Feb. 16, 1937. C. H. LARSON 2,070,740

RELAY

Original Filed June 8, 1932 3 Sheets-Sheet 1

Fig. 1

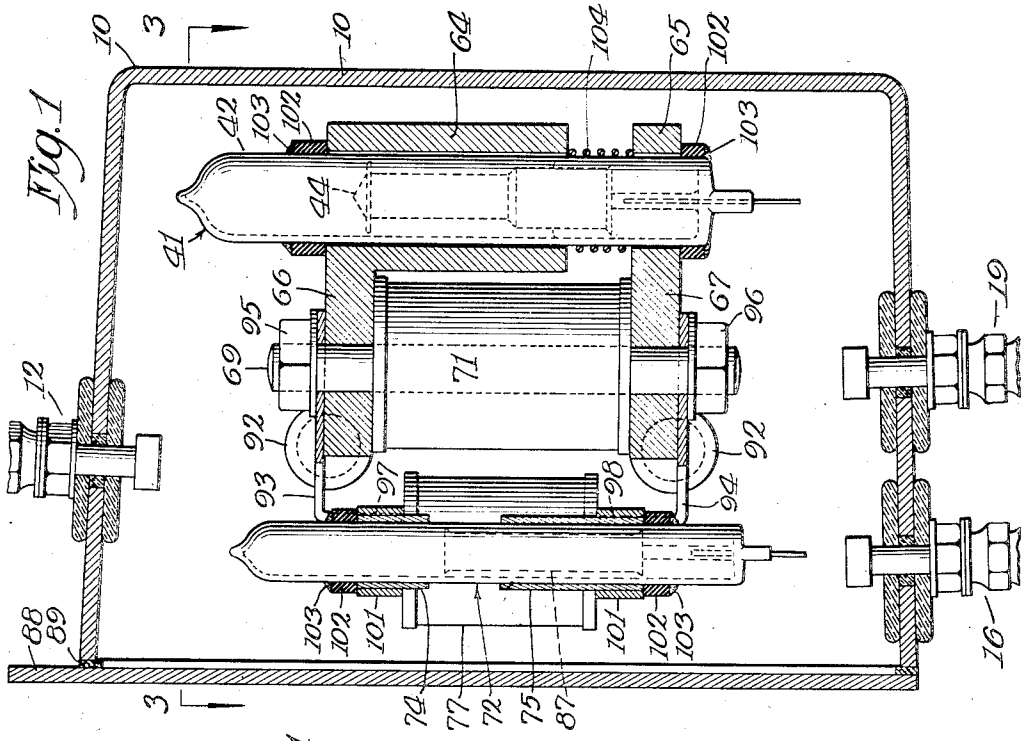
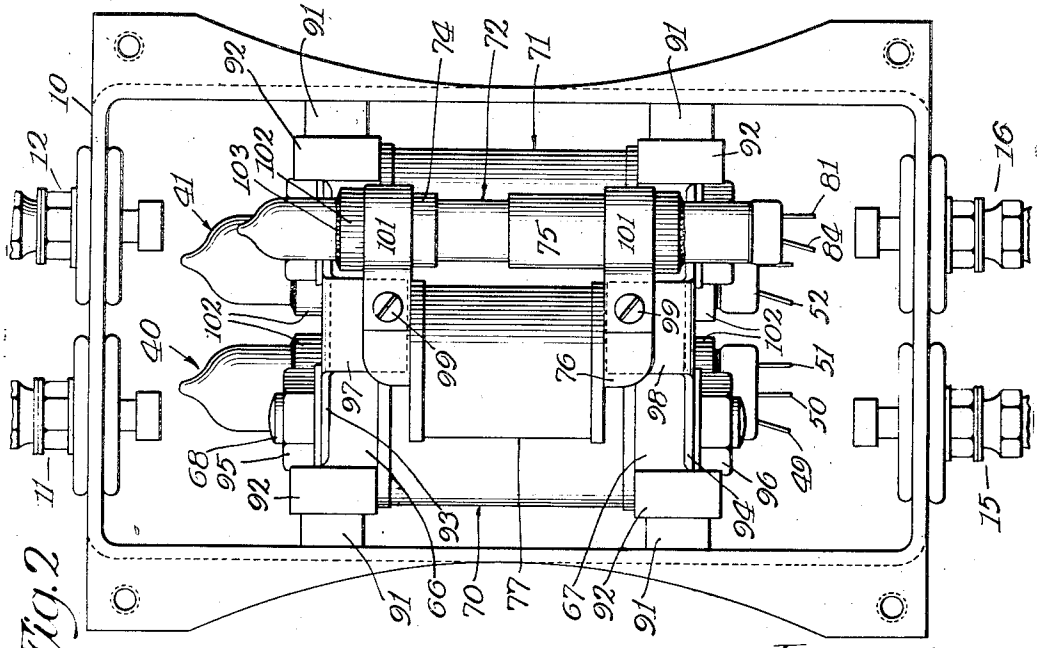


