April 8, 1958 M. B. SMILO 2,830,155

THERMAL TIME-DELAY RELAY

Filed May 31, 1956 2 Sheets-Sheet 1

FIG. 1

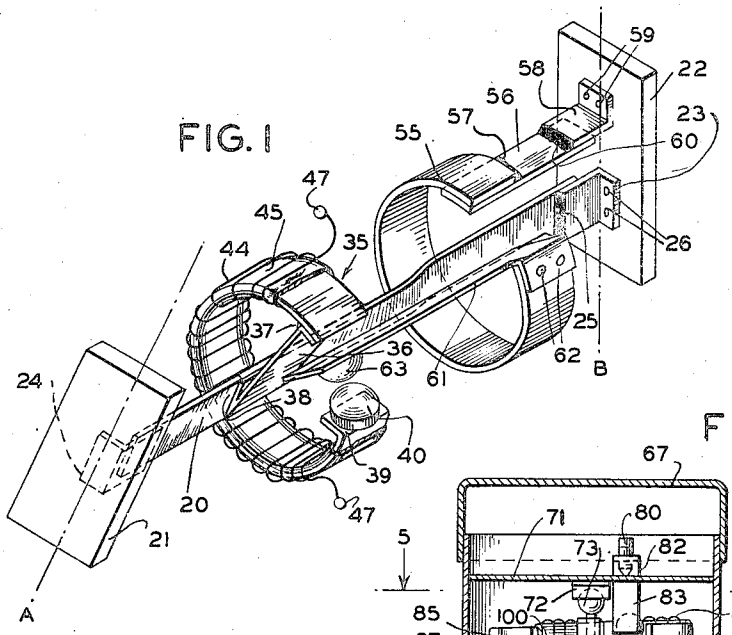


FIG. 3

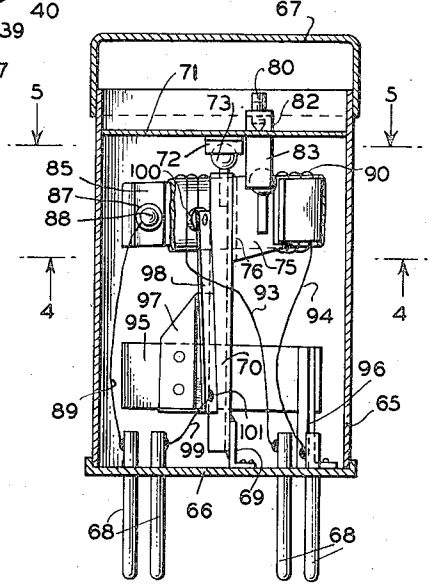
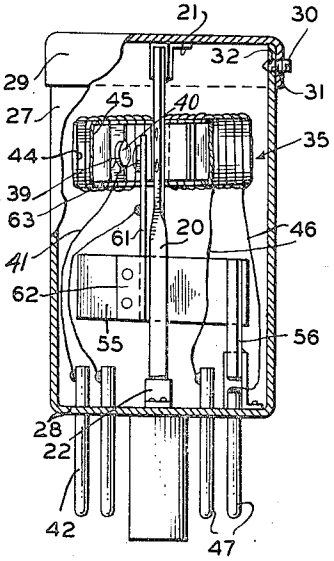


