

Nov. 16, 1965

A. DE FALCO
THERMAL TIME DELAY RELAY WITH PRECISE
TIME DELAY ADJUSTMENT MEANS

3,218,416

Filed June 19, 1963

3 Sheets-Sheet 1

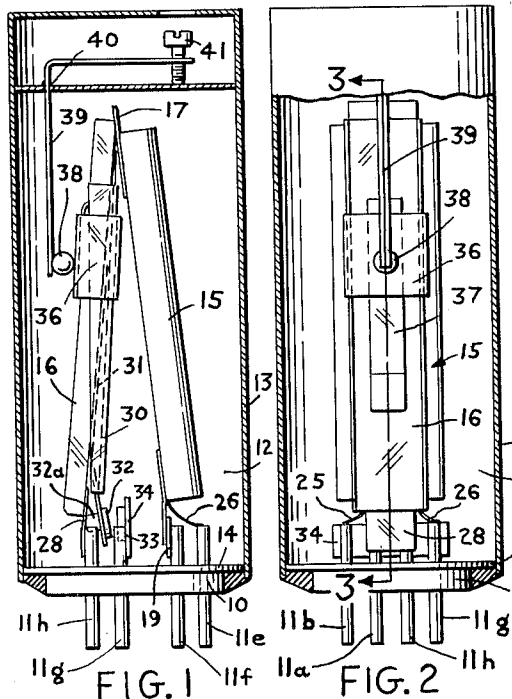


FIG. 1

FIG. 2

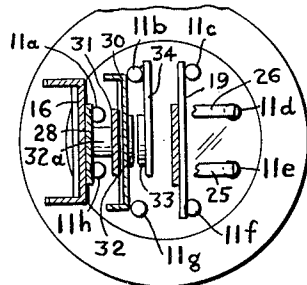


FIG. 5

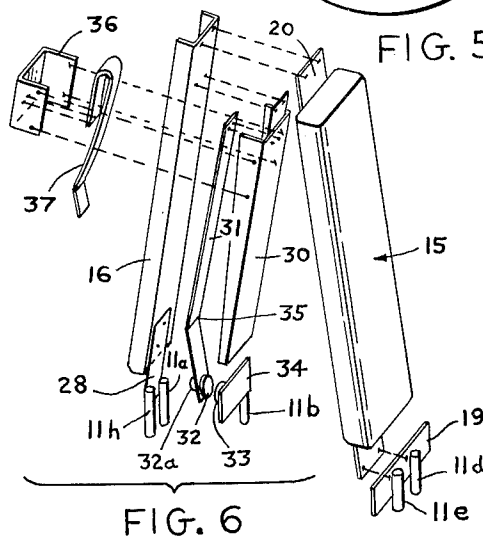


FIG. 6

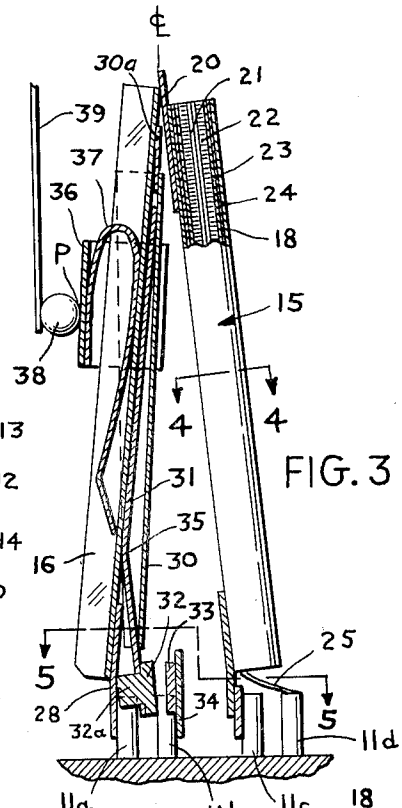


FIG. 3

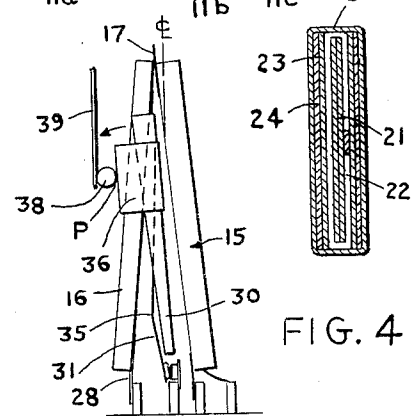


FIG. 4

FIG. 7
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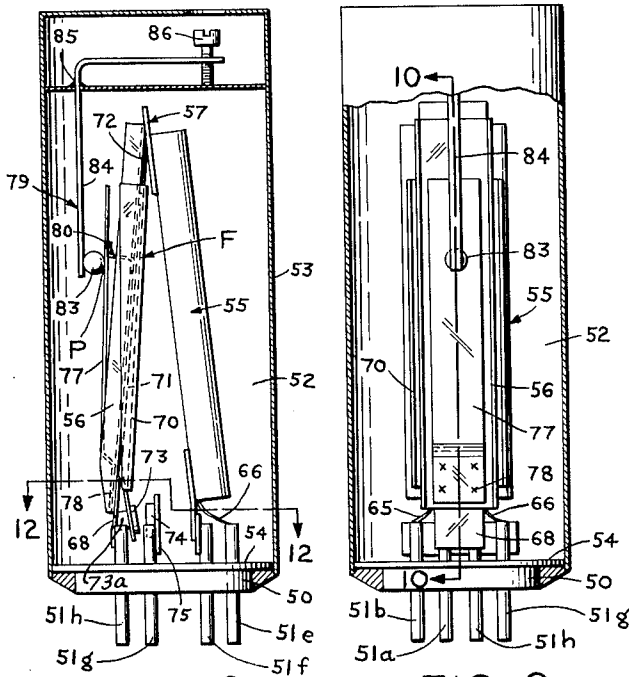