Fig. 2



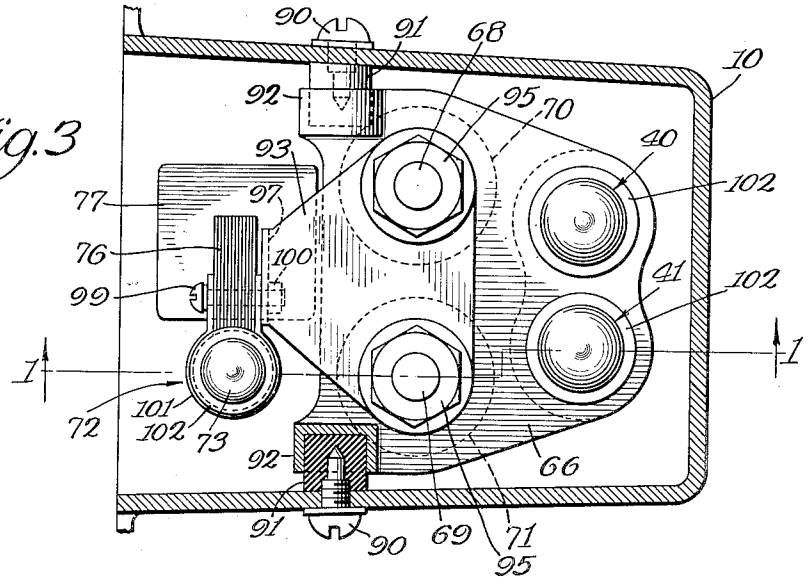
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Fig. 3



