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TIME DELAY SWITCHING APPARATUS

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FIG. 1

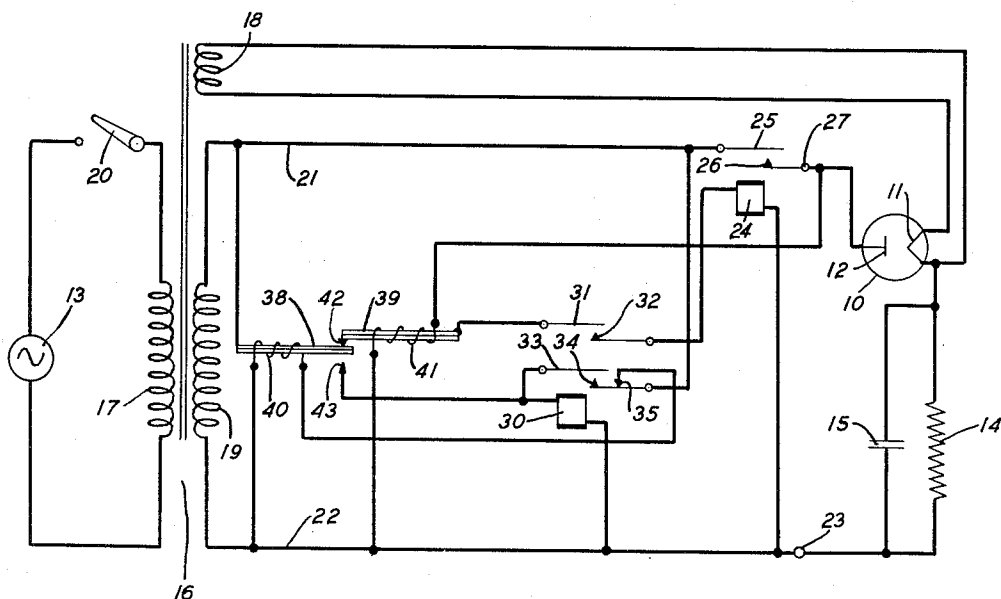


FIG. 2

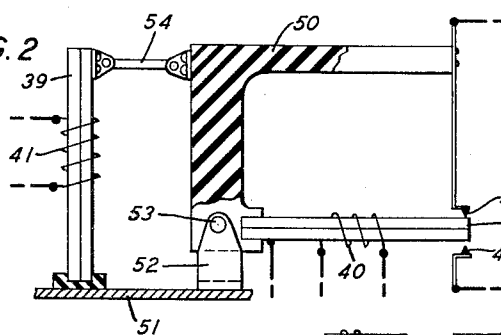


FIG.3

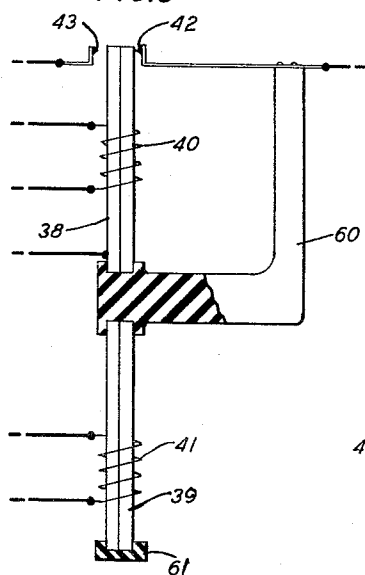


FIG. 5

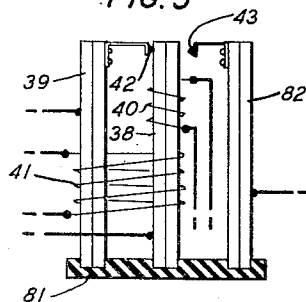
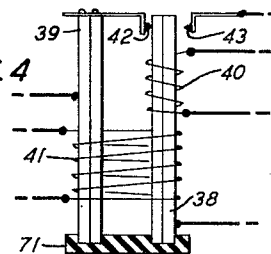


FIG. 4



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TIME DELAY SWITCHING APPARATUS

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7 Claims. (Cl. 317—132)

This invention relates to a time delay switching apparatus and particularly to such apparatus for providing a time delay period which is variable in response to a change of an operating condition.