FIG. 8

FIG. 9

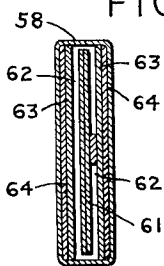


FIG. 11

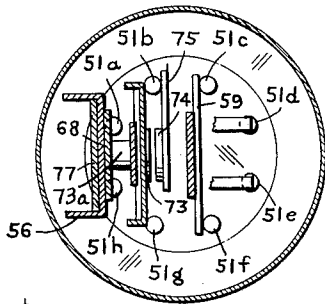


FIG. 12

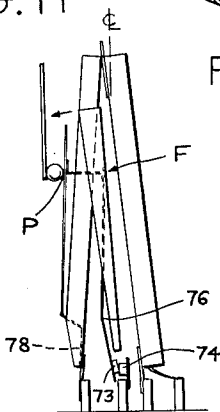


FIG. 14

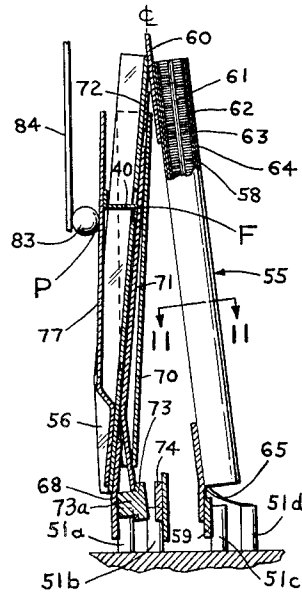


FIG. 10

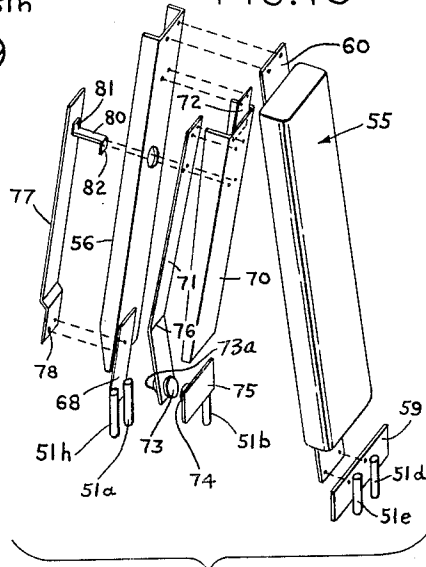


FIG. 13

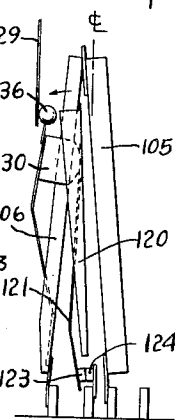
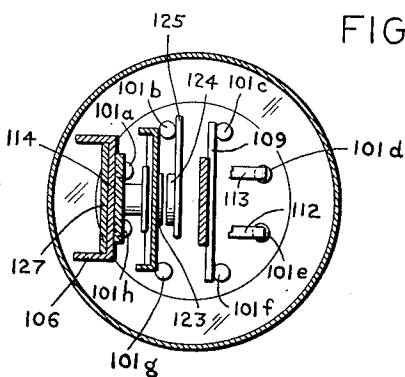
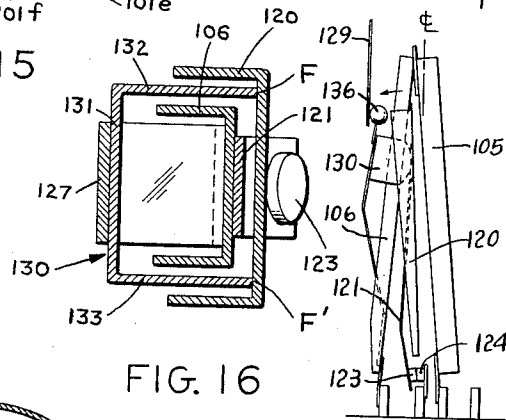
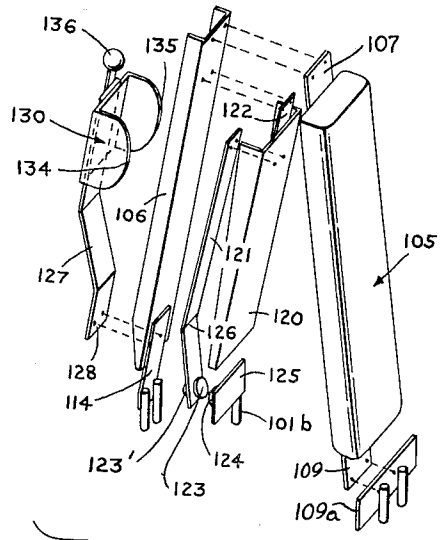
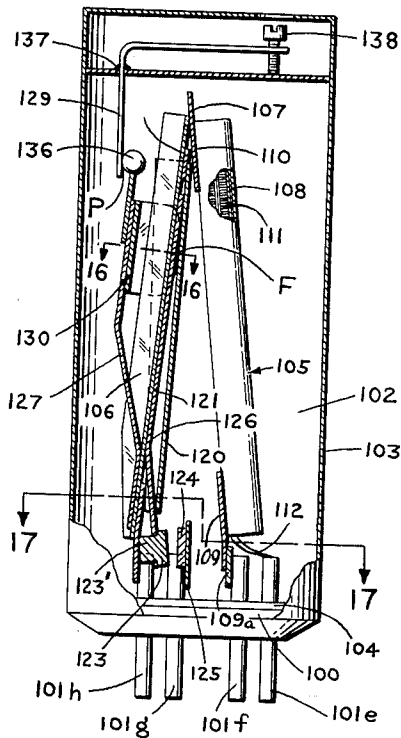
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3 Sheets-Sheet 3



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THERMAL TIME DELAY RELAY WITH PRECISE TIME DELAY ADJUSTMENT MEANS

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Filed June 19, 1963, Ser. No. 292,187

10 Claims. (Cl. 200—122)

This application is a continuation-in-part of my co-pending U.S. application Serial No. 6,275 filed February 2, 1960, now abandoned.

This invention relates generally to a control device for an electrical circuit and more particularly to a thermally actuated time delay mechanism or relay for use in such electrical circuit which has means for setting the time delay easily and to provide uniform time delay operation before, during and after variations in pressure, temperature and humidity in the environment in which the relay is operating.

Patent 2,817,731 and pending application for Letters Patent in the United States, Ser. No. 654,903 filed April 24, 1957 now Patent 3,156,802, disclose thermally actuated time delay devices for use in electrical circuits.

One of the problems with these disclosed structures is that in commercial practice they do not provide a sufficiently high breakdown voltage in the full open position of the contacts for certain important applications.

Stated another way, it is known that the air space between any pair of contacts provides a dielectric which will not conduct current until the voltage difference is raised to a point which will cause the current to jump or arc across the gap between these contacts. The closer the contacts or the smaller the gap the smaller the voltage difference required to jump the gap between these contacts and, conversely, the larger the gap between the contacts the greater the voltage difference required.

Increasing the width of the gap between the respective contacts and more particularly in the full open position, however, affects the accuracy and efficiency of thermally actuated time delay devices because the size of the gap is in part a function of the amplification obtainable between actuating means and the lever means for operating the movable contact relative the fixed contact in these devices, that is, the ratio of movement or the length of the lever means carrying one of the contacts with respect to the movement or length of the heating member and the control arm.

The present invention overcomes this problem by effecting an increase in the width of the gap between the movable contact and the fixed contact by increasing amplification between these elements.

Thus, the present invention covers a time delay device to be connected into a circuit including a thermally responsive actuating member to expand and contract in response to variations in the current in said circuit, a relatively stiff control member disposed to form a triangularly-shaped structure with said actuating member which structure is designed and operatively associated with a first class lever means including, a movable member having one end flexibly connected adjacent the apex of said triangular structure and the free end remote therefrom having a contact to be moved into and out of engagement with a stationary contact, and an adjustable pivot or fulcrum means intermediate the connected end and the contact-carrying end of the movable member about which said movable member will pivot as said actuating member expands.

The present invention overcomes this problem by providing an adjusting means or an adjustable pivot or fulcrum means intermediate the connected end and the contact carrying end of the movable member about which said movable member can pivot as the actuating member

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expands wherein operation is obtained by pivoting or flexing movement between spaced portions of the pivot or fulcrum means eliminating entirely the problem of friction and engagement between the adjustment means.