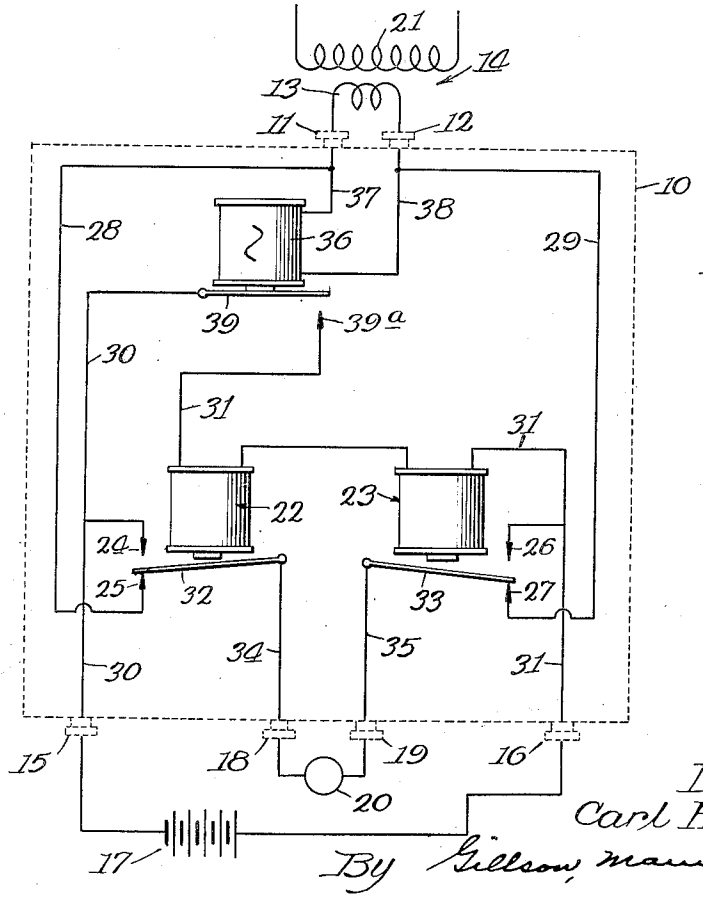


Fig. 4

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Fig. 5

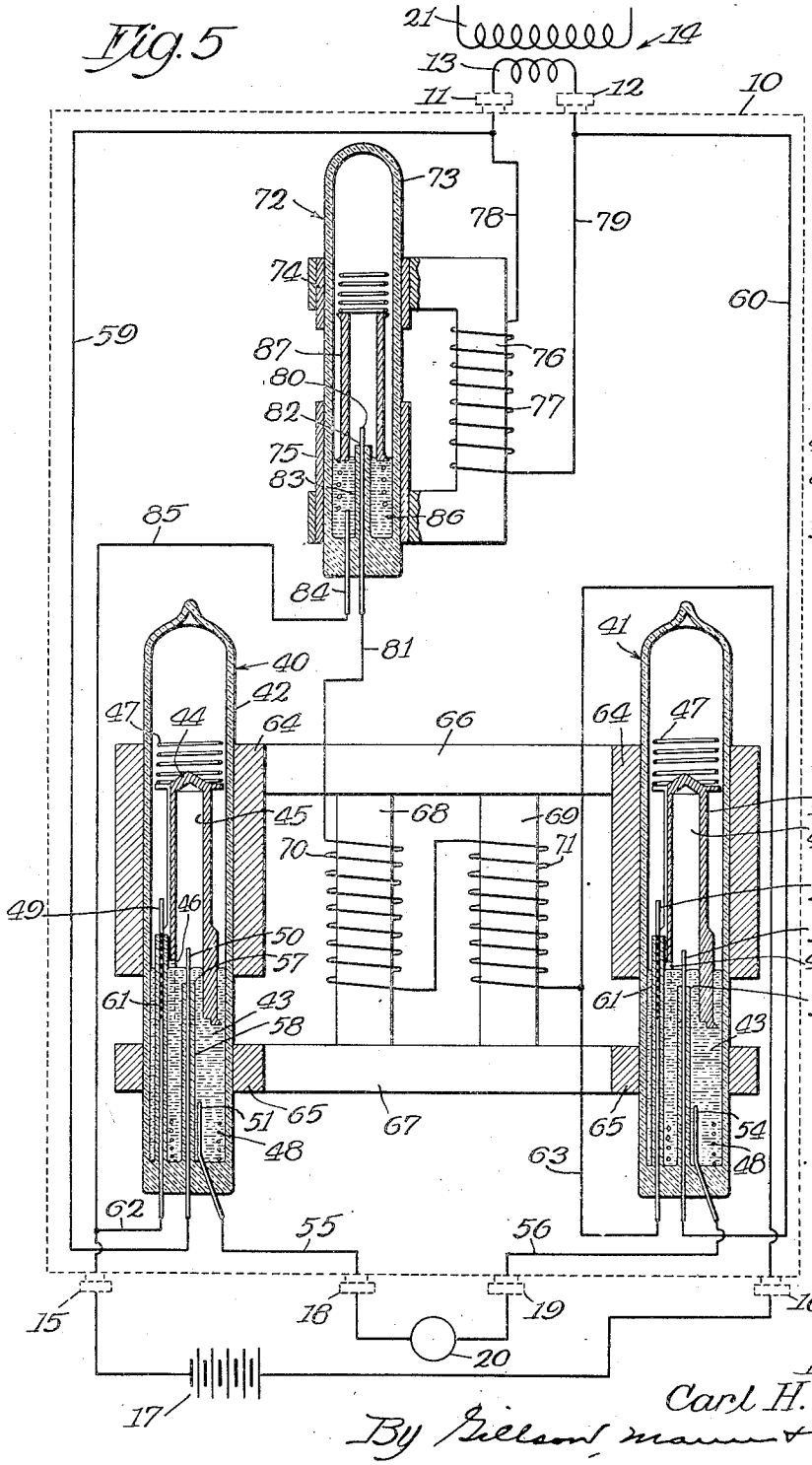


Fig. 6

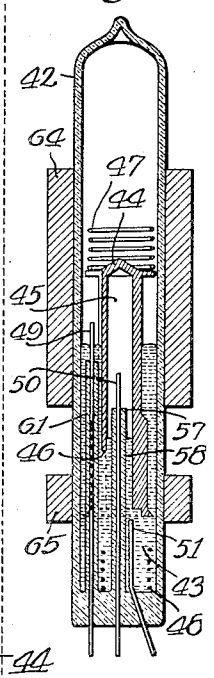
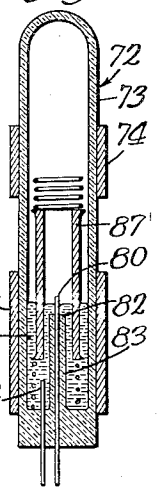


Fig. 7



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UNITED STATES PATENT OFFICE

2,070,740

RELAY

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Application June 8, 1932, Serial No. 616,091
Renewed January 27, 1936

7 Claims. (Cl. 171—97)

This invention relates to a standby relay adapted to transfer a load from one source of electrical energy to another, whenever the former falls below a predetermined standard.

Further and other objects and advantages of the invention will become apparent as the disclosure proceeds and the description is read in conjunction with the accompanying drawings, in which

Fig. 1 is a vertical, sectional view of a relay embodying one form of the invention;

Fig. 2 is a rear view of the relay, the back cover have been removed;

Fig. 3 is a horizontal sectional view taken on the line 3—3 of Fig. 1 and looking down on the relay mechanism;

Fig. 4 is a circuit diagram showing an application of this invention to mechanical relays;

Fig. 5 is a circuit diagram similar to the one shown in Fig. 4 except that mercury switch relays are substituted for the mechanical relays shown in that figure;

Fig. 6 is a sectional view showing one of the three electrode mercury switches with its plunger depressed; and

Fig. 7 is a sectional view of the two electrode control switch showing the magnetic plunger in the position it assumes after the collapse of the magnetic field.

Railway signals are generally operated by a series of relays deriving their energy from a line circuit. The line in present day practice carries 110 volts A. C. which is dropped to 10 volts A. C. by suitable transformers placed at intervals along the line. The relays themselves which actuate the signal mechanism all operate on the reduced voltage line (i. e. 10 volts).

The high degree of reliability required of apparatus of this kind demands that a local battery circuit be kept in readiness for operating the signal mechanism if the line circuit is cut off or falls below a predetermined standard. The change from line circuit to local circuit is accomplished by stand-by or power-off relays and it is with this type of relay that the present invention is concerned.

Up to the present time, mechanical relays have been generally used for this purpose and they consist essentially of an electro-magnetic switch connected across the 10 volt alternating current line and equipped with an armature adapted to throw in the local battery upon failure of the line circuit. As long as the alternating current maintains a predetermined voltage standard, the switch will maintain a connection between the alternating current source and the signal mechanism, but should the alternating current fall below the prescribed standard, the armature will fall and establish a connection between the local battery and the signal.

In order to prevent back E. M. F. in the transformer due to improper breaking of the alternating current circuit prior to the making of the direct current circuit, a second electromagnetic switch is often employed to break the circuit at a second point. The two electromagnets are connected in series and therefore operate conjointly.

Experience has shown that standby relays of the kind above described are only called upon to operate on the average of once each year. This is an important fact to keep in mind as the old type of standby relay requires from one and one-half to two watts to uphold the armatures within the range of safety prescribed by the American Railway Association.

In the present invention, the two electromagnetic switches which change the signal mechanism from alternating current to direct current are placed in the direct current circuit and are normally deenergized. A small relay is incorporated into the alternating current circuit and serves as a control unit for throwing the signal mechanism on direct current when the alternating current falls below the prescribed standard. This relay consumes but a small fraction of a watt and when it is remembered that many such relays are used over miles and miles of track, the saving in cost becomes an appreciable item.

This invention also contemplates the use of a mercury switch, not only as the dynamic element of the relay, but also as the control unit placed in the alternating current circuit. This, however, is but a preferred embodiment of the invention, for the invention is applicable to mechanical relays as well.

The employment of mercury switches of the type disclosed in this application has a distinct advantage, however, over the mechanical relays ordinarily used. This is particularly true in railway signalling systems where reliability of operation is of utmost importance.

The periodical literature conclusively shows that mechanical relays have not been entirely satisfactory, and that in spite of every possible precaution, they will, at times, fail. From as early as 1898 to as late as 1932, one may find many articles telling of the difficulties which have been experienced with mechanical relays, and expressing the need for improved apparatus.

The most common causes of failure in mechanical relays are:

1. Fused contacts brought about by lightning striking a power line.

2. Moisture condensation and frost which forms a film and prevents current from flowing between the contacts.

3. Dirt and dust which inevitably finds its way into the relay and eventually causes failure.

4. Residual magnetism which affects the operation of the armature. The American Railway Association, recognizing this problem has prescribed a minimum air gap of eleven thousandths of an inch to minimize the possibility of failure from this cause.

A mercury switch of the type disclosed in this application is peculiarly suited for use as a circuit breaker in the disclosed combination because it not only inherently eliminates the usual faults of mechanical relays, but because it is capable of coming well within the rigid requirements of the American Railway Association with respect to such operating characteristics as the drop-away and pick up values, air gaps, contact resistance, etc. The principal advantages resulting from the use of a mercury switch of the type hereinafter described may be briefly listed as follows:

The contacts are permanently sealed in an atmosphere of inert gas and are consequently free from oxidation; the thickness of the glass envelope constitutes a permanent air gap substantially greater than required by the American Railway Association specifications, so that residual magnetism is completely eliminated; the enclosing of all moving parts within a hermetically sealed switch envelope containing an inert gas makes inspection unnecessary and reduces maintenance cost; the relay operates with an extremely low contact resistance unaffected by temperature changes ranging from forty degrees below to three hundred degrees above zero; there can be no fusing or pitting of the contacts; there is no wear on the contact material; there are no movable leads to the contacts; the relay operates without noise; the relay is but one-half or one-third the size of the usual mechanical relay; the relay is unaffected in its operation by mounting conditions, as for example, tilting within wide limits; and the cost of manufacture is considerably less than mechanical relays of the same specification.

Although the relay of this invention has been designed for use in railway signal service, it is obvious that its use is not limited to that field. It is also obvious that the circuits may be varied and elements substituted for the ones specifically described, without departing from the spirit of this invention and the invention is, therefore, not to be limited by the specific description which follows.

Referring now to the drawings, and particularly to Fig. 4, a relay box 10 is indicated in dotted lines having binding posts 11 and 12 connected to the secondary winding 13 of a transformer 14, binding posts 15 and 16 connected in series with a local battery 17, and binding posts 18 and 19 connected to the load 20.

It will be understood that the primary winding 21 of the transformer is connected to the usual 110 volt alternating current source and that the transformer reduces the voltage to ten volts.

A pair of electromagnetic switches 22 and 23 are mounted in the relay box and are provided with front and back contacts 24 and 25 and 26 and 27, respectively. For the purpose of this disclosure, a front contact will be understood to be one that is normally open when the associated electromagnet is de-energized and a back contact is one that is normally closed when the associated electromagnet is de-energized.

The back contacts 25 and 27 are connected by conductors 28 and 29, respectively, to the 10 volt alternating current and the front contacts 24 and 26 are connected to the battery 17 by conductors 30 and 31. An armature 32 controlled by the electromagnet of the switch 22 cooperates with the front and back contacts 24 and 25 and an armature 33 controlled by the electromagnet of the switch 23 cooperates with the contacts 26 and 27. The two armatures are placed in series with the load 20 by conductors 34 and 35.

The switches 22 and 23 are controlled by a relay or electro-magnetic switch 36 connected to the 10 volt alternating current by conductors 37 and 38. The switch includes an armature 39 connected to one side of the battery 17 by conductor 30 so that upon failure of the alternating current, the armature 39 will fall on back contact 39*a* and establish a direct current circuit through the electro-magnetic switches 22 and 23. The establishment of this circuit causes the armatures 32 and 33 to be picked up, thereby breaking the alternating current circuit through the load at 25 and 27 and establishing a direct current circuit through the load at 24 and 26.