An object of the invention is to provide an improved time delay switching apparatus.

In accordance with the invention there is provided a switching apparatus having an armature adapted to engage a pair of spaced contacts successively and a thermal responsive element for varying the spacing of the contacts.

In a specific embodiment of the invention herein shown and described for the purpose of illustration, a time delay switching apparatus is provided for connecting a load circuit to a current supply line after the supply line is initially connected to a current supply source and also for reconnecting the load circuit to the supply line after a failure and subsequent restoration of the current supply. The switching of the load circuit to the supply line is delayed for a period the length of which varies in accordance with the length of the period during which the current supply is interrupted or reduced to an abnormally low voltage. The apparatus comprises a first thermal element for engaging a first contact when the element is relatively cool. Current supplied from the supply line to a heater for the first thermal element causes the thermal element to move out of engagement with the first contact and into engagement with a second contact. The heater current is interrupted in response to the energization of an electromagnetic relay by current from the supply line when the thermal element engages its second contact, thus causing the thermal element to cool and return to its first contact. The electromagnetic relay remains operated by current supplied through a lock-up circuit from the supply line. The re-engagement of the first contact by the thermal element completes a circuit through a contact of the electromagnetic relay for operating a contactor. The contactor, when operated, connects the load circuit to the supply line. A second thermal element is provided for moving the first contact toward the second contact in response to a temperature increase of the second thermal element and vice versa. A heater for the second thermal element is connected to the load circuit so that, when current is being supplied to the load circuit, the heater for the second thermal element is energized to cause the second thermal element to move in a direction to decrease the spacing of the contacts. When a power supply interruption of short duration occurs, for example, the spacing of the first and second contacts is relatively small. As a result, there is a relatively short delay between the time that the current supply is restored and the time that the load circuit is reconnected to the supply line.

Fig. 1 of the accompanying drawing is a schematic view of a current supply circuit embodying the invention; and

Figs. 2, 3, 4 and 5 are schematic views of modifications of a portion of Fig. 1.

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Referring to the drawing, there is provided a load circuit comprising a rectifier tube 10 having a thermionic cathode 11 and an anode 12 for rectifying current from an alternating-current supply source 13 and for supplying the rectified current to a load 14 across which is connected a filtering condenser 15. There is provided a transformer 16 having a primary winding 17 and secondary windings 18 and 19. A switch 20 is provided for connecting the supply source 13 to the transformer primary 17. When the switch 20 is closed, current is supplied through secondary transformer winding 18 to the cathode 11 for heating the cathode to bring it gradually to its normal operating temperature. Closure of switch 20 also causes an alternating voltage to be induced in the secondary transformer winding 19, this voltage being impressed across the supply line 21, 22. One side, 22, of the supply line is connected directly to a terminal 23 of the load circuit comprising the rectifier 10 and the load 14. There is provided a contactor 24 having an armature 25 and a fixed contact 26. The armature 25 is connected to the other side, 21, of the supply line and the contact 26 is connected to a terminal 27 of the load circuit. When the contactor or relay 24 is de-energized, the armature 25 is spaced from the contact 26 and the load circuit is disconnected from the supply line. When the relay 24 operates to cause the armature 25 to engage the contact 26, the supply line is connected to the load circuit and current flows from one terminal of secondary transformer winding 19 through the supply line 21 and through the armature and contact of relay 24 to the anode 12 of the rectifier tube 10 and, from the cathode 11 of the tube, through the load 14 to terminal 23 and thence through the supply line 22 to the other terminal of secondary winding 19.

