

May 31, 1960

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2,938,981

RELAY

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2 Sheets-Sheet 1

FIG. 1

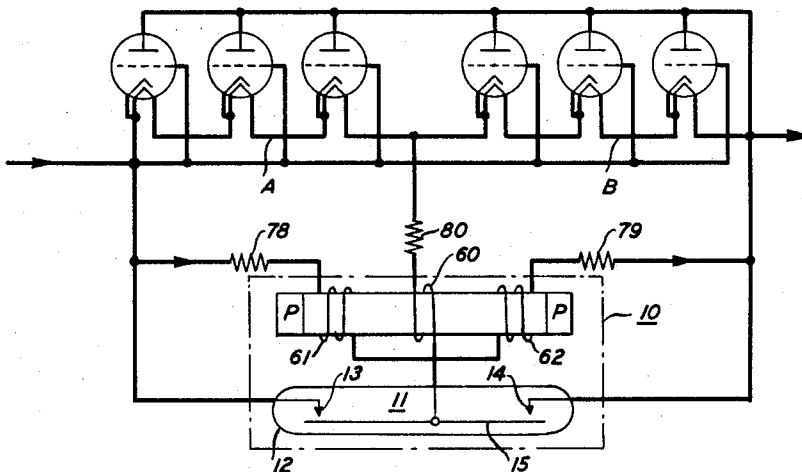


FIG. 2

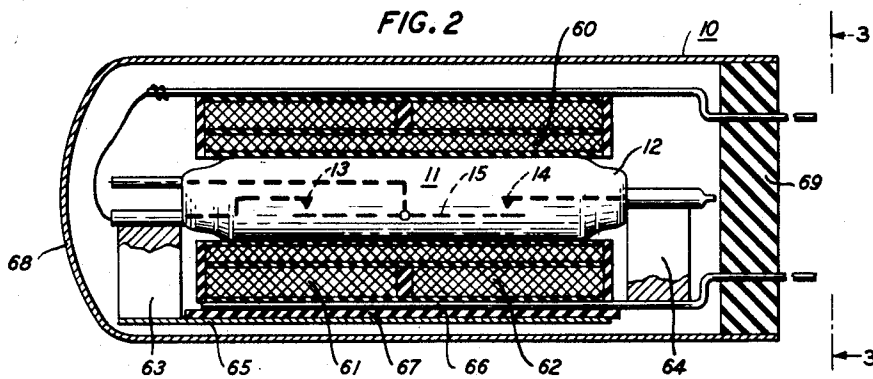
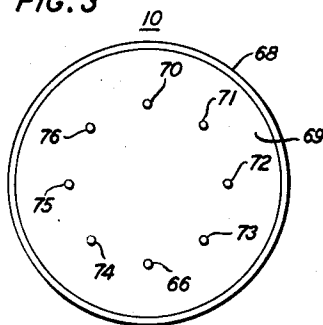


FIG. 3



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FIG. 4

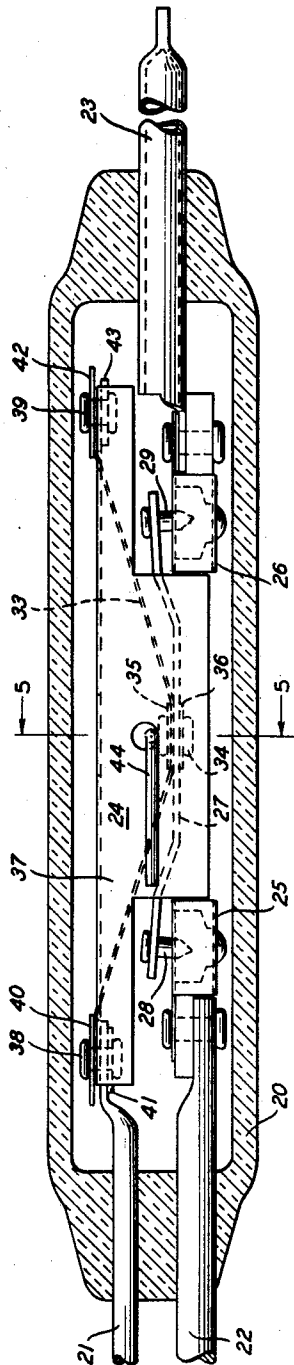


FIG. 5

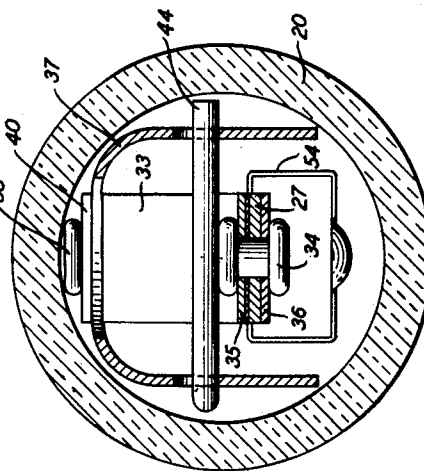
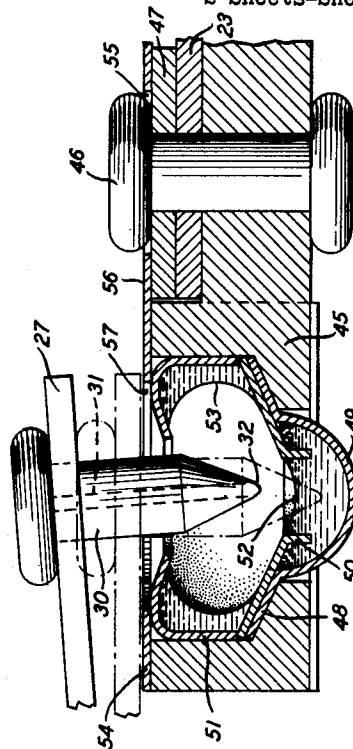


FIG. 6



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RELAY

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10 Claims. (Cl. 200—112)

This invention relates in general to protective devices for electrical circuits. More particularly it relates to a relay for maintaining circuit continuity when one of a plurality of series connected components fails.

It is contemplated that the various features of this invention will be useful in electrical circuits of many different types. However, for the purpose of illustration the invention is described herein as adapted to a repeated transmission system.

In a repeated electrical transmission system the heater filaments of the electron tube amplifiers are frequently connected in series with the transmission system and energized by direct current transmitted through the system. Should one of the heater filaments fail, a gap in the line would result and the entire system would be inoperative. It is therefore advisable to provide the system with a protective device.

An object of this invention is to provide a relay which assures the continued operation of one of a pair of series connected filaments should the other of said filaments fail.

This and other objects of the present invention are realized in an illustrative embodiment thereof wherein the relay comprises a switch unit including an armature mounted at its center to a spring member. The spring member allows the armature to rotate but it tends to maintain the armature in an unrotated position. Affixed to each end of the armature is a contact face and positioned in juxtaposition with each contact face is a fixed contact. Rotation of the armature in either direction causes one of the contact faces to engage its adjacent fixed contact, thereby completing the circuit.

Disposed about the switch unit are two half windings and one full winding. Each half winding encompasses one of the fixed contacts and is connected in parallel with the fixed contact it encompasses. Furthermore, the half windings are connected in series and wound in a reverse direction from each other. The full winding encompasses both fixed contacts and is connected to the armature.

In accordance with one feature of this invention, the relay is connected to a pair of series connected filaments so that when one of the filaments fails, the current that normally flows through the open filament flows through and energizes a half winding and a full winding of the relay, bypassing the inoperative filament and continuing to flow through the operative filament.

In accordance with another feature of the invention, the energized relay windings actuate the relay so as to short circuit the energized half winding, leaving the energized full winding to retain the relay in an actuated condition.

A complete understanding of the invention and of these and other features and advantages thereof may be gained from consideration of the following detailed description taken in conjunction with the accompanying drawing wherein one embodiment of the invention is illustrated. It is to be expressly understood that the drawing is for the purposes of the illustration and descrip-

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tion and is not to be construed as defining the limits of the invention.

In the drawing:

Fig. 1 is a schematic representation of the relay of this invention joined to two strings of filaments connected in series;

Fig. 2 is a front view of the relay partly in section;

Fig. 3 is a side view of the relay shown in Fig. 2 looking in the direction of the arrows 3—3;

Fig. 4 is a front view of the relay switch unit partly in section;

Fig. 5 is an enlarged vertical section of the switch unit shown in Fig. 4 taken along the line 5—5 and looking in the direction of the arrows; and

Fig. 6 is an enlarged view, partly in section, of a portion of the switch unit shown in Fig. 4.

Referring to Fig. 1 of the drawing, there is shown a string of filaments A connected in series with a string of filaments B, both strings being connected to a relay 10. The relay includes a switch unit 11 that comprises a switch envelope 12 enclosing fixed contacts 13 and 14 and a rotatively mounted armature 15. The fixed contacts are positioned adjacent each end of the armature so that rotation of the armature in either direction closes one of the contacts.

Although the switch unit may be of any suitable type, a preferred embodiment, a mercury switch, is illustrated in Figs. 4—6. As shown therein, the elements of the switch unit are enclosed in an envelope 20 made of a dielectric material such as glass. In order to suppress contact arcing the envelope may be filled with an inert gas such as hydrogen, though this is not essential for the operation of the switch unit. Inserted in the ends of the envelope are electrodes 21, 22, and 23. These electrodes should be made of a material having good conductivity and a coefficient of expansion approximating that of the material of the envelope. As shown in Fig. 4, the electrode 23 is partly tubular in shape thereby facilitating fabrication of the switch unit, since both mercury and an inert gas may be inserted into the envelope through this electrode.

Respectively secured to the electrodes 21, 22, and 23 are an armature bracket assembly 24 and mercury cup assemblies 25 and 26. The armature bracket assembly includes an armature 27 having pointed contact faces 28 and 29 affixed to its ends. The armature is formed from a material, such as permalloy, that has a high permeability and a low hysteresis loss. As shown in Fig. 6, the contact faces are advantageously fabricated from a pin 30 that is not wettable by mercury but has an axial core 31 that is mercury wettable. The configuration of the contact face is such that only a tip 32 of the mercury wettable core is exposed. Thus the rest of the exposed contact face is not mercury wettable. This configuration has several advantages. The tip 32 retains a thin film of mercury thereon that provides a low resistance mercury-to-mercury electrical contact when one of the contact faces engages a mercury-filled cup. Furthermore, when the contact face disengages there is very little surface tension tending to hold it immersed in the mercury and consequently the sensitivity of the switch unit is greatly increased. A convenient method of fabricating the contact faces is to form them from a stainless steel wire that has a platinum core. The stainless steel gives support to the platinum both from a mechanical and a conductivity standpoint. Since platinum wets readily with mercury while stainless steel does not, the advantages of a mercury-to-mercury contact are retained without affecting the sensitivity of the switch unit.

The armature 27 is supported by a spring member 33 that permits the armature to rotate but tends to maintain it in the neutral position shown in Fig. 4. The armature

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is secured to the spring member by a rivet 34, and spacers 35 and 36 are interposed adjacent the heads of the rivet to protect the armature and spring member from deformation. The spring member is made from a resilient, nonmagnetic material such as AISI 310 stainless steel.

The ends of the spring member 33 are secured to a bracket 37 by rivets 38 and 39. Spacers 40, 41, 42, and 43 are interposed adjacent the rivet heads to protect the spring member from deformation. The bracket is made of a nonmagnetic material, and it should be made of the same material used for the spring member since this will prevent relative expansion or contraction due to changes in temperature from changing the location of the armature. As shown in Fig. 5, the bracket is U-shaped and it fits snugly within the envelope 20. Thus the bracket is held firmly in place inside of the envelope and the armature bracket assembly is protected against external shock.

Extending through apertures in the sides of the bracket 37 is a right angle stop wire 44. The stop wire protects the spring member and armature against lateral deflection due to external shock.

Turning now to Fig. 6, the cup assembly 26 of the switch unit includes a cup holder 45 that is secured to the electrode 23 by means of a rivet 46, a spacer 47 being interposed between the upper head of the rivet and the electrode to prevent deformation. The cup holder is fabricated from a material like permalloy which has a high permeability and a low hysteresis loss.

A cup member 48 is inserted inside of the cup holder 45, the bowl 49 of the cup member extending below the bottom of the cup holder. A funnel-shaped member 50 rests on top of the cup member, and a centrally apertured cover member 51 rests on top of the funnel-shaped member. The aperture in the cover member is in register with the opening in the funnel-shaped member and the bowl of the cup member, permitting a contact face to enter through the aperture and engage the mercury in the bowl.

The cup members housed by the cup holder 45 are all formed from a mercury wettable material such as platinum thereby providing surfaces to which mercury will adhere. When a drop of mercury strikes either the top surface of the cover member 51 or the bottom surface of the bowl 49, capillary forces pull it inside of the cup members, and the surface tension of the mercury makes it take the shape shown in Fig. 6. The mercury pool 52 in the bowl 49 is quite stable, its level changing very little with any change in the mercury surface 53 adhering to the inside surface of the cover member 51. Also, the particular configuration of the cup members and the adherence of the mercury thereto make it very difficult to displace the mercury either by jarring or inversion of the switch unit. Consequently, the switch may be mounted for operation in any position.

The cup members are held in place by a clamp member 54, a rectangular sleeve which substantially encloses the top and sides of the cup holder 45 and biases itself against the bottom of the cup holder. The clamping member is slid longitudinally over the cup member, and when it is properly positioned, an aperture 55 in a tongue portion 56 seats over the upper head of the rivet 46, placing an aperture 57 in juxtaposition with the cup portion of the cup members.

The cup assembly 25 is practically identical to the cup assembly 26 the only difference being a change in the configuration of the cup holder due to the change in configuration of the supporting electrode 22.

All of the metal members of the switch unit except for those made of a mercury wettable material such as platinum may be advantageously covered with a chromium oxide to provide a surface that does not wet with mercury. The chromium oxide is obtained by applying a flash of chromium to the member and annealing it in wet hydrogen. If a member is made from a material,

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such as stainless steel, that has chromium in it, the flash of chromium is unnecessary.

Referring now to Fig. 2 it is seen that the switch unit is encircled by a full winding 60 and two half windings 61 and 62. The full winding encompasses the gaps in the switch unit between the ends of the armature 15 and the fixed contacts 13 and 14. The half winding 61 only encompasses the gap between the left end of the armature and the fixed contact 13, and the half winding 62 only encompasses the gap between the right end of the armature and the fixed contact 14. As illustrated in Fig. 1, the half windings are connected in series, and one is wound in a reverse direction from the other. The full winding is connected to the junction of the two half windings and to the switch armature. Each half winding is connected in parallel with the fixed contact that it encloses.

Permanent magnets 63 and 64 are respectively secured to the electrodes of the fixed contacts 13 and 14. The magnets are oriented in the same direction, polarizing the relay in a balanced manner. Attached to the lower end of the magnet 63 is a magnetic shunt member 65, and attached to the lower end of the magnet 64 is a magnetic shunt member 66 that is also a terminal of the relay. A dielectric member 67 electrically insulates the shunt members one from the other.

Housing the elements of the relay is a cup-shaped container 68, the open end of the container being sealed by a header 69. As illustrated in Fig. 3, terminals 70, 71, 72, 73, 74, 75, and 76, and magnetic shunt member 66 extend through the header. The container 68 may be advantageously made of a magnetic material to shield the relay from the magnetic effects of adjacent electronic equipment and to shield adjacent electronic equipment from the magnetic effects of the relay. All of the terminals except for the magnetic shunt member 66 are only current conducting members and therefore need not be of a magnetic material.

Referring again to Fig. 1 it is seen that the fixed contact 13 and the half winding 61 are connected to the incoming end of the string of filaments A, the arrows in Fig. 1 pointing in the direction of current flow. The fixed contact 14 and the half winding 62 are connected to the outgoing end of the string of filaments B, and one end of the full winding 60 is connected to the junction of the string of filaments A and the string of filaments B.

So that little current flows through the relay under normal conditions, it is desirable that the individual half winding circuits be of a high resistance. The resistance may be in the windings themselves or it may be supplied externally such as by resistors 78 and 79. The full winding circuit, on the other hand, should be of a low resistance. Again this resistance may be in the winding itself or supplied by a resistor 80.

Other details will be understood from the following description of the mode of operation of the relay.

If both strings of filaments A and B are operative most of the current flows through the filaments as they offer less resistance than the windings. The small amount of current that does flow through the windings generates some magnetic flux, but because the half windings 61 and 62 are reverse wound, the magnetic flux generated by one half winding opposes the magnetic flux generated by the other half winding. The permanent magnets 63 and 64 generate magnetic flux which respectively aids the flux generated by the half windings 61 and 62. So again the flux generated by one magnet is in opposition to the flux generated by the other magnet. Thus, insufficient magnetic flux is generated to cause the relay to operate.

Should, however, a filament fail in the string of filaments A, the current that flowed through the filaments must flow through the half winding 61. Because the circuit of the full winding 60 is of far less resistance than the circuit of the half winding 62, the greatest portion

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of the filament current, after passing through the half winding 61 will flow through the full winding 60 to the string of filaments B. It is seen that the current flows through the full winding 60 in the same direction as the current flowing through the half winding 61 but in the opposite direction from the current flowing through the half winding 62. Thus, the flux generated by the full winding aids the large amount of flux generated by the half winding 61 and opposes the small amount of flux generated by the half winding 62. This results in the armature rotating in a clockwise direction as viewed in Fig. 1, closing the contact 13. With the contact 13 closed, a path of very little resistance is available to the current, and almost all of the current that flowed through the half winding 61 flows through the switch unit instead. The high resistance circuit of the half winding 61 is thereby eliminated from the path of the current, and the flux generated by the full winding in combination with the flux generated by the permanent magnet 63, though opposed by the flux generated by the half winding 62 and the permanent magnet 64, maintains the contact closed.

Should a filament fail in the string of filaments B, the current that formerly flowed through this string of filaments must flow through the full winding 60 and the half winding 62. The current flows through the full winding 60 in the same direction as the current flowing through the half winding 62 and in the opposite direction from the small amount of current flowing through the half winding 61. Thus, the flux generated by the full winding aids the large amount of flux generated by the half winding 62 and opposes the small amount of flux generated by the half winding 61, causing the armature to rotate in a counterclockwise direction as viewed in Fig. 1 and closing the contact 14. With the contact 14 closed, almost all of the current that flowed through the half winding 62 flows through the low resistance path of the switch unit, eliminating the high resistance circuit of the half winding 62 from the path of the current. Again the flux generated by the full winding aided by the flux generated by the permanent magnet 64 though opposed by the flux generated by the half winding 61 and the permanent magnet 63 maintains the contact closed.

By proper proportioning of the turns in the full winding and the half windings it is possible to prevent an external shock from operating the relay. Thus, should an external shock rotate the armature of the switch unit and close contact 13 when both strings of filaments are operative, only a proportion of the filament current would flow through the switch unit and through the full winding 60 and the half winding 62. The turns in the full winding and the half windings may be proportioned so that the ampere turns or magnetomotive force of the full winding combined with the magnetomotive force of the permanent magnet 63 and opposed by the ampere turns or magnetomotive force of the half winding 62 and the permanent magnet 64 is insufficient to keep the contact closed. Similarly, should an external shock close the contact 14, the contact would open.

Although one embodiment of the invention has been described and illustrated in detail it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the invention being limited only by the terms of the appended claims.

What is claimed is:

1. A relay comprising in combination, a tubular dielectric switch envelope, a first and second electrode extending through one end of said envelope, a third electrode extending through the other end of said envelope, a U-shaped bracket secured to said first electrode, the ends of a spring member secured to said bracket, an armature rotatively mounted at its center to the center of said spring member, a mercury nonwetable contact

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face secured to each end of said armature, said contact face having a mercury wettable point, a mercury-filled cup secured to each of said second and third electrodes, each of said mercury-filled cups being in juxtaposition with one of said contact faces so that rotation of said armature in either direction causes one of said contact faces to engage the mercury in its juxtaposed cup, said contact faces and said mercury-filled cups defining a first and second pair of contacts, a first and second series connected winding respectively disposed about and connected in parallel with said first and second pair of contacts, said first and second windings being wound in a direction which is the reverse each of the other, and a third winding disposed about both of said first and second pair of contacts and connected between the junction of said first and second windings.

2. A relay comprising in combination, a dielectric switch envelope, a first and second electrode extending through one end of said envelope, a third electrode extending through the other end of said envelope, a bracket secured to said first electrode, a spring member secured to said bracket, an armature rotatively mounted at its center to said spring member, a mercury nonwetable contact face secured to each end of said armature, said contact face having a mercury wettable point, a mercury-filled cup secured to each of said second and third electrodes, each of said mercury-filled cups being in juxtaposition with one of said contact faces so that rotation of said armature in either direction causes one of said contact faces to engage the mercury in its juxtaposed cup, said contact faces and said mercury-filled cups defining a first and second pair of contacts, a first and second series connected winding respectively disposed about said first and second pair of contacts, said first and second windings being wound in a direction which is the reverse each of the other, and a third winding disposed about both of said first and second pair of contacts.

3. In an electrical circuit wherein a first and second string of filaments are connected in series, the combination with said first and second string of filaments of a relay for insuring the continued operation of one of said strings of filaments should the other of said strings of filaments fail, said relay comprising a resilient member, an armature rotatively mounted to said resilient member, contact faces affixed to the respective ends of said armature, a portion of said contact faces being mercury wettable, a mercury-filled cup positioned in juxtaposition with said contact faces so that rotation of said armature in either direction causes one of said contact faces to engage the mercury in its juxtaposed cup, said contact faces and said mercury-filled cups defining a first and second pair of contacts, a first and second series connected winding respectively disposed about and connected in parallel with said first and second pair of contacts, said first and second windings being respectively connected in parallel with the first and second string of filaments and having an individual resistance value substantially greater than the resistance value of the filaments, said first and second windings further being wound in a direction which is the reverse each of the other, a third winding disposed about said first and second pair of contacts and connected between the junction of the first and second string of filaments and the junction of said first and second windings, said third winding having a resistance value which is substantially less than the individual resistance values of said first and second windings, so that the failure of one of said filaments causes the current that normally flows therethrough to flow through the parallel connected winding, thereby generating sufficient flux to close the contacts in parallel with said parallel connected winding, said contacts being retained in the closed position by the current flowing through the third winding.

4. In an electrical circuit wherein a first and second string of filaments are connected in series, the combination with said first and second string of filaments of a

relay for insuring the continued operation of one of said strings of filaments should the other of said strings of filaments fail, said relay comprising an armature, means for rotatively supporting said armature, fixed contacts positioned in juxtaposition with the ends of said armature so that rotation of said armature in either direction closes one of said fixed contacts, the ends of said armature and said fixed contacts defining a first and second pair of contacts, a first and second series connected winding respectively disposed about and connected in parallel with said first and second pair of contacts, said first and second windings being respectively connected in parallel with the first and second string of filaments and having an individual resistance value substantially greater than the resistance value of the filaments, said first and second windings further being wound in a direction which is the reverse each of the other, a third winding disposed about said first and second pair of contacts and connected between the junction of the first and second string of filaments and the junction of said first and second windings, said third winding having a resistance value which is substantially less than the individual resistance values of said first and second windings, so that the failure of one of said filaments causes the current that normally flows therethrough to flow through the parallel connected winding, thereby generating sufficient flux to close the contacts in parallel with said parallel connected winding, said contacts being retained in the closed position by the current flowing through the third winding.

5. In an electrical circuit wherein a pair of filaments are connected in series, the combination with said pair of filaments of a relay for insuring the continued operation of one of said filaments should the other of said filaments fail, said relay comprising first and second series connected windings connected in parallel with said filaments, said first and second windings having an individual resistance value which is substantially greater than the resistance value of said filaments, a third winding connected between the junction of said filaments and the junction of said first and second windings, said third winding having a resistance value substantially less than the individual resistance values of said first and second windings, a first and second pair of contacts respectively connected in parallel with said first and second windings, said first and second windings being respectively disposed about said first and second pair of contacts and disposed so as to be magnetically opposed to each other, said third winding disposed about both said first and second pair of contacts, so that the failure of one of said filaments causes the current that normally flows therethrough to flow through the parallel connected winding thereby generating sufficient flux to close the contacts in parallel with said parallel connected windings, said contacts being retained in the closed position by the current flowing through the third winding.

6. In an electrical circuit wherein a pair of electrical components are connected in series, the combination with said pair of electrical components, of a relay for insuring the continued operation of one of said components should the other of said components fail, said relay comprising first and second series connected windings connected in parallel with said components, said first and second windings having individual resistance values such that normally little current flows therethrough, a third winding connected between the junction of said components and the junction of said first and second windings, said third winding having a resistance value substantially less than the individual resistance values of said first and second windings, a first and second pair of magnetic members adapted to make contact under the influence of magnetic flux respectively connected in parallel with said first and second windings, said first and second windings being respectively disposed about said first and second pair of magnetic members and disposed so as to be magnetically opposed to each other, said third winding

disposed about both said first and second pair of magnetic members, so that the failures of one of said components causes the current that normally flows therethrough to flow through the parallel connected winding thereby generating sufficient flux to close the magnetic members in parallel with said parallel connected windings, said magnetic members being retained in the closed position by the current flowing through the third winding.

7. In an electrical circuit wherein a pair of electrical components are connected in series, the combination with said pair of electrical components of a relay for insuring the continued operation of one of said components should the other of said components fail, said relay comprising first and second series connected windings connected in parallel with said components, a third winding connected between the junction of said components and the junction of said first and second windings, a first and second pair of magnetic members adapted to make contact under the influence of magnetic flux respectively connected in parallel with said first and second windings, said first and second windings being respectively disposed about said first and second pair of magnetic members and disposed so as to be magnetically opposed to each other, said third winding disposed about both said first and second pair of magnetic members, so that the failure of one of said components causes the current that normally flows therethrough to flow through the parallel connected winding thereby generating sufficient flux to close the magnetic members in parallel with said parallel connected winding, said magnetic members being retained in the closed position by the current flowing through the third winding.

8. In an electrical circuit wherein a pair of electrical components are connected in series, the combination with said pair of electrical components of a relay for insuring the continued operation of one of said components should the other of said components fail, said relay comprising first and second series connected windings connected in parallel with said components, said first and second windings being disposed so as to be magnetically opposed to each other, a third winding connected between the junction of said components and the junction of said first and second windings, a first and second pair of magnetic members adapted to make contact under the influence of magnetic flux respectively connected in parallel with said first and second windings, so that the failure of one of said components causes the current that normally flows therethrough to flow through the parallel connected winding thereby generating sufficient flux to close the magnetic members in parallel with said parallel connected winding, said magnetic members being retained in the closed position by the current flowing through the third winding.

9. In an electrical circuit wherein a pair of electrical components are connected in series, the combination with said pair of electrical components of a relay for insuring the continued operation of one of said components should the other of said components fail, said relay comprising first and second series connected flux generating means connected in parallel with said components, said first and second flux generating means being disposed so as to be magnetically opposed to each other, a third flux generating means connected between the junction of said components and the junction of said first and second flux generating means, a first and second pair of magnetic members adapted to make contact under the influence of magnetic flux respectively connected in parallel with said first and second flux generating means so that the failure of one of said components causes the current that normally flowed therethrough to flow through the parallel connected flux generating means thereby generating sufficient flux to close the magnetic members in parallel with said parallel connected flux generating means, said magnetic members being retained in the closed position by the current flowing through the third flux generating means.

10. In an electrical circuit wherein a pair of electrical components are connected in series, the combination with said pair of electrical components of a relay for insuring the continued operation of one of said components should the other of said components fail, said relay comprising first and second series connected flux generating means respectively connected in parallel with said components, said first and second flux generating means being disposed so as to be magnetically opposed to each other, a first and second pair of magnetic members adapted to make contact under the influence of magnetic flux respectively connected in parallel with said first and second flux gen-

erating means, whereby the failure of one of said components causes the current that normally flows there-through to flow through the parallel connected flux generating means thereby generating sufficient flux to close the magnetic members in parallel with said parallel connected flux generating means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,491,986	Larson	Dec. 20, 1949
2,539,259	McCabe	Jan. 23, 1951