The relay 36 may be made so that when the alternating current falls to say sixty volts in the main line (or six volts in the reduced voltage line), the armature 39 will fall and establish the direct current circuit through the load in the manner above described. As soon as the alternating current picks up to sixty five or seventy volts, for example, the armature 39 will be lifted and the electro-magnets of the switches 22 and 23 de-energized, which in turn reestablishes an alternating current through the load and back contacts 25 and 27. The voltage figures are merely illustrative, for they may readily be varied by changing the characteristics of the control relay.

In Figs. 5, 6 and 7, there is shown an adaptation of the same circuit to a relay employing mercury switches as the actuating elements. In this figure, the relay box 10 is indicated in dotted lines as before, and is equipped with binding posts 11 and 12, 15 and 16, 18 and 19 connected to the transformer 14, battery 17 and load 20, respectively.

Electro-magnetic mercury switches 40 and 41 correspond to the electro-magnetic mechanical switches 22 and 23 shown in Fig. 4. Each switch comprises a sealed glass tube 42, exhausted and then filled with a suitable inert gas. A quantity of mercury 43 is placed in the tube and floats a plunger 44 made of high quality magnetic iron. Each plunger is drilled out at 45 to provide a cavity which is in communication with the interior of the tube only when the plunger is floating sufficiently high to uncover a port 46 formed by cutting a slot in the side of the plunger. Springs 47 and 48 are provided to cushion the plunger and prevent injury to the tube from rough handling.

Each switch is provided with three electrodes sealed through the bottom of a tube, the switch 40 having front contact 49, back contact 50 and neutral contact 51, and the switch 41 having

front contact 52, back contact 53 and neutral contact 54.

The neutral contacts 51 and 54 are connected in series with the load 20 by conductors 55 and 56. The back contacts 50 and 53 are insulated from the mercury to a point 57 by a glass shank 58 or other suitable means, and are connected to one side of the 10 volt alternating current line by conductors 59 and 60, respectively. The front contacts 49 and 52 are likewise insulated from the mercury by glass shanks, indicated at 61, and are connected in series with the battery 17 by conductors 62 and 63.

The switches 40 and 41 are operated by an electro-magnet adapted to set up a strong magnetic flux through the switch plungers 44. One pole 64 of the electro-magnet is sleeved around the upper portions of the switches and the other pole 65 is sleeved around the lower portions so that when a magnetic field is set up between the two poles, the plungers 44 will be drawn downwardly in an effort to reduce the air gap.

As the plungers are lowered by the magnetic force, the port 46 will first be closed, creating an air pocket in the bore 45 and, at the same time, mercury will be displaced around the plunger causing the level of the mercury to rise in the tube. The amount of mercury in the tube, the volume of the cavity 45, the position of the port 46 and the height of the contacts 49 and 52 are so proportioned that energization of the associated electro-magnet will first cause the contacts 50 and 53 to be uncovered by the mercury and thereafter the mercury will rise a sufficient distance to cover or establish contact with the front contacts 49 and 52. Fig. 6 shows the position of the switch parts when the electro-magnet is energized.

The pole pieces 64, 64, which are sleeved on the upper portion of the switches 40 and 41 are connected by an integral ferro-magnetic web 66, and similarly, the poles 65, 65 sleeved on the lower portion of the switches are connected by an integral ferro-magnetic web 67. The two webs 66 and 67 are joined by studs 68, 69 which serve as cores for the windings 70 and 71 of the electro-magnet. Cast gray iron is a suitable ferro-magnetic material for these parts.

It will be understood that current flowing through the coils 70 and 71 will set up a magnetic flux through the magnetic circuit which is closed except for the gap between the poles 64 and 65. The plungers 44 being of magnetic material tend to close this gap and are consequently lowered in the tubes to the position shown in Fig. 6, thus breaking the electrical circuit between the contacts 50 and 51 and 53 and 54, respectively, and establishing electrical connection between the contacts 49 and 51, and 52 and 54, respectively. As stated before, the contacts 50 and 53 are always uncovered before the contacts 49 and 52 are immersed in the mercury.

The energization of the coils 70 and 71 is controlled by a switch 72 interposed in the alternating current circuit. The tube, or envelope 73 of the switch is telescoped by pole pieces 74 and 75 of an electromagnet, the core 76 of which carries the winding 77 connected across the 10 volt alternating current by conductors 78 and 79. The poles 74 and 75 are preferably made of cast gray iron and are in the form of sleeves adapted to fit over the tube 73 and abut the ends of the core piece 76.

A central electrode 80, connected to the windings 70 and 71 of the switches 40 and 41 by a conductor 81, is enveloped to a point 82 by a glass shank 83 integral with the tube envelope. A second electrode 84 is sealed through the end of the envelope and is connected by a conductor 85 to one side of the battery 17. The tube contains a quantity of mercury 86 adapted to establish electric connection between the electrodes 80 and 84 at suitable times.

A tubular plunger 87 of high quality ferro-magnetic material is placed in the tube and normally displaces a sufficient quantity of mercury to close the circuit through the contacts 80 and 84. (See Fig. 7.) The position of the poles 74 and 75 with respect to the envelope is such, however, that when the electromagnet is energized, the plunger is raised in its effort to lessen the air gap between the poles, and as a consequence, the mercury recedes in the envelope and uncovers the contact 85. (See Fig. 5.)

As long as the alternating current delivered to the transformer 14 maintains a predetermined standard, sufficient current flows through the conductor 78, winding 77 and conductor 79 to maintain the plunger in elevated position, thus holding the direct current circuit open. The electromagnetic switches 40 and 41 are consequently de-energized and the plungers 44 float on the mercury and establish electric connection between the back contact 50 and 53 and the neutral contacts 51 and 54, respectively. The circuit through the load can then be traced from binding post 11 through the conductor 59, back contact 50, neutral contact 51, conductor 55, binding post 18, load 20, binding post 19, conductor 56, neutral contact 54, back contact 53, conductor 60 back to the binding post 12.

If now the alternating current for any reason falls below the predetermined standard, the plunger 87 of the control switch 72 will displace enough mercury to establish a connection between the contacts 80 and 84 which will immediately energize the coils 70 and 71. As the plungers 44 are lowered in their respective tubes, the ports 46 will close, forming an air pocket in the bore 45; thereupon the mercury is forced down from the contacts 50 and 53 and elevated on the outside of the plungers to the contacts 49 and 52.

Upon subsiding from the contacts 50 and 53, the mercury breaks the alternating current circuit through the load 20 and establishes a direct current circuit in its place which may be traced from the battery 17 through binding post 15, conductor 62, front contact 49, neutral contact 51, conductor 55, binding post 18, load 20, binding post 19, conductor 56, neutral contact 54, front contact 52, through conductor 63 and binding post 16, back to the battery 17.

As one of the features of the present relay resides in the saving of cost, the following specifications for the relay coils are given by way of illustration. The windings 70 and 71, considered as a unit, may have 928 ampere turns with a resistance of 6½ ohms. The combined relays will then draw about 7½ watts from a 10 volt battery.

The control relay may have 130 ampere turns with a resistance of 10 ohms. Operating on ten volt A. C., the relay draws .35 watt to hold the plunger 87 in elevated position.

The relay units may be assembled in the relay box 10 in any suitable manner, but a preferred assembly is shown in Figs. 1, 2 and 3. In these figures, the box 10 is made in a single casting open in the rear and adapted to be closed by a rear

cover plate 88. A gasket 89 is preferably used to make the assembly weatherproof.

The relay mechanism is mounted in the box by screws 90 engaging rubber blocks 91 fitted in the ears 92 which are integral with the webs 66 and 67 of the electromagnetic switches. As will be seen from Fig. 2, the mechanism is supported in four places, the rubber blocks 91 serving as cushions to protect the mechanism from injury by jarring and rough handling.

The upper pole piece 64, (including web 66), rests upon coils 70 and 71, which in turn rest upon the lower pole piece 65, (including web 67). The cores 68 and 69 of the coils pass through the upper and lower pole pieces and are threaded on both ends to receive nuts 95 and 96. Before the nuts are applied, however, triangular brackets 93 and 94 are placed against the upper and lower faces of the pole pieces 64 and 65, respectively, so that the entire assembly may be clamped together by the single means.

The forward portions of the brackets are bent inwardly at 97, 98 to form a suitable clamping face for the control relay 72.

The core 76 of the control relay 72 is preferably laminated as shown in Fig. 3 and is fastened to the triangular brackets by machine screws 99 which pass through nuts 100 soldered on the inner face of the inwardly bent portions 97 and 98 of the brackets.

The machine screws also serve to secure clips 101, which encircle the pole sleeves 74 and 75 of the switch to the brackets. The mercury switches are held within their respective sockets by rubber jackets 102 tightly fitted over the tubes and cemented to the glass envelopes by any suitable rubber cement 103. A light spiral spring 104 of non-magnetic material is sprung over the large tubes 42 and assist in maintaining the tubes in their proper relation to the poles.

The control relay being in the alternating current circuit, consumes but a fractional portion of the current required by relays now generally in use. It is estimated that a saving of nearly seventy-five per cent can be effected. In addition, the relay is comparatively inexpensive to manufacture, and is unusually compact.

The expression "inert gas" as it is used in this specification in describing the gas fill within the switch envelopes is intended to include any gas fill other than air which suppresses the electric arc, prevents oxidation, or otherwise contributes to longevity of switch operation, unless, of course, the prior art requires a narrower construction.

I claim as my invention:

1. In a railway signalling system, the combination of a primary source of electrical energy, a load connected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under pre-determined conditions, said means comprising a coil, front and back contacts in the auxiliary and primary circuits respectively, an elongated vertically disposed switch envelope into which the contacts of the switch are sealed, a quantity of mercury in the envelope in electrical connection with the load, a displacer vertically movable within the envelope under the influence of the coil for changing the mercury level and in consequence to determine which of the contacts are electrically connected to the load, and means associated with the displacer for preventing one of the contacts from being made before the breaking of the other, said envelope being filled with an inert gas and being hermetically sealed with all moving parts within the switch envelope whereby the operation of the switch is unaffected by external atmospheric conditions.

2. In a railway signalling system, the combination of a primary source of electrical energy, a load connected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under pre-determined conditions, said means comprising a coil, front and back contacts in the auxiliary and primary circuits respectively, a plurality of elongated, vertically disposed switch envelopes into which the contacts of the switch are sealed, mercury in the envelopes, and displacers vertically movable within the envelopes under the influence of the coil for determining which of the contacts is in electrical connection with the load, said envelope being filled with an inert gas and being hermetically sealed with all moving parts within the switch envelope whereby the operation of the switch is unaffected by external atmospheric conditions.

3. In a railway signalling system, the combination of a primary source of electrical energy, a load connected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under pre-determined conditions, said means comprising a coil, front and back contacts in the auxiliary and primary circuits respectively, hermetically sealed from the atmosphere, mercury associated with said contacts, and means controlled by the coil for determining which of said contacts is in electrical connection with the load.

4. In a railway signalling system, the combination of a primary source of electrical energy, a load connected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under pre-determined condition, said means including an electromagnetic switch, and a control switch responsive to conditions in the primary circuit for energizing the electromagnetic switch whenever the primary source of electric energy falls below a pre-determined standard, said electromagnetic switch comprising a coil, front and back contacts in the auxiliary and primary circuits respectively, hermetically sealed from the atmosphere, mercury associated with said contacts, and means controlled by the coil for determining which of said contacts is in electrical connection with the load, said coil being energized from said auxiliary source.

5. In an electrical system, the combination of a primary source of electrical energy, a load connected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under predetermined conditions, said means comprising a coil, and front and back contacts in the auxiliary and primary circuits respectively.

6. In an electrical system, the combination of a primary source of electrical energy, a load connected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under predetermined conditions, said means comprising a coil, front and back contacts in the auxiliary and primary circuits respectively, and means for preventing one of the contacts from being made before the breaking of the other.

7. In an electrical system, the combination of a primary source of electrical energy, a load con-

nected to said source, an auxiliary source of electrical energy, means for transferring the load from the primary source to the auxiliary source under predetermined conditions, said means including an electromagnetic switch and a control switch responsive to conditions in the primary circuit for energizing the electromagnetic switch whenever the primary source of electrical energy falls below a predetermined standard, said electromagnetic switch comprising a coil, and front and back contacts in the auxiliary and primary circuits, respectively, said coil being energized from said auxiliary source.

CARL H. LARSON.