FIG. 2



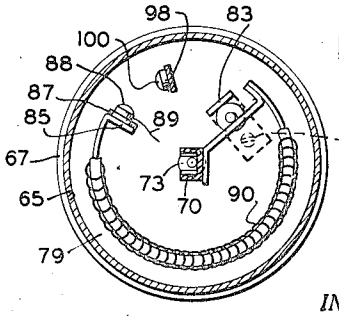


FIG. 4

INVENTOR.
Mitchell B. Smilo
BY
John Graham
his Agent

April 8, 1958 M. B. SMILO 2,830,155

THERMAL TIME-DELAY RELAY

Filed May 31, 1956 2 Sheets-Sheet 2

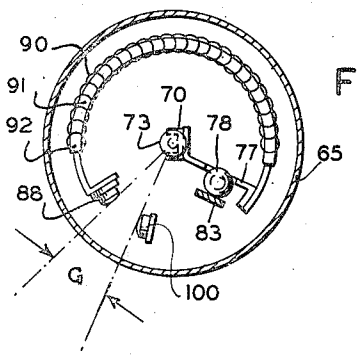


FIG.5

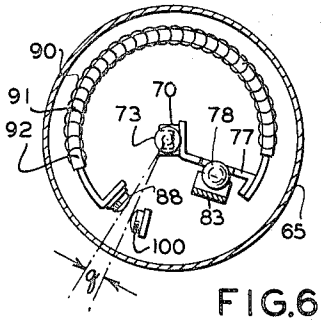


FIG.6

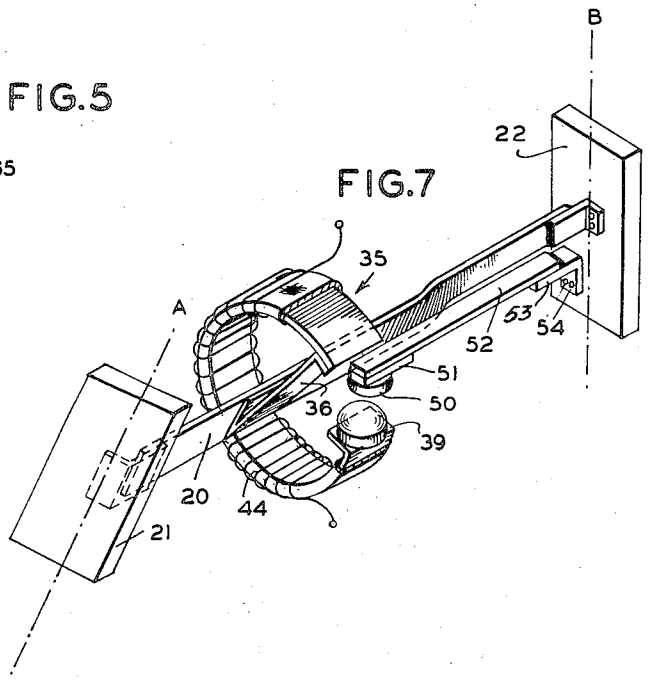


FIG.7

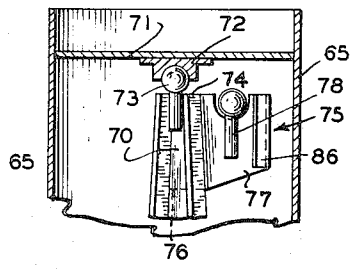


FIG.8

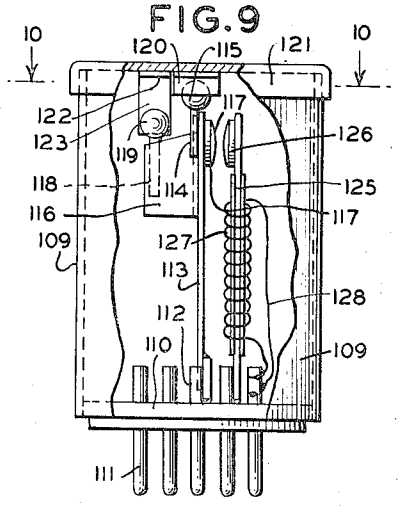


FIG.9

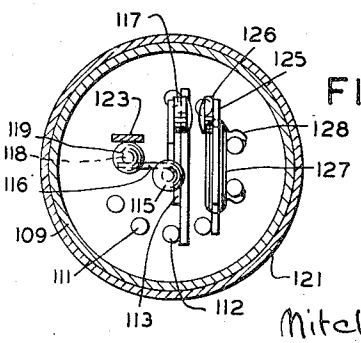


FIG.10

INVENTOR
Mitchell B. Smilo
BY John H. Graham
his Agent.

United States Patent Office 2,830,155 Patented Apr. 8, 1958

2,830,155

THERMAL TIME-DELAY RELAY

Mitchell B. Smilo, Mount Vernon, N. Y.