Thus the present invention further covers a time delay device having a precise time delay adjustment means for an electrical circuit which includes, a thermally responsive actuating member to expand and contract in response to variations in the current in said circuit, a relatively stiff control member disposed to form a triangularly-shaped structure with said actuating member which structure is designed and operatively associated with a first class lever means including, a movable member having one end flexibly connected adjacent the apex of said triangular structure and the free end remote therefrom having a contact to be moved into and out of engagement with the stationary contact, and an adjustable pivot or fulcrum means including a resilient element and means connected between said resilient element and intermediate the connected end and the contact-carrying end of the movable member about which said movable member will pivot as said actuating member expands which connecting means includes pivotal and/or flexible portions in spaced relation which pivot or flex on movement of the movable member; and means in contact with said adjustable pivot or fulcrum means to engage and move said resilient means and movable member to move the movable contact into adjusted position.

The present invention is further characterized by a lost motion arrangement connecting said contact to said movable member which permits the movable member to over-travel and thus relieves unnecessary stress during operation of the device.

Accordingly, it is an object of the present invention to provide a hermetically sealed thermal time delay relay having a greater breakdown voltage than heretofore obtainable.

Accordingly, it is an object of the present invention to provide a thermal time delay mechanism or relay having means to permit simple adjustment of the time delay in said device and further to provide precise and uniform repetition of the present time delay under all conditions of operation.

Further objects and advantages of the invention will become evident from the following description with reference to the accompanying drawings, in which:

FIGURE 1 is a side view showing the invention in open position, with the casing in vertical section.

FIGURE 2 is an end view showing the invention with the casing in a partial vertical section.

FIGURE 3 is a partial vertical section of the control member and the actuating member in open position.

FIGURE 4 is a cross-section taken on line 4—4 of FIGURE 3.

FIGURE 5 is a cross-section taken on line 5—5 of FIGURE 3.

FIGURE 6 is an exploded view showing the relation between the elements which combine and coact with the movable contact.

FIGURE 7 is a diagrammatic sketch showing the invention in closed position.

FIGURE 8 is a side view showing an alternate form of the invention with the casing in vertical section and the contacts in open position.

FIGURE 9 is an end view showing the alternate form of the invention with the casing in a partial vertical section.

FIGURE 10 is a partial vertical section of the control member and the actuating member and the associated operative parts of the alternate form of the invention.

FIGURE 11 is a cross-section taken on line 11—11 of FIGURE 10.

FIGURE 12 is a cross-section taken on line 12—12 of FIGURE 8.

FIGURE 13 is an exploded view showing the details of the actuating assembly and the movable arm for the form of the invention shown in FIGURES 8 to 10;

FIGURE 14 is a diagrammatic sketch showing the alternate form of the invention with the contacts in closed position.

FIGURE 15 is a partial vertical section of a further form of the present invention showing the contacts in open position.

FIGURE 16 is a cross-section taken on line 16—16 of FIGURE 15.

FIGURE 17 is a cross-section taken on line 17—17 of FIGURE 15.

FIGURE 18 is an exploded view showing the details of the actuating assembly and the movable arm for the form of the invention shown in FIGURE 15.

FIGURE 19 is a diagrammatic sketch of the form of the invention shown in FIGURE 15 showing the contacts in closed position.

Referring to the drawings, FIGURE 1 shows a thermally actuated time delay control device having a header or support base 10 of a non-conducting or insulating type of material which base has a plurality of circumferentially spaced contact prongs, 11a, 11b, 11c, 11d, 11e, 11f, 11g and 11h, extending therethrough so that a portion of the contact prongs will extend to the exterior of the time delay control device and a portion will extend into the chamber 12 formed when the casing 13 is connected to the flange 14 formed on the header or support base 10 as by welding or any other suitable means well known in the art. The container or casing 13 is soldered or sealed to the base 10 by any suitable means and thereafter the air in chamber 12 is withdrawn and the chamber 12 sealed in the manner well known in the art, hence not more fully discussed herein.

In the chamber a primary or actuating member generally designated 15 and a secondary or control member 16 are connected to the respective prongs 11f and 11c, and 11h and 11a at one of their respective ends and to each other as at 17 at the ends remote from the base-connected ends to form a triangular-shaped assembly.

Actuating member

The actuating member 15 includes a shell or expander element 18 which is struck from a piece of sheet metal. Connecting brackets 19 and 20 are provided for connecting the actuating member to the contact prongs 11c and 11f and to the associated end of the control member remote therefrom. FIGURES 3 and 4 show that the expander element 18 houses or encloses in compact and closely sandwiched form a heater comprising the conventional mica elements 21, a coil of electric conducting wire 22 wound thereabout insulating elements 23 on opposite sides of the electric conducting wire 22, and transverse filler members 24, as is clearly shown in FIGURES 3 and 4.

FIGURES 1, 2 and 5 show that the contact elements 11d and 11e are connected by means of current-carrying wires 25 and 26 to the heater coil 22 and in assembled position in the current-carrying circuit the prongs 11d and 11e will receive signals from the circuit for varying the current in the coil and thus produce a corresponding elongation or contraction of the expander element 18 during operation of the time delay control device.

The expander or shell 18, the transverse filler members 24 and the control member or arm 16 will be made of stainless steel or the like type alloy having a high coefficient of expansion. The relative mass to surface area of the expander element or shell 18 being regulated by the added thickness of the elements 24 and the insulation 23 therebetween to provide the desired degree of expansion and contraction with variation in the heat developed by the current delivered to the coil of wire 22 in the heater.

Control member

The control member or arm 16 is a relatively stiff channel type element of a predetermined length which varies for the purposes of the present invention only with changes in temperature in the member itself and in operational effect.

Attached to one end of the control member or arm 16 is a bracket 28 which provides means for connecting this end of the control member 16 to the ends of contact prongs 11a and 11h disposed in the chamber 12, the end remote from the bracket end being connected at 17 as above described. In assembled position as shown in FIGURES 1 and 3, the control arm 16 and actuating member 15 form a triangularly shaped structure, which may be other than the isosceles shape illustrated without departing from the scope of the present invention, it being understood that an isosceles-shaped arrangement was chosen because it provides optimum operating conditions.

This triangularly-shaped structure formed from the actuating member 15 and control member 16 operates a first class lever arrangement having a contact at one end which is moved into and out of engagement with a stationary contact as the actuating member 15 is expanded and contracted in response to signals delivered thereto from the circuit in which the relay is connected. This is shown with reference to the deviation from the equilibrium position marked as the centerline in FIGURE 7 of the drawings.

The first class lever arrangement includes an elongated movable member or arm 30 and an elongated flexible member 31. The movable member or arm 30 is a relatively stiff channel type member similar to the control arm 16 and is flexibly connected as by the flexible strip 30a at one end, to the side of the control member 16 facing the actuating member. Further, the movable 30 is so sized that the control member 16 nests within the movable member 30 to a limited degree, in which position the members 30 and 16 are so spaced as to permit the flexible strip member 31 to be connected to the movable member 30 inwardly of its connection to the control arm 16 so that it depends downwardly between the movable member 30 and the control member 16 as is clearly shown in FIGURES 1, 3 and 6 of the drawings.

The movable member 30 also depends freely from its connected end and as shown in FIGURES 1, 3 and 6 the flexible strip member 31 extends below the end of the movable arm which extended end holds contact 32 and will act as hereafter described to move this contact into and out of engagement with a stationary contact 33 connected to one end of a current-carrying strip 34 which in turn is connected at its remote end to the inner aspect of contact prong 11b, as shown in FIGURES 1, 3 and 5 of the drawings.

The flexible strip member 31 is bent as at 35 and will be made of a material which has a slight resiliency so that this element can coact with the movable arm 30 and will when released by the action of the movable arm move the contact 32 into firm abutting and contacting relation with the contact 33.

The movable member or arm 30 however is normally urged to force the flexible strip member 31 so that the contact 32 is not in engagement with the contact 33. This is accomplished by a U-shaped bracket 36 and a spring member 37. The U-shaped bracket extends about the portion of the control member 16 remote from the face to which the movable member is connected and is attached to the sides of the movable member 30. The spring 37 is mounted between the rear or outer face of the channel member and the U-shaped bracket in the arch formed by the U-shaped bracket about the control arm. In this position the spring 37 exerts force which moves the movable member 30 away from the actuating member until the spring action is balanced by the counter force of the resilient strip member 31, and the fulcrum or pivot means hereinafter described.

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The movable contact 32 is further characterized by a lateral projection 32a which acts as a stop means as it abuts the bracket 28 associated with the control arm 16.

The elements above described do not acquire their lever operation until the fulcrum means is added. This is accomplished by means of a ball 38 which is adjustably held in contact with the outer face of the U-shaped bracket 36 as at the point P about which the bracket 36 and the movable member will rotate when the control member 15 is actuated on heating of the actuating member.

The ball 38 is fixedly held at one end of an L-shaped element 39 pivotably connected through the casing 13 by any suitable means such as a fluid-tight weld 40. If the casing is of sufficiently flexible material and the adjusting movement required small, the L-shaped element 39 can be moved by adjusting the threaded member 41 connected to the leg disposed exteriorly of the inner chamber 12 into which the outer leg extends, as is clearly shown in FIGURES 1 and 2 of the drawings. When the threaded element 41 moves the arm to which it is connected down then the ball exerts less pressure against the fulcrum point P on the U-shaped bracket 36. As a result the spring 37 can move movable arm through the bracket 36 and the flexible strip element 31 so that the contacts 32 and 33 are spaced a greater distance from each other. Conversely, when the threaded element moves the arm of the L-shaped member 39 up the contacts 32 and 33 will be moved closer to each other.

It is believed easily understood by those skilled in the art that adjusting the gap between the contacts 32 and 33 will provide means for regulating the desired time delay for the particular circuit in which the relay is connected.

Further referring to FIGURES 1, 3 and 6, it will be noted that the elements 30 and 31 are independent of each other and the movable arm 30 is so disposed that when it is actuated as hereinafter described to release the force exerted on the flexible strip member 31 it can over-travel or continue in motion beyond the position where contact has been established between contacts 32 and 33. This lost motion means is established to prevent excessive pressure from being exerted by the actuating member 15 and control member 16 during operation of the device which might distort or damage the parts and thus render the device either inaccurate or inoperative for the desired purpose.

Operation

The device is connected into the circuit and if insufficient current or no current passes through the wire coil 22 the position of the elements for normally open operation will be as shown in FIGURES 1 and 3 of the drawings.

In this position the actuating member 15 and the control member 16 are in equilibrium, neither element being under tension. The ball element 38 will of course have been adjusted to provide a gap between the contacts 32 and 33 for the desired time delay.

As signals are fed into the actuating member 15 the coil is caused to heat the member 15 to cause it to elongate. However, because the control member 16 is a substantially rigid channel type member and cannot elongate, in order to effect elongation of the actuating member the units in their joined relation are misaligned in a sidewise direction, that is, the apex of the triangle where the units are joined as at 17 is caused to move laterally as shown in FIGURE 7 of the drawings with reference to the centerline CL.

Since the movable member 30 is flexibly connected to and movable with the central arm 16, the connected end will pivot about the point P and also be displaced laterally. However, because the ball member 38 abuts against the fulcrum point formed at P on the U-shaped bracket 36, the movable member 30 is caused to simultaneously

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pivot about the point P in the direction indicated by the arrow.

As the movable member 30 pivots the end remote from the connected end is caused to gravitate towards and to swing over the stationary contact 33 releasing as it swings the flexible strip member 31 to permit it to also move laterally and to thus bring the contact 32 at the end thereof into engagement with the contact 33.

The contacts 32 and 33 will remain in engagement until the current to the actuating member 15 is cut off causing the actuating member 15 to contract. This swings the apex of the triangle back to the original position as shown in FIGURES 1 and 3, causing the movable member 30 to pivot in the opposite direction.

As the movable member 30 pivots the end remote from the connected end forces the flexible strip member 31 to move laterally away from the stationary contact 33 and to cause the contact 32 to break engagement therewith.

This construction provides a relatively wide gap between the movable contact 32 and stationary contact 33 because with the elements joined in the manner indicated it permits relatively high amplification, i.e., the ratio of movement of the movable member with respect to the length of the control member, the desired dielectric between the contacts is obtained and the break-down voltage in the full open position of the contacts will be sufficiently high to meet the commercial requirements for those applications in which it will be required.

Alternate form of the invention

Referring to the drawings, FIGURES 8, 9 and 12 show a thermally actuated time delay control device having a header or support base 50 of a non-conducting or insulating type of material, which base has a plurality of circumferentially spaced contact prongs 51a, 51b, 51c, 51d, 51e, 51f, 51g and 51h, extending therethrough so that a portion of the contact prongs will extend to the exterior of the time delay control device and a portion will extend into the chamber 52 formed when the casing 53 is connected to the flange 54 formed on the header or support base 50 as by welding or any other suitable means well known in the art. The container or casing 53 is soldered or sealed to the base 50 by any suitable means and thereafter the air in chamber 52 is withdrawn and the chamber 52 sealed in the manner well known in the art, hence not more fully discussed herein.

In the chamber a primary or actuating member generally designated 55 and a secondary or control member 56 are connected to the respective prongs 51f and 51c, and 51h and 51a at one of their respective ends and to each other as at 57 at the ends remote from the base-connected ends to form a triangular-shaped assembly.

Actuating member

The actuating member 55 includes a shell or expander element 58 which is struck from a piece of sheet metal. Connecting brackets 59 and 60 are provided for connecting the actuating member to the contact prongs 51c and 51f and to the associated end of the control member remote therefrom. FIGURES 10 and 11 show that the expander element 58 houses or encloses in compact and closely sandwiched form a heater comprising the conventional mica elements 61, a coil of electric conducting wire 62 wound thereabout insulating elements 63 on opposite sides of the electric conducting wire 62, and transverse filler members 64, as is clearly shown in FIGURES 10 and 11.

FIGURES 8, 9 and 12 show that the contact elements 51d and 51e are connected by means of current-carrying wires 65 and 66 to the heater coil 62 and in assembled position in the current-carrying circuit the prongs 51d and 51e will receive signals from the circuit for varying the current in the coil and thus produce a corresponding elongation or contraction of the expander element 58 during operation of the time delay control device.

The expander or shell 58, the transverse filled mem-

bers 64 and the control member or arm 56 will be made of stainless steel or the like type alloy having a high coefficient of expansion. The relative mass to surface area of the expander element or shell 58 being regulated by the added thickness of the elements 64 and the insulation 63 therebetween to provide the desired degree of expansion and contraction with variation in the heat developed by the current delivered to the coil of wire 62 in the heater.

Control member

The control member or arm 56 is a relatively stiff channel type element of a predetermined length which varies for the purposes of the present invention only with changes in temperature in the member itself and in operational effect.

Attached to one end of the control member or arm 56 is a bracket 68 which provides means for connecting this end of the control member 56 to the ends of contact prongs 51a and 51h disposed in the chamber 52, the end remote from the bracket end being connected at 57 as above described. In assembled position as shown in FIGURES 8 and 10, the control arm 56 and actuating member 55 form a triangularly-shaped structure, which may be other than the isosceles shape illustrated without departing from the scope of the present invention, it being understood that an isosceles-shaped arrangement was chosen because it provides optimum operating conditions.

This triangularly-shaped structure formed from the actuating member 55 and control member 56 operates a first class lever arrangement having a contact at one end which is moved into and out of engagement with a stationary contact as the actuating member 55 is expanded and contracted in response to signals delivered thereto from the circuit in which the relay is connected. This is shown with reference to the deviation from the equilibrium position marked as the centerline in FIGURE 14 of the drawings.

The first class lever arrangement includes an elongated movable member or arm 70 and an elongated flexible member 71. The movable member or arm 70 is a relatively stiff channel type member similar to the control arm 56 and is flexibly connected as by the flexible strip 72 at one end, to the side of the control member 56 facing the actuating member. Further, the movable member 70 is sized so that the control member 56 nests within the movable member 70 to a limited degree, in which position the members 70 and 56 are so spaced as to permit the flexible strip member 71 to be connected to the movable member 70 inwardly of its connection to the control arm 56 so that it depends downwardly between the movable member 70 and the control member 56 as is clearly shown in FIGURES 8, 10 and 13 of the drawings.

The movable member 70 also depends freely from its connected end and as shown in FIGURES 8, 10 and 13, the flexible strip member 71 extends below the end of the movable arm which extended end holds contact 73 and will act as hereafter described to move this contact into and out of engagement with a stationary contact 74 connected to one end of a current-carrying strip 75 which in turn is connected at its remote end to the inner aspect of contact prong 51b, as shown in FIGURES 8, 10 and 12 of the drawings.

The flexible strip member 71 is bent as at 76 and will be made of a material which has a slight resiliency so that this element can coact with the movable arm 70 and will when released by the action of the movable arm move the contact 73 into firm abutting and contacting relation with the contact 74.

The movable member or arm 70 however is normally urged by the resiliency of the connecting strip 72 to force the flexible strip member 71 so that the contact 73 is not in engagement with the contact 74. This resiliency or spring action also aids in counterbalancing the force exerted by the fulcrum or pivot means hereinafter described.

The movable contact 73 is further characterized by a lateral projection "73a"; similar to part 32a in FIGURES 1 and 3, which acts as a stop means as it abuts the bracket 68 associated with the control arm 56 as is clearly shown in FIGURE 10 of the drawings.

Precise time delay adjustment means

It is believed easily understood by those skilled in this art that adjusting the gap between the contacts 73 and 74 in the device above described will provide means for regulating the desired time delay for the particular circuit in which the relay is connected.

Furthermore, the movable member and its associated parts do not acquire their lever type operation until the fulcrum means is added intermediate the connected end and the free end.

In the present invention the fulcrum means and the adjustment means are in operative relation to accomplish the precise adjustment of the time delay desired and further to provide uniformity of operation under all conditions or variations in temperature or pressure.

Thus, FIGURES 8, 9, 10 and 13 show a resilient element 77 disposed in chamber 52 on the side of the control arm 56 opposite from that of the movable member 70. The resilient element 77 is connected at one end to any suitable point such as the support base 50 or as shown in the preferred form of this invention by welding as at 78 in the lower portion of the channel of the control member 56.

The resilient element 77 is a strip-like member slightly narrower than the width of the channel and the end remote from the connected end is free so that the element 77 can be forced by the adjusting element generally designated 79 towards or away from the channel portion of the control member 56.

The resilient element 77 is operatively connected to the movable member 70 by means of the connecting rod 80 which as shown in FIGURE 13 may be a single Z-shaped element wherein the legs 81 and 82 are relatively easily flexed relative the body of the connecting rod 80 during adjustment of the time delay or operation of the relay.

As shown in FIGURES 10 and 13 the connecting rod 80 extends through the control member 56 to permit the resilient element 77 and movable element 70 to be connected together.

It will be understood that the present device shows a relatively simple form of the connecting rod 80. This connecting rod 80 could have pivot means at 81 and 82 or a combination of a pivot means at 81 and flexing means at 82 or vice versa, without departing from the scope of or varying the operation of the present invention.

The fulcrum means represented by the resilient element 77 and connecting rod 80 are by reason of the connecting and coacting relationship with the movable member 70 used to adjust the position of the movable contact 73 relative the stationary contact 74.

The adjusting means 79 coacts with the fulcrum means for this purpose and includes a non-conducting ball member 83 which is held in contact with the outer face of the resilient element 77 as at the point P, the force being exerted at P being transmitted through the resilient element 77 and the connecting rod 80 to the point F which serves as the fulcrum or pivot point about which the movable member 70 will rotate when the control member 55 expands under action of the heating element 62 therein.

The non-conducting ball element 83 is disposed at one end of an L-shaped element 84 pivotally connected through the casing 53 by any suitable means such as a fluid tight well 85.

Since the casing is of sufficiently flexible material and the adjustment to be made relatively small, the L-shaped element 84 can be moved by a threaded member 86 connected to the leg of the L disposed externally of the inner

chamber 52 into which the outer leg extends as is clearly shown in FIGURES 1 and 2 of the drawings.

When the threaded element 86 moves the leg to which it is connected down then the ball exerts less pressure against the point P in the resilient element 77. Whatever force is exerted however is transmitted through the resilient arm 77 and connecting rod 80 against the fulcrum point F on the movable member 70 and the member will be moved initially to bring the contacts 73 and 74 into an initial time delay setting.

Conversely, when the threaded element 86 moves the exterior leg up the elements in operative relation increase the force acting at the point F and the contacts move away from each other to provide a different setting.

It is believed clear however that so long as the members are held in any adjusted position there will always be a fixed force acting substantially transverse to the longitudinal line of the movable member 70 to provide the desired fulcrum for the operation as hereinafter described, and this force will maintain the gap between the contacts 73 and 74 for the desired time delay setting.

Further referring to FIGURES 8, 10 and 13, it will be noted that the elements 70 and 71 are independent of each other and the movable arm 70 is so disposed that when it is actuated as hereinafter described to release the force exerted on the flexible strip member 71 it can overtravel or continue in motion beyond the position where contact has been established between contacts 72 and 73. This lost motion means is established to prevent excessive pressure from being exerted by the actuating member 55 and control member 56 during operation of the device which might distort or damage the parts and thus render the device either inaccurate or inoperative for the desired purpose.

Operation

Assuming the ball element 83 has been adjusted to provide a gap between the contacts 73 and 74 for the desired time delay, the device is connected into the circuit and if insufficient current or no current passes through the wire coil 62 the position of the elements for normally open operation will be as shown in FIGURES 8 and 10 of the drawings.

In this position the actuating member 55 and the control member 56 are in equilibrium, neither element being under tension.

As signals are fed into the actuating member 55 the coil is caused to heat the member 55 and it will elongate. Since the control member 56 is a substantially rigid channel type member and cannot elongate, in order to effect elongation of the actuating member the units in their joined relation are misaligned in a sidewise direction, that is, the apex of the triangle where the units are joined as at 57, is caused to move laterally as shown in FIGURE 14 of the drawings with reference to the centerline CL.

Since the movable member 70 is flexibly connected to and movable with the control arm 56, the connected end will pivot about the points F and will also be displaced laterally.

As the movable member 70 pivots the end remote from the connected end is caused to gravitate towards and to swing over the stationary contact 74 releasing as it swings the flexible strip member 71 to permit it to also move laterally and to thus bring the contact 73 at the end thereof into engagement with the contact 74.

The contacts 73 and 74 will remain in engagement until the current to the actuating member 55 is cut off causing the actuating member 55 to contract. This swings the apex of the triangle actuating means back to the original position as shown in FIGURES 8 and 10, causing the movable member 70 to pivot in the opposite direction.

As the movable member 70 pivots the end remote from the connected end forces the flexible strip member 71 to move laterally away from the stationary contact 74 and to cause the contact 73 to break engagement therewith.

Thus this construction also provides a relatively wide gap between the movable contact 73 and stationary contact 74 because with the elements joined in the manner indicated it permits relatively high amplification, i.e., the ratio of movement of the movable member with respect to the length of the control member, the desired dielectric between the contacts is obtained and the breakdown voltage in the full open position of the contacts will be sufficiently high to meet the commercial requirements for those applications in which it will be required.

Second alternate form of the invention

FIGURES 15, 16, 17 and 18 show an alternate form of the invention and this thermally actuated time delay control device has substantially similar structure to the forms of the invention above described.

Thus FIGURE 15 shows a header or support base 100 of a non-conducting or insulating type of material having a plurality of circumferentially spaced contact prongs as at 101a, 101b, 101c, 101d, 101e, 101f, 101g and 101h identical to those shown in FIGURES 5 and 12 of the drawings.

The contact prongs extend through the header 100 so that a portion of each of the contact prongs will extend to the exterior of the time delay control device and a portion will extend into the chamber 102 formed where the casing 103 is connected to the flange 104 formed on the header or support base 100 as by welding or any other suitable means well known in the art.

The container or casing 103 is soldered or sealed to the base 100 by any suitable means and thereafter the air in chamber 102 is withdrawn and the chamber 102 sealed in the manner well known in the art.

In the chamber 102 a primary or actuating member generally designated 105 and a secondary or control member 106 are connected to the respective prongs 101f and 101c and 101h and 101a at one of their respective ends and to each other as at 107 at the ends remote from the base connected ends to form a triangular-shaped assembly.

Actuating member

The actuating member 105 is identical with that above described for the forms of the invention shown in FIGURES 1 and 8 of the drawings. Accordingly, to avoid repetition it will not be described extensively.

Thus FIGURES 15 and 18 show the shell or expander element 108 of the actuating member 105 as connected by bracket 109a to the contact prongs 101c and 101f and by bracket 110 to the associated end of the control member remote from the contact prongs.

The actuating member includes a heater means having a coil of electric conducting wire 111 which is connected by current-carrying wires 112 and 113 to the contact prongs 101d and 101e. In assembled position in a current-carrying circuit prongs 101d and 101e will receive signals from the circuit for varying the current in the coil and thus produce a corresponding elongation or contraction of the shell or expander element 108 during operation of the time delay control device.

The relative mass to surface area of the expander element 108 is regulated in the same manner as the corresponding elements 18 and 58 in the FIGURE 1 and FIGURE 8 forms of the present invention, to provide the desired degree of expansion and contraction with variations in the heat developed by the signal current delivered to the coil 111.

Control member

The coacting control member or arm 106 is identical with the FIGURES 1 and 8 form of the invention and thus is a relatively stiff channel type element of a predetermined length which varies for the purposes of the present invention only with changes in temperature in the member itself and in operational effect.

The end of the control member 106 remote from the end connected to bracket 107 on the actuating member

has a bracket 114 which provides means for connecting this end to the contact prongs 101a and 101b disposed in the chamber 102.

In assembled position as shown in FIGURE 15 the actuating member 105 and the control member 106 form a triangularly-shaped structure which may be other than the isosceles shape illustrated without departing from the scope of the present invention, this shape however has been chosen because it provides optimum operating conditions.

As in the form of the invention shown in FIGURES 1 and 8, this triangularly-shaped structure formed from the actuating member 105 and the control member 106 operates a first class lever arrangement having a contact at one end which is moved into and out of engagement with a stationary contact as the actuating member 105 is caused to expand and contract in response to signals delivered thereto from the circuit in which the relay is connected. This is shown with reference to the deviation from the equilibrium position marked as the centerline CL in FIGURE 19 of the drawings.

The first class lever arrangement includes an elongated movable member or arm 120 and an elongated flexible member 121. The movable member or arm 120 is a relatively stiff channel type member similar to the control arm 106. It is flexibly connected as by the flexible strip 122 at the end adjacent the apex of the triangularly-shaped structure, to the side of the control member 106 facing the actuating member. Further the movable member 120 is sized so that the control member 106 is nested within the movable member 120 to a limited degree, in which position the members 120 and 106 are so spaced as to permit the flexible strip member 121 to also be connected to the movable member 120 inwardly of its connection to the control arm 106 whereby it depends downwardly between the movable member 120 and the control member 106 as is clearly shown in FIGURES 15, 16 and 19 of the drawings.

The movable member also depends freely from its connected end and as shown in FIGURES 15, 16, 18 and 19, the flexible strip member 121 extends below the end of the movable arm which extended end holds contact 123, and will act as hereinafter described in conjunction with the movable arm 120 and the control arm 106 to move this contact 123 into and out of engagement with a stationary contact 124 connected to one end of a current-carrying strip 125 in turn connected at its remote end to the inner aspect of contact prong 101b.

The flexible strip 121 is bent as at 126 and will be made of a material which has a slight resiliency so that this element can coact with the movable arm 120 and will when released by the action of the movable arm move the movable contact 123 into firm abutting and contacting relation with the contact 124.

The movable member or arm 120 is normally urged by the resiliency of the connecting strip 122 to force the flexible strip member 121 so that the contact is not in engagement with stationary contact 124. This resiliency or spring action also aids in counterbalancing the forces exerted by the fulcrum or pivot means hereinafter described.

The movable contact 123 is also characterized by a lateral projection 123 which acts as a stop means when it abuts the bracket 114, as is shown in FIGURE 15.

Precise time delay adjustment means—Second alternate form of the invention

It is believed easily understood by those skilled in this art that adjusting the gap between the contacts 123 and 124 in the second alternate form of the invention above described will provide means for regulating the desired time delay for the particular circuit in which the relay is connected.

In this form of the invention the movable member 120 is biased in one direction by the flexible strip 122 and

acquires its lever characteristics when a fulcrum means is caused to coact with the movable member intermediate the connected end and the free end thereof.