There is provided an electromagnetic relay 30 having an armature 31 and contact 32 and a make-before-break spring combination comprising an armature 33 and contacts 34 and 35. Two bimetallic thermal elements 38 and 39 are provided. An electric heating element 40 is wound about or otherwise suitably associated with the thermal element 38. A similar heater 41 is provided for the thermal element 39. The thermal element or armature 38 engages a contact 42 when no heating current is being supplied to the heater 40. The thermal element 38 is deflected in response to heat supplied by the heater 40, when energized, so that the thermal element 38 moves into engagement with the contact 43. The contact 42 is secured to the thermal element 39. Heating current supplied to the heater 41 causes the thermal element 39 to deflect so as to move the contact 42 toward the fixed contact 43. The spacing between contacts 42 and 43 is thus decreased. One terminal of heater 40 is connected to the supply line 22 and its other terminal is connected through contact 35 to the supply line 21. The heater 41 is connected across the load circuit, one terminal of the heater being connected to terminal 23 and the other terminal of the heater 41 being connected to the terminal 27.

When the switch 20 is closed, heating current is supplied from secondary transformer winding 18 to the cathode 11 of tube 10. At the same time current is supplied from transformer winding 19 to the heater 40 through a circuit comprising the supply line 21, 22 and contact 35 of relay 30. The resulting heating of the thermal element 38 causes it to deflect and to engage the contact 43. A circuit is thus completed from the supply line 21 through thermal element 38, contact 43 and winding of relay 30 to the supply line 22, causing relay 30 to operate. Operation of relay 30 causes armatures 31 and 33 to engage contacts 32 and 34, respectively. A lock-up circuit for relay 30 is thus closed through armature 33 and contact 34 to the supply line 21. When armature 33 engages con-

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tact 34, the energizing circuit for the heater 40 is opened at contact 35. The thermal element 38 thus cools and moves to re-engage the contact 42. When this occurs, an energizing circuit for contactor relay 24 is completed from supply line 21, through thermal element 38, contact 42, thermal element 39, armature 31 and contact 32 of relay 30 and the winding of contactor 24 to the supply line 22. Contactor relay 24 thus operates to move its armature 25 into engagement with its contact 26, thereby connecting line 21 to terminal 27 of the load circuit. Current may then flow from line 21 through the space current path of rectifier tube 10 and through the load 14 to the line 22.

When the supply line 21 is connected to the load circuit through the armature 25 and contact 26 of relay 24, current is supplied to the heater 41 for the thermal element 39, the heater 41 being connected across the load circuit. As a result, the thermal element 39 is deflected to move contact 42 toward the contact 43. The spacing of contact 42 with respect to contact 43 is thus decreased. If, subsequently, the supply source 13 should fail, relays 30 and 24 will release, the heater 41 will become de-energized and thermal element 39 will cool to increase the spacing of contacts 42 and 43. When the supply source is restored, the thermal element 38 will move from contact 42 to contact 43 to complete an energizing circuit for relay 30 and then the thermal element will return to contact 42 to cause the completion of an energizing circuit for relay 24, as previously described. Thus the time required for connecting the load circuit to the supply line after restoration of the current supply is equal to the time required for the thermal element 38 to move from contact 42 to contact 43 and back again to contact 42. This time interval is dependent upon the spacing of contacts 42 and 43 which, in turn, is dependent upon the temperature of the thermal element 39.

If the interruption of the current supply is very brief, the temperature of the cathode 11 and the temperature of the thermal element 39 will have decreased only slightly and the spacing of contacts 42 and 43 will be relatively small at the time that the current supply is restored. Therefore, the time required, after restoration of the current supply, for the thermal element to travel from contact 42 to contact 43 and back to contact 42 will be relatively short and the load circuit will be connected to the supply line after a brief delay period following the restoration of the current supply. If the interruption of the current supply is somewhat longer, the cathode 11 and the thermal element 39 will have cooled to relatively lower temperatures and the spacing of contacts 42 and 43 will be somewhat longer at the time of restoration of the current supply. In that case, the delay in connecting the load circuit to the supply line after restoration of the current supply will also be longer. Thus the flow of space current through the anode-cathode path of the tube 10 is delayed until the cathode has been heated to operating temperature, this delay period increasing as the period of interruption of the current supply is increased. When the period of interruption is sufficiently long that the thermal element 39 is cooled to the ambient temperature, the contacts 42 and 43 are spaced a maximum distance and a maximum delay period is introduced between the time of restoration of the current supply and the connection of the load circuit to the supply line. Of course, the time delay switching circuit will function not only when a complete interruption of the power supply occurs but also when the failure is such that the voltage across the supply line is reduced sufficiently to cause relays 30 and 24 to release.

In Fig. 1, when current is supplied to the heater 41, and, as a result, the thermal element 39 is deflected to move the contact 42 toward the contact 43, the thermal element 39 must supply sufficient force through the contact 42 to the thermal element 38 to deflect the thermal element 38 toward the contact 43. In some cases it may be preferable to provide a modified arrangement for con-

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trolling the spacing of contacts 42 and 43 such as is shown in Figs. 2, 3, 4 or 5. In each of these modifications there are provided, as in Fig. 1, a thermal element 38 operating between contacts 42 and 43, a heater 40 for thermal element 38, a thermal element 39 and a heater 41 for thermal element 39. When any one of these modifications is substituted for the corresponding portion of Fig. 1, one terminal of heater 40 is connected to the supply line 22 and its other terminal is connected to contact 35, the heater 41 is connected across the load circuit, contact 43 is connected to a common terminal of the winding of relay 30 and armature 33 and thermal element 38 is connected to the supply line 21. In Figs. 2 and 3 the contact 42 is directly connected to the armature 31 while in Figs. 4 and 5 the contact 42 may be connected through a portion at least of the thermal element 39 to the armature 31. In Fig. 5 the contact 43 may be connected to the common terminal of the winding of relay 30 and armature 33 through a portion at least of a thermal element 32.

In Fig. 2 there is provided a member 50 of insulating material to which the contact 42 and the thermal element 38 are secured. The member 50 is mounted on a support 51 by means of a hinge 52 or other suitable device so that the member 50 may be displaced about an axis 53. One end of thermal element 39 is secured to the support 51 and its other end is coupled through a suitable mechanical linkage 54 to the member 50. Deflection of thermal element 39 in response to current supplied to the heater 41 will thus move the member 50 about the axis 53 in a direction to cause the contact 42 and the thermal element 38 to move together toward the fixed contact 43. The contact pressure between thermal element 38 and contact 42 remains substantially constant when the thermal element 38 is at ambient temperature. The heating of thermal element 38 by current supplied to the heater 40 will move the element 38 out of engagement with the contact 42 and into engagement with the contact 43.

As shown in Fig. 3, a member 60 of insulating material is secured to the upper end of thermal element 39 and the lower end of thermal element 39 is secured to a support 61. The contact 42 and the lower end of thermal element 38 are each secured to the insulating member 60. Heating of the thermal element 39 due to current supplied to the heater 41 will deflect the thermal element 39 to move the contact 42 and the thermal element 38 together toward the contact 43. Heating of thermal element 38 by current supplied to the heater 40 will cause the thermal element 38 to be deflected so as to move it out of engagement with contact 42 and into engagement with contact 43.

In Fig. 4, the lower ends of thermal elements 38 and 39 are secured to a support 71. The heater 41, when energized, supplies heat to both thermal elements 38 and 39 while the heater 40, when energized, supplies heat only to the thermal element 38. For example, the heating winding 41 may be wound about both thermal elements and the heating winding 40 may be wound about thermal element 38 only. Therefore, when the heater 41 is energized, the contact 42 and the thermal element 38 are moved together toward the contact 43. The energization of heater 40 will cause thermal element 38 to leave the contact 42 to move into engagement with the contact 43.

Fig. 5 is a modification of the embodiment shown in Fig. 4. There is provided a third thermal element 82 to which the contact 43 is secured. The thermal elements 38, 39 and 82 are each secured at one end to a support 81. The thermal element 82 is provided for compensating for changes of ambient temperature. Assuming no temperature change of the thermal elements 38 and 39 due to heat supplied by the heaters 40 and 41, if a change of ambient temperature occurs which would cause the thermal elements 38 and 39 to be deflected toward the right, as viewed in the drawing, for

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example, the ambient temperature change will also cause thermal element 82 to move toward the right. Therefore a change of ambient temperature will not change the spacing of contacts 42 and 43.

What is claimed is:

1. Switching apparatus comprising a pair of spaced contacts, a thermal element, means for heating said thermal element to cause it to move from a first of said contacts into engagement with a second of said contacts, means responsive to the engagement of said thermal element with said second contact for interrupting said heating and thereby cause said thermal element to move from said second contact to said first contact and means responsive to the re-engagement of said thermal element with said first contact for decreasing the spacing of said contacts.

2. In combination, a first and a second thermal element, a first and a second contact, a first heating means for heating said first thermal element to cause it to move from one of said first and second contacts to the other of said contacts and means for moving said first contact and said first thermal element substantially simultaneously with respect to said second contact, said last-mentioned means comprising a second heating means for simultaneously heating said first and second thermal elements.

3. In combination, an insulating member, a first contact secured to said insulating member, a first thermal element secured to said insulating member, a second contact, a first electric heater for heating said first thermal element to cause it to move from said first contact to said second contact, a second thermal element mechanically coupled to said insulating member and a second electric heater for heating said second thermal element to cause the movement of said first contact and said first thermal element toward said second contact.

4. In combination, a first, a second and a third thermal element, a first contact secured to said first thermal element, a second contact secured to said second thermal element, a first electric heater for heating simultaneously said first and third thermal elements to cause said first and third thermal elements to move simultaneously with respect to said second thermal element, thereby changing the spacing of said contacts, and a second electric heater for heating said third thermal element to cause it to move from one of said contacts to the other.

5. The combination with a current supply source and a load of a first electromagnetic relay having a first contact which is closed when the relay is de-energized and a second and a third contact each of which is open when the relay is de-energized, a second electromagnetic relay having a fourth contact which is open when the second relay is de-energized, a first and a second thermal element, a first and a second electric heater for said first and second thermal elements, respectively, a fifth contact secured to said second thermal element, a sixth contact, a first circuit connected across said supply source comprising said first heater and said first contact in series, the current flowing in said first circuit causing said first thermal element to move away from said fifth contact into engagement with said sixth contact, said first relay being connected in a second circuit across said supply source through said sixth contact and said first thermal element in series, thereby causing said first relay to operate to open said first contact and to close said second and third contacts, the op-

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eration of said first relay opening the energizing circuit for said first heater to cause said first thermal element to return into engagement with said fifth contact, a circuit for holding said first relay operated completed through said second contact and said first relay, the re-engagement of said first thermal element with said fifth contact completing a third circuit across said current supply source comprising in series said first thermal element, said fifth contact, said second thermal element, said third contact and said second relay, thereby causing said second relay to operate to close said fourth contact, the closing of said fourth contact completing a fourth circuit across said supply source comprising said second heater and said fourth contact in series, the resulting energization of said second heater causing said fifth contact to move towards said sixth contact, and said load being connected through said fourth contact to said supply source.

6. Switching apparatus comprising a pair of spaced contacts, an armature in engagement with one of said contacts, a common support of insulating material, means for securing said armature and said one contact to different portions, respectively, of said common support, a first current responsive means for actuating said common support to apply substantially equal forces to said armature and to said one contact, respectively, to move said armature and said one contact simultaneously toward the other of said contacts while maintaining the contact pressure between said armature and said one contact substantially constant, and a second current responsive means for causing said armature to move out of engagement with said one contact and into engagement with said other contact.

7. In combination a first and a second thermal element, a first and a second contact, an insulating member, means for securing said first contact to one portion of said insulating member, means for securing said first thermal element to another portion of said insulating member, means for mechanically coupling said second thermal element to said insulating member, a first heating means for heating said first thermal element to cause it to move out of engagement with one of said first and second contacts and into engagement with the other of said contacts, and means for applying substantially equal forces to said first contact and to said first thermal element, respectively, to move said first contact and said first thermal element toward said second contact while maintaining the contact pressure between said first contact and said first thermal element substantially constant, said last-mentioned means comprising a second heating means for heating said second thermal element.

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