Application May 31, 1956, Serial No. 588,316

10 Claims. (Cl. 200—122)

The present invention relates to improvements in electro-thermally actuated time delay relays of the type particularly designed of small size and known to the art as miniature or sub-miniature thermal relays. Where smallness of size and compact construction are factors in the designing and production of electrical components of the type herewith contemplated, many problems arise both in the construction of the device and in the operation and use thereof. Time delay thermal relays of this type are used for introducing a factor of time into an electric circuit. The efficient miniature thermal relay must be economical to produce, have small volume, light weight, be suitable for a wide range of temperatures and pressures, be positive in action, be resistant to changes due to vibrational forces and be a precise device.

Furthermore, a wide range of time delay is desirable, with means preferably provided to calibrate the device to suit the time delay selected, together with a positive response to the initiating force and a short reoperation cycle.

Thermal relays of this nature are usually operated by the unequal heating of two members or strips each carrying an electrical contact, one member being suitably heated by a constant source of electric power when it is desired to close the contacts.

Since smallness of size is a most important factor in many uses of such devices and since long time delays must often be provided for, the mass of the strips or members, the linkage therebetween and the mass or size of the operating heating element all limit the degree to which the device may be reduced in volume and weight.

In some uses for a device of this nature it is not imperative that changes in ambient temperature be compensated for. Where, for example, the device is to be used for its time delay function in an atmosphere or environment where constant ambient temperatures are encountered or where the variant in the ambient temperature is of too small a range to have any real effect on the time delay function of the device, a single member may be provided operating to move an electrical contact toward or away from a fixed contact point under the influence of the heat engendered in a heating coil surrounding, or in proximity to, the strip.

It is a principal object of the present invention to provide an electro-thermally actuated time delay relay wherein the volume and weight are greatly reduced relative to the time delay period which can be accommodated by the relay.

It is a further object of the invention to provide an electro-thermally actuated relay for controlling time delays wherein the operating parts are rugged, vibration-resistant and positive in action with quick initial response and rapid recovery for reoperation while the volume and weight as well as cost of production are small enough to be economically used in industries where such factors are a problem.

It is a specific object of the invention to produce a small economical thermal relay of the type described

having a novel operating mechanism which is positive, fast in recovery time, durable, precise, adjustable for varying time delays and vibration resistant.

Generally, in carrying out the present invention there is provided a thermal time delay unit having at least one metal strip, which may be bi-metallic, supported at one end upon a torsion bar and adapted to move under urge of temperature changes in an associated thermally conducive coil so that its free end moves carrying with it an electrical contact toward or away from a further fixed electrical contact to close or open an associated circuit as dictated by thermal conditions. The torsion bar is held so that a predetermined degree of torsion is applied thereto to pre-load the bar and cause damping out of vibration any forces which may be existent in the environment of the thermal time delay unit. If desired, means may be provided to adjust the torsional force applied to the bar whereby the distance between the contacts may be initially adjusted, to thus calibrate the unit and set the device for a specific time lag operation.

More specifically, in practicing the preferred modification of the present invention, there is provided a thermal time delay unit having a pair of substantially circular metal C-shaped strips which are bi-metallic, supported each at one end to move in a helical path parallel to each other, one of said strips being adapted to move eccentrically more than the other under urge of changes in thermal energy derived from a constant electrical source, there being contacts on the strips adapted to be moved in contact to close a circuit under thermal delay actuation or out of contact to open to break the circuit, or vice versa. Linkage means are provided between the strips to permit of adjustment of the contacts relative to each other, to permit calibration for varying time delays within the maximum and minimum inherent in the device, as governed mainly by the dimensions and characteristics of the metallic strips. Such means include a torsion bar which preferably carries one bi-metallic strip, by supporting it at one end and acting as a fulcrum around which the free end may move in a helical path in a differential amount whereby to move an electrical contact associated with the free end of the bi-metallic strip relative to another in an approaching, contact-making, direction or in an opposed contact-breaking direction. The torsion bar is so mounted and carried within a conventional casing that a degree of torsional force may be applied thereto to preset the torsion bar and so carry the bi-metallic strip that vibrational forces applied thereto will be dampened and reduced if not eliminated entirely.