Furthermore, as in the other forms of the present invention the fulcrum means and the adjustment means are in operative relation to accomplish the precise adjustment of the time delay desired and further to provide uniformity of operation under all conditions and under variations in temperature or pressure.

Thus, FIGURES 15, 16, 17 and 18 show a resilient element 127 disposed in chamber 102 on the side of the control arm 106 opposite from that of the movable member 120. The resilient element 127 is connected at one end to any suitable point such as the support base 100 or as shown in the preferred form of this invention by welding as at 128 in the lower portion of the channel of the control member 106.

The resilient element 127 is a strip-like member slightly narrower than the width of the channel and the end remote from the connected end is free so that the element 127 can be forced by the adjusting member generally designated 129 towards or away from the channel portion of the control member 106.

The resilient element 127 is operatively associated with the movable member through a fulcrum block 130 as shown in FIGURES 15, 16 and 17.

The fulcrum block 130 is a U-shaped element having a center portion 131 and leg portions 132 and 133. The center portion 131 is connected adjacent the free end of the resilient element 127 so that the leg portions 132 and 133 extend about the control arm 106 and the respective ends 134 and 135 are in contact with the face of the movable member 120 remote from the actuating member 105, as shown in FIGURES 18 and 19.

The ends 134 and 135 of the respective legs of the fulcrum block 130 are rounded or arcuate so as to establish rather free rolling or pivoting contact for the normally biased movable member 120, so that adjusting the operation of this form of the device is rendered easier and the construction simultaneously provides the desired uniformity of performance for each time delay operation.

The fulcrum means represented by the resilient element 127 and the fulcrum block 130 are by reason of their co-acting relationship with the movable member 120 used to adjust the position of the movable contact 123 relative to the stationary contact 124.

The adjusting means 129 coacts with this fulcrum means for this purpose and includes a non-conducting ball member 136 which is held in contact with the outer face of the resilient element 127 as at the point P, the force being exerted at P being transmitted through the resilient element 127 and the fulcrum block 130 to the points F and F' which serve as the fulcrum or pivot point about which the movable member 120 will rotate when the actuating member 106 expands under action of the heating element therein.

The non-conducting ball member 136 is disposed for engagement by one end of L-shaped adjusting element 129 pivotally connected through the casing 103 by any suitable means such as a fluid tight weld 137.

Since the casing is of sufficiently flexible material and the adjustment to be made relatively small, the L-shaped adjusting element 129 can be moved by a threaded member 138 connected to the leg of the L disposed externally of the inner chamber 102 into which the outer leg extends as is shown by FIGURE 15 of the drawings.

When the threaded member 138 moves the leg to which it is connected down then the ball member 136 exerts less pressure against the point P on the resilient element 127. Whatever force is exerted however is transmitted through the resilient arm 127 and fulcrum block 130 against the fulcrum points F and F' for the movable member 120 and this will move member 120 to bring the contacts 123 and 124 into the initial time delay setting.

Conversely, when the threaded member 138 moves the exterior leg up the elements in operative relation increase the force acting at the points F and F' and the contacts move away from each other to provide a different setting.

It is believed clear however that so long as the contacts are held in any adjusted position there will always be a fixed force acting substantially transverse to the longitudinal line of the movable member 120 to provide the desired fulcrum for the operation and this force will maintain the gap between the contacts 123 and 124 for the desired time delay setting.

Further referring to FIGURES 15 and 16, it will be noted that the elements 120 and 121 are independent of each other and the movable arm 120 is so disposed that when it is actuated as hereinafter described to release the forces exerted on the flexible strip member 121 it can overtravel or continue in motion beyond the position where contact has been established between contacts 123 and 124. This lost motion means prevents excessive pressure from being exerted by the actuating member 105 and control member 106 during operation of the device which might distort or damage the parts and thus render the device either inaccurate or inoperative for the desired purpose.

Operation—Second alternate form of the invention

Assuming the ball member 136 has been adjusted to provide a gap between the contacts 123 and 124 for the desired time delay, the device is connected into the circuit and if insufficient current or no current passes through the wire coil 111 the position of the elements for normally open operation will be as shown in FIGURES 15 and 17 of the drawings.

In this position the actuating member 105 and the control member 106 are in equilibrium, neither element being under tension.

As signals are fed into the actuating member 105 the coil is caused to heat the member 105 and it will elongate. Since the control member 106 is a substantially rigid channel type member and cannot elongate, in order to effect elongation of the actuating member the units in their joined relation are misaligned in a sidewise direction, that is, the apex of the triangle where the units are joined as at 107, is caused to move laterally as shown in FIGURE 19 of the drawings with reference to the centerline CL.

Since the movable member 120 is flexibly connected to and movable with respect to the control arm 106, the connected end will pivot about the points F and F' and will be displaced laterally.

As the movable member 120 pivots the free end remote from the connected end is caused to gravitate towards and to swing over the stationary contact 124 releasing as it swings the flexible strip member 121 to permit it to also move laterally and to thus bring the contact 123 at the end thereof into engagement with the contact 124.

The contacts 123 and 124 will remain in engagement until the current to the actuating member 105 is cut off causing the actuating member 105 to cool and then contract. This swings the apex of the triangle back to the original position as shown in FIGURE 15 and causes the movable member 120 to pivot in the opposite direction.

As the movable member 120 pivots the end remote from the connected end forces the flexible strip member 121 to move laterally away from the stationary contact 124 and the contact 123 will break engagement therewith.

Thus this construction also provides a relatively wide gap between the movable contact 123 and stationary contact 124 because with the elements joined in the manner indicated it permits relatively high amplification, i.e., the ratio of movement of the movable member with respect to the length of the control member, the desired dielectric between the contacts is obtained and the breakdown voltage in the full open position of the contacts will be sufficiently high to meet the commercial requirements for those applications in which it will be required.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a time delay control device to be connected in a current-carrying circuit,

- (a) a support base,
- (b) a stiff thermally responsive actuating member connected at one end to said support base and disposed in the control device to permit the end remote from the connected end to expand and contract in accordance with signals from said circuit,
- (c) a control member of at least equal stiffness connected to said support base at a spaced distance from said actuating member and directly to the end of said actuating member remote from the connected end to form a triangularly-shaped structure,
- (d) a movable member flexibly connected at one end to the control member,
- (e) a contact connected to the movable member remote from the connected end,
- (f) a fixed contact connected to said support base and disposed for engagement by the contact on the movable member,
- (g) a resilient element in said control device,
- (h) a rod-like means disposed to be flexibly connected between said resilient element and to a point on the movable member intermediate the connected end and the contact carrying end,
- (i) said resilient element disposed in assembled position to bias said movable member towards said control member,
- (j) and fulcrum means connected in said control device operatively coacting with the resilient element and said rod-like means for counter-biasing said movable member to bring the contact thereon into predetermined spaced relation with said fixed contact and to provide substantially point contact whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will move laterally and the movable member will rotate about said fulcrum means to bring the contact at the remote end of the movable member into and out of engagement with said fixed contact for the desired time delay period.

2. In a time delay control device to be connected in a current carrying circuit,

- (a) a support base,
- (b) a stiff thermally responsive actuating member connected at one end to said support base and disposed in the control device to permit the end remote from the connected end to expand and contract in accordance with signals from said circuit.
- (c) a control member of at least equal stiffness connected to said support base at a spaced distance from said actuating member and directly to the end of said actuating member remote from the connected end to form a triangularly-shaped structure,
- (d) a movable member flexibly connected at one end to the control member,
- (e) a contact connected to the movable member remote from the connected end,
- (f) a fixed contact connected to said support base and disposed for engagement by the contact on the movable member,
- (g) fulcrum means connected in said control device and disposed to provide pivot point contact with said movable member intermediate the connected end and the contact carrying end whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will move laterally and the movable member will rotate about said fulcrum means to bring the contact at the remote end of the movable member into and out of engage-

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- ment with said fixed contact for the desired time delay period,
- (h) a bracket connected to said resilient element,
 - (i) said bracket having the end remote from the end connected to the resilient element rounded and disposed for substantially point contact with the movable member intermediate the connected end and the contact carrying end whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will be displaced laterally and said movable member will rotate thereabout to bring the contact at the end of the movable member into and out of engagement with the fixed contact,
 - (j) means normally biasing said movable member towards said control member,
 - (k) and adjustable means connected in said control device operatively coacting with said resilient element and said bracket means to set the contact at the end of the movable member in predetermined relation to the fixed contact to provide a desired time delay period on operation of the device.
3. In a time delay control device to be connected in a current carrying circuit,
- (a) a support base,
 - (b) a stiff thermally responsive actuating member having one end connected to the support base and communicating with said circuit to allow the free end of said member to expand and contract longitudinally relative the support base in response to thermal changes carried by variations in the current in said circuit,
 - (c) a control member of at least equal stiffness connected to the support base a spaced distance from the actuating member and directly to the free end of the actuating member to form a triangularly-shaped structure,
 - (d) a fixed contact on said support base,
 - (e) a movable member and a strip member connected at the same one of their respective ends to the control member at a point adjacent the apex of said triangular structure and disposed to depend between the actuating member and the control member,
 - (f) a contact on the free end of the strip member to be moved into engagement with the fixed contact on movement of the movable member,
 - (g) said strip member having a length greater than the movable member and movable therewith until the contact on the end thereof is in engagement with the fixed contact,
 - (h) a resilient element connected at one end on the side of said control member remote from the movable member and having the end remote from the connected end disposed to permit the resilient element to be moved towards and away from the control member,
 - (i) means operatively connecting said resilient element to said movable member to provide a fulcrum therefor intermediate the connected end and the contact carrying end whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will move laterally and the movable member will rotate about the fulcrum to permit the contact on the strip member into and out of engagement with the fixed contact,
 - (j) and time delay adjustment means for positioning the contact on the free end of the strip means in predetermined spaced relation to the fixed contact to provide the desired time delay during operation of the control device.
4. In a time delay control device to be connected in a current carrying circuit,
- (a) a support base,
 - (b) a stiff thermally responsive actuating member connected at one end to said support base and disposed

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- in the control device to permit the end remote from the connected end to expand and contract in accordance with signals from said circuit,
- (c) a control member of at least equal stiffness connected to said support base at a spaced distance from said actuating member and directly to the end of said actuating member remote from the connected end to form a triangularly-shaped structure,
 - (d) a movable member flexibly connected at one end to the control member,
 - (e) a contact connected to the movable member remote from the connected end,
 - (f) a fixed contact connected to said support base and disposed for engagement by the contact on the movable member,
 - (g) a fulcrum holder connected to the support base,
 - (h) fulcrum means operatively connected to the fulcrum holder in a position to engage the movable member intermediate the connected end and the contact carrying end whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will move laterally and the movable member will rotate about said fulcrum means to bring the contact at the remote end of the movable member into and out of engagement with said fixed contact,
 - (i) means normally biasing the movable member towards the control member,
 - (j) and said fulcrum means operatively connected to said biasing means to adjustably counter-bias said movable member to bring the contact thereon into predetermined spaced relation with the fixed contact for obtaining the desired time delay period during operation of the control device.
5. In a time delay control device as claimed in claim 4 wherein said fulcrum means includes, a resilient element, a rod-like means disposed to be flexibly connected between said movable member and said resilient element, and adjustable means operatively connected to said fulcrum means to move the contact on said movable member to the predetermined spaced relation to the fixed contact for the desired time delay period.
6. In a time delay control device as claimed in claim 4 wherein said fulcrum means includes, a resilient element, a bracket connected to said resilient element, said bracket having the end remote from the end connected to the resilient element rounded and disposed for substantially point contact with said movable means, and adjustable means operatively connected to said fulcrum means to move the contact on said movable member to the predetermined spaced relation to the fixed contact for the desired time delay period.
7. In a time delay control device as claimed in claim 4 including, a strip member to coact and move with the movable member, said contact for the movable member connected to the end of the strip member, and said strip member independent of the movable member to permit said movable member to overtravel after said contact at the end thereof engages the fixed contact.
8. In a time delay control device to be connected in a current carrying circuit,
- (a) a support base,
 - (b) a stiff thermally responsive actuating member connected at one end to said support base and disposed in the control device to permit the end remote from the connected end to expand and contract in accordance with signals from said circuit,
 - (c) a control member of at least equal stiffness connected to said support base at a spaced distance from said actuating member and directly to the end of said actuating member remote from the connected end to form a triangularly-shaped structure,
 - (d) a movable member flexibly connected at one end to the control member,

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- (e) a contact connected to the movable member remote from the connected end,
- (f) a fixed contact connected to said support base and disposed for engagement by the contact on the movable member,
- (g) fulcrum means connected in said control device and disposed to provide pivot point contact with said movable member intermediate the connected end and the contact carrying end whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will move laterally and the movable member will rotate about said fulcrum means to bring the contact at the remote end of the movable member into and out of engagement with said fixed contact for the desired time delay period.
9. In a time delay control device to be connected in a current carrying circuit,
- (a) a support base,
- (b) a stiff thermally responsive actuating member connected at one end to said support base and disposed in the control device to permit the end remote from the connected end to expand and contract in accordance with signals from said circuit,
- (c) a control member of at least equal stiffness connected to said support base at a spaced distance from said actuating member and directly to the end of said actuating member remote from the connected end to form a triangularly-shaped structure,
- (d) a movable member flexibly connected at one end to the control member,
- (e) a contact connected to the movable member remote from the connected end,
- (f) a fixed contact connected to said support base and disposed for engagement by the contact on the movable member,
- (g) fulcrum means connected in said control device

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- and disposed to provide pivot point contact with said movable member intermediate the connected end and the contact carrying end whereby on expansion and contraction of said actuating member the flexibly connected end of said movable member will move laterally and the movable member will rotate about said fulcrum means to bring the contact at the remote end of the movable member into and out of engagement with said fixed contact,
- (h) means normally biasing the movable member towards the control member,
- (i) and said fulcrum means operatively connected to said biasing means to adjustably counter-bias said movable member to bring the contact thereon into predetermined spaced relation with the fixed contact for obtaining the desired time delay period during operation of the control device.

10. In a time delay control device as claimed in claim 5 wherein said movable member is normally biased for the desired direction of operation, and the time delay adjustment means coacts with the resilient element and the movable member to counter-bias the movable member for movement of the contact on the end of the strip member to the predetermined spaced position relative the fixed contact.

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