position by the set screws 33 and 34.

Secured to the underside of the horizontal arms 17 and 18, but insulated therefrom, is a terminal plate 35, which is provided with angular projections 36 extending upward. A somewhat similar plate 37 is mounted on the upper side of the horizontal arms and is provided with angular projections 38 which extend downward, partially dovetailing with the projections 36. The upper plate is also characterized by a connector member 39. A second connector member 41, preferably of metal unlike that of the member 39, is also mounted on the right hand side of the switch, as viewed in Fig. 1, and is spaced electrically from and extends over the member 39. A third connector member 42 is insulatedly mounted to extend from the left hand side of the switch.

The present preferred embodiment of the invention utilizes four mercury switch units 43 each enclosed in a glass tube and having the terminals thereof connected to the terminal plates in such a manner that one terminal of each unit is connected to the upper plate 37 and the other terminal of each unit is connected to the lower plate 35. The switch units 43 are mounted in a row in the horizontal arms 17 and 18 as may be seen in Figs. 1 and 3.

In order to obtain simultaneous functioning of the four units despite slight physical variations in the individual units, suitable adjusting means are provided. Fig. 5 shows in detail one such unit supported near one end by a bushing 44 which is concentric with the hole through the arm 17. A hollow adjusting screw 45 is threaded into the hole from the other side of the arm 17 and is provided with an eccentric bushing 46 which serves as a second support for the switch unit 43. A series of holes 47 in the shoulder portion of the screw 45 are suitable for receiving

a spanner wrench or similar tool by which the screw may be threaded into or out of the arm 18. Because of the eccentricity of the bushing, the switch unit may thus be inclined sufficiently to effect the desired adjustment. In making these adjustments, the switch units are aligned substantially perpendicular to the vertical arms 13 and 14. It will be noted that longitudinal movement of the switch unit 43 is prevented by the connections of the terminals to the plates 35 and 37.

Fig. 2 shows the coil spools 15 and 16 upon each of which are wound two windings, the connections to which are shown protruding from the spools. The connections 48 lead to a relatively high resistance winding comprised of a large number of turns and the connections 49 lead to a relatively low resistance winding of a small number of turns. The windings are interconnected with other parts of the switch as will be indicated hereinafter.

Two permanent magnets 51 and 52, each equipped with one "north" pole piece 53, centrally disposed, and two spaced "south" pole pieces 54 are mounted on the panel 11 in such a manner that the spools 15 and 16 may move between the south pole pieces while the central openings in the spools permit the intrusion of the north pole pieces. Adjustable screws 55 are mounted in the magnets 51 and 52 and serve to limit the movements of the moving element 12. The top screw 55 is adjusted to permit movement of the element 12 beyond its vertical position to only the degree necessary to effect the bridging of the switch unit electrodes by the mercury pools. The bottom screw 55 is similarly adjusted to permit only a sufficient movement of the element 12 in the opposite direction to deposit the mercury in the other ends of the tubes.

Fig. 2 also shows two of the mercury cups 56 and 57 which are supported by the threaded studs 58 and 59 respectively extending through to the rear of the panel 11 where external connections may be made thereto. The ends of the contacting members 39 and 41 are constantly immersed in pools of mercury contained in these cups, thereby providing flexible couplings between the switch and external circuits which do not interfere with the mechanical balance of the moving element 12.

In Fig. 6 a schematic representation of the interconnections of the various parts of the switch is made. Reference characters correspond to the physical counterparts of the switch. The positive lead 61 is connected to the structure or cable that it is desired to protect, and the negative lead 62 is connected to the negative bus of the power source or to the adjacent structure to which the cable leakage occurs. A permanent high resistance path between the two structures is thus afforded, and includes a variable resistance 63, external of the moving element of the switch, and the two potential, or high resistance, windings 64 in series connection. The total resistance of this path may be adjusted by the resistance 63 to suit each particular installation of the switch. When the switch is operated to its closed position, the mercury bridges the terminals of the switch units 43 and shunts the high resistance path with one of low resistance comprising the current windings 65 connected in multiple.

All of the operating windings are connected to aid one another in the closing of the switch and, being polarized in their action, only effect

a closure when the potential is of such polarity that the terminals 61 and 62 are positive and negative, respectively. Because of the large number of turns in the potential windings 64 only a small value of current (about ten milliamperes) is required to move the switch from its open to its closed position. When, subsequently, the current decreases to a zero value or reverses in direction, the switch is restored to its unoperated position, thus opening the low resistance connection.

As viewed in Fig. 2, the switch is operated by being pivoted in a counterclockwise direction. As previously described, the mercury switch units are adjusted so that closure of the contacts does not occur until after the moving element 12 has passed its vertical position. The satisfactory functioning of the switch is dependent in a large measure on the balancing of the moving element 12. For the purpose of accurately securing the desired balance a counterweight 66 is provided. Normally this weight is adjusted so that, with all of the windings de-energized, the moving element 12 has a very slight bias toward the open position, that is, in a clockwise direction.

Figs. 7, 8 and 9 illustrate the manner in which the shifting of the weight of the mercury in the switch units contributes to the positive action of the switch embodying this invention. In Fig. 7 the switch is shown in the open position, or the position which is taken when the cable is of negative polarity with respect to the negative bus of a power station or other surrounding structures to which the cable is being drained. It is seen that the center of gravity of the mass of mercury 67 is situated on the same side of the fulcrum 68 as is the weight 66. The result is a tendency to maintain the moving element 12 in this position, or in other words to keep the switch open.

However, when the negative condition of the cable has become nonexistent and, in fact, a slightly positive condition is manifested, the flux thus created in the potential windings sets up a torque in opposition to that of the mercury 67 and the weight 66, and causes the moving element 12 to rotate counter-clockwise to the vertical position shown in Fig. 8. It is seen that now the mercury 67 occupies a substantially neutral position in the system and the torque created by the potential windings is opposed solely by the slight bias caused by the weight 66. Hence only a small increase in the positive condition of the cable is needed to complete the closure of the switch contacts.

The fully operated position of the switch is shown in Fig. 9 where it may be seen that the mass of mercury 67 and the counterweight 66 are disposed on opposite sides of the fulcrum 68. Since the moving element 12, in this position, is mechanically out of balance by only a slight amount in favor of the open position, it requires but very little electromagnetic effort to maintain the switch in this operated position. Thus, despite the marked reduction in the number of ampere turns (about in the ratio of ten to one) which is effected when the low resistance current winding is connected into the circuit, the switch is held securely in its operated position.

With such an arrangement, it may be seen that the switch will be operated to its closed position whenever the current leaking from the cable through the potential windings attains a value of ten milliamperes. However, immediately upon operation, the influence of the potential wind-

ings is replaced by that of the low resistance current windings which, as stated above, have only one-tenth the number of turns of the potential windings. The torque applied to the moving element by the energization of the current windings with ten milliamperes of current is thus comparable to that applied by the energization of the potential windings with one milliampere, or about one-tenth of that necessary to effect and sustain the operation of the switch. The remaining nine-tenths of the torque necessary to sustain operation is supplied mechanically by the shifting of the mercury pool, as described hereinbefore. In addition, this mechanical torque is sufficient to maintain the switch operative until the current subsequently decreases to substantially a zero value.

The preferred embodiment of the invention shown and described herein utilizes a conventional type of mercury switch which serves both as an electrical connector and as a means of transferring weight from one side of the fulcrum to the other. But it is contemplated that the invention embrace all equivalent forms, such as those in which the electrical connector, or circuit closing means, and the weight shifting means are not embodied in the one unitary structure.

Once operated, the switch is capable of conducting currents of substantial values through its low resistance winding. In this manner, a path is provided between the cable sheath and the railway system negative bus or other structure which is sufficiently lower in resistance than the earth path, that no leakage from the cable occurs by way of the latter path. The distribution of the weights in the system may be so accurately adjusted that not until the current has been reduced to a zero value will the switch move to its open position.

Obviously, there is a limit to the current carrying capacity of the switch depending upon the size of the wire and the number of turns in the current windings. For exposures where the maximum leakage current is more than the present switch can safely accommodate, an auxiliary switch may be employed to provide a supplementary connection. This auxiliary switch may be of any conventional type which is dependent for its operation upon relatively high values of current. By connecting the operating winding of the auxiliary switch in series with the reverse current switch of this invention and by having its contacts arranged to provide a second low resistance bond between the cable and the adjacent structure paralleling that provided by the reverse current switch, the capacity of the protective system may be substantially increased. It should be noted that, in the present instance as well as where the reverse current is used alone, it is effective in providing the protection in the low current range, a result which heretofore has been difficult to attain.

The nature of the invention may be determined from the foregoing description of a preferred embodiment thereof, but it will be apparent to those skilled in the art that the novelties residing therein may be embodied in numerous other forms including non-polarized types of switches. Accordingly, it is contemplated that the scope of the appended claims will define the invention.

What is claimed is:

1. An electromagnetic switch comprising a circuit controlling device, an electromagnet having two windings, a tiltable support for said device, means including a first winding for producing

an electromagnetic force sufficient to operate said device from a normal position, means tending to return said device to its normal position, means including said device in the operated position thereof for shunting said first winding by the second winding, the characteristics of said windings being such that the combined electromagnetic forces produced by said windings tend to retain said device in its operated position but are insufficient to do so, and means to furnish a non-electromagnetic force insufficient in itself to retain said device in its operated position but which when added to said electromagnetic forces is sufficient to maintain said device in its operated position.

2. An electromagnetic switch comprising a sealed tube having a pair of electrodes inserted in one end thereof and a pool of mercury movable between both ends of said tube, a high resistance winding, a low resistance winding, a tiltable member for supporting said tube and said windings, means including said high resistance winding to produce an electromagnetic force for tilting said member to effect the engagement of the pool of mercury with said electrodes, means tending to return said device to its unoperated position, and means including said mercury engaged electrodes for shunting said high resistance winding with said low resistance winding, the combined electromagnetic forces produced by said shunting tending to maintain said member in its tilted position but being insufficient to do so, said pool of mercury in its electrode engaging position being disposed to produce a non-magnetic force which when added to said electromagnetic forces is sufficient to maintain said member in its tilted position.

3. An electromagnetic switch comprising a circuit controlling device, an electromagnet having two windings, means including a first winding of said electromagnet for producing an electromagnetic force sufficient to operate said device from a normal position, means tending to return said device to its normal position, a pivoted support for said device and said electromagnet, means including said device in the operated position thereof for shunting said first winding with the second winding of said electromagnet, the combined electromagnetic forces produced by said windings tending to maintain said device in its operated position but being insufficient to do so, and means including a weight movable by the tilting of said support from one side of the pivot to the other to furnish a non-electromagnetic force which when added to said electromagnetic forces is sufficient to maintain said device in its operated position.

4. A polarized electromagnetic switch comprising a plurality of sealed tubes each having a pair of electrodes inserted in one end thereof and a pool of mercury movable between both ends thereof, an electromagnet having an operating

winding and a holding winding, said operating winding being capable of producing a relatively high torque when acting by itself, a pivoted member for supporting said tubes and said electromagnet, a permanent magnet disposed adjacent said electromagnet, means including said operating winding to produce an electromagnetic force sufficient to tilt said member in a manner to cause the mercury pools to be moved to one or the other ends of the respective tubes depending upon the polarity of the flux produced by said operating winding, means tending to return said member to a normal position, means including said mercury engaged electrodes for shunting said operating winding with said holding winding in a manner to additively combine the fluxes produced by said windings, the combined forces produced by said combined fluxes tending to maintain the engagement of said mercury pools with said electrodes but being insufficient to do so, the pools in their electrode engaging positions being so disposed with reference to the pivot of said member to produce another force which when added to said electromagnetic forces is sufficient to maintain said engagement.

5. A reverse current switch comprising a plurality of sealed tubes each having a pair of electrodes inserted in one end thereof and a pool of mercury movable between both ends thereof, electromagnet having an operating winding and a holding winding, said operating winding being capable of producing a relatively high torque when acting by itself, a pivoted member for supporting said tubes and said electromagnet, said member being tiltable between operated and unoperated positions, a permanent magnet disposed adjacent said electromagnet, means including said operating winding to produce an electromagnetic force sufficient to tilt said member in a manner to cause the mercury pools to be moved to one or the other ends of the respective tubes depending upon the polarity of the flux produced by said operating winding, means including said mercury engaged electrodes for shunting said operating winding with said holding winding in a manner to additively combine the fluxes produced by said windings, the combined electromagnetic forces produced by said combined fluxes tending to maintain the engagement of said mercury pools with said electrodes but being insufficient to do so, the pools in their electrode engaging positions being so disposed with reference to the pivot of said member to produce another force which when added to said electromagnetic forces is sufficient to maintain said engagement, and a counterweight carried by said member to cause tilting of said member to its unoperated position when the combined fluxes produced by said electromagnet is reduced substantially to zero.

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