In the device according to the present invention, means are provided, in a preferred form of operation, to adjust the amount of torsion on the bar in a predetermined manner to thereby alter the initial positioning of the contact controlled by the free end of the bi-metallic strip. Thus, by altering the degree of torsion, as by twisting the torsion bar about its longitudinal axis, the contacts can be moved closer together or further apart, thus modifying the delay factor of the device, it being obvious that the amount of delay which the unit will deliver when actuated by thermal forces tending to distort the bi-metallic strip in a helical path or eccentrically of its support, is a function, in part at least, of the distance between the contacts governed by the free ends of the bi-metallic strips.

For a given size, mass and type of metallic strip there will be within such a device, an inherent maximum and minimum delay factor within which maximum and minimum limits, it is possible, according to the present invention, to adjust the device to a desired delay factor by adjusting the amount of torsional force applied to the torsion bar, while still obtaining from the use of the

torsional bar the desired function of damping of forces created by environmental vibrations.

In one form, the bi-metallic strip utilized in the present invention may be generally circular, and C-shaped, as herein defined, the said strips may actually be of any desired contour generally of a circular nature. For example, the bi-metallic strip may have a definite cylindrical contour taking most of the periphery of a circle such as 300°. It may be the major portion of a somewhat oval contour. Generally, therefore, in defining the bi-metallic strip as generally circular and C-shaped is meant a curved strip having an open section forming two ends one of which can be attached to a support, namely, the torsion bar, and the other left free to move in a generally helical or eccentric orbit.

By this arrangement, it will be clear that the action between the operating contact members will be in a tangential direction, thus applying a wiping movement or force in both make and break positions. This increases the life of the contact surfaces, prevents pitting and tends to eliminate welding of the contacts which can occur particularly when a rapid sequence of make and break operations occur in cycle.

Alternatively, the metallic strip may be of elongated flat form and adapted to arc or curve under thermal forces applied thereto to which end a bi-metallic material will be selected for the primary strip, the secondary, or compensating strip, when used, being of like shape and material to the primary.

Where intensification of heat is needed in the primary strip a C-shaped bi-metallic member is used since radiation of heat is thus obtained. A straight strip must rely on conduction of heat only, but this is suitable for some structures.

By practicing the present invention, the thermal linkage between primary and secondary strips is reduced to a minimum, quick dissipation of heat from the coil surrounding the primary is achieved, convection currents are reduced to a minimum, and a large conduction path is provided between primary and secondary strips. This results in a fast reoperating device, which is precise, accurate, and dependable, while keeping the mass of the unit to a desired low value. Because of the relatively small mass of the bi-metallic strip or strips of the present invention and because of the relative isolation or segregation of the two bi-metallic strips, where a pair thereof is used, a fast reoperation time is achieved.

The loading or pre-setting of the torsion bar hereinbefore referred to, will be utilized in all cases where vibration resistance is an important factor. In such cases, a pre-loading of 700 grams on the torsion bar will preferably be utilized although greater or lesser degrees of pre-loading may be employed depending on the use to be made of the device.

It is practical in those cases where no vibration will be encountered to utilize zero pre-loading on the torsion bar while still obtaining the advantages of light weight, positive action and small compact size of the unit with rapid reoperation as hereinbefore set forth.

Since thermal time delay devices or relays of the type herein contemplated are often evacuated and/or hermetically sealed, it is a further feature of the present invention to provide means to adjust and modify the torsional force applied to the torsion bar carrying the strip or strips from outside a hermetically sealed and/or gas filled or evacuated casing or can whereby such sealing and internal treatment of the atmosphere in the can can be carried out during manufacture and the sealed unit adjusted to suit its working requirements of time delay at a later date such as upon installation in a circuit.

Reference will now be made to the accompanying drawings which illustrate certain embodiments of the present invention and serve to disclose the details of the present invention, in certain forms thereof.

In the drawings:

Figure 1 is an isometric elevation of the principal parts of the thermal time delay relay unit according to the present invention;

Figure 2 is an elevation with parts in cross-section, of one form of thermal time delay relay according to the present invention;

Figure 3 is an elevation with some parts in cross-section of another form of thermal time delay relay constructed in accordance with the present invention;

Figure 4 is a cross-section of the relay of Figure 3 taken on the lines 4—4 of Figure 3;

Figure 5 is a cross-section in plan of the relay of Figure 3 with the parts in one operating position, taken on the lines 5—5 of Figure 3;

Figure 6 is a view similar to Figure 5 but with the parts in another operating position than those of Figure 5;

Figure 7 is an isometric view of another form of device according to the present invention, similar to Figure 1, but with some parts thereof not utilized;

Figure 8 is a detail of part of the operational structure of Figure 3, to show this more clearly;

Figure 9 is an elevation of another form of thermal relay according to the present invention; and

Figure 10 is a cross-sectional view of the device of Figure 9, taken on the line 10—10 of Figure 9.

In general, the present invention is concerned with a thermal sub-miniature relay of the type where the contacts are actuated by virtue of the unequal heating of two contact-carrying or contact-operating members. One contact-carrying member only is heated but since it is not practical in a small unit of this nature to insulate the second contact-carrying member from the heated member, the contact motion is a function of the differential temperature. Bi-metallic strips are usually employed for such relays, suitably supported. A heater is thermally coupled to the strip to be heated. In a unit employing two strips, the use of the secondary unheated strip is largely to compensate for changes in ambient temperature.

In such a device, the contact gap at the beginning of the timing period or at the initial stages of operation is therefore completely independent of ambient temperatures. Ranges of timing usually are 2 seconds to 5 minutes for such devices and the variants of timing are obtained by use of bi-metallic strips of varying mass and therefore of varying thermal capacity. Also, use may be made of different atmospheres within the casing or can of the relay, to vary the timing characteristics of the devices. Since the secondary bi-metallic strip is only a compensator for variable conditions of ambient temperature, where such variants can be disregarded, the secondary may be dispensed with and a suitable rigid support for the second contact will then be used.

With the above general indication of the type of device with which the present invention is concerned reference is now made to the drawings and particularly Figures 1 and 7.

In Figs. 1 and 7 there is shown, diagrammatically, the principle of operation of one form of thermal time delay relay having at least one bi-metallic element.

There is provided a torsion bar 20 formed as an elongated flat strip of metal, such as stainless steel, which is mounted in any conventional manner at each end to end pieces or caps 21 and 22. As illustrated, the mounting thereof is by angle brackets 23, 24 which are spot-welded onto the metal torsion bar 20 as at 25 and are screwed to their respective end caps as shown at 26. As shown in Fig. 1, the two end caps 21 and 22 are not in the same plane in one direction but are twisted relative to each other as evidenced by the lines A and B so that the bar 20 is under direct torsion as clearly seen by its change of longitudinal plane in the figure. In order to preserve this torsioning of the bar, for the purpose hereinafter described, the end caps 21 and 22 will be suitably held in the positions selected by any conventional means

mounted in a can or container having a lid. This is shown in Fig. 2 where can 27 holds end cap 21. A means for fixing the can and lid in desired position is shown as a screw 30 passing through an aperture 31 in lid 29 into a tapped bore 32 in the can 27.

Mounted upon the torsion bar 20 is a primary C-shaped circular bi-metallic member 35, there being a mounting bracket 36 at one end of the member 35 welded thereon as at 37 and also welded to the body of bar 20, as at 38. The free end of bi-metallic strip 25 has mounted thereon an insulated bushing 39 and supported by the bushing is a metallic contact point 40 which would have a wire connection or terminal attached thereto when in use. This is omitted for clarity in Fig. 1 but is shown in Fig. 2 at 41 extending to a terminal pin 42 in can end 28.

Surrounding the major portion of bi-metallic strip 35 and wound thereupon is a spiral coil of resistance wire to form a heating element 44, an insulating sleeve 45 being between the bi-metallic strip and the heating element to prevent direct contact therebetween. Heating element 44 is connected by wires 46 to terminal pins 47 in the end 28 of can 27. If a source of electrical energy is applied through terminals 47 to heating element 44, the thermal energy will directly act on metallic strip 35 to cause it to move in a helical path around the fulcrum of the point of support 38 of angle 36 to torsion bar 20 whereby the contact 40 will travel through a portion of a helical path or move eccentrically relative to the fulcrum. It will thus move generally toward the fixed end of the strip 35 but not in a true circular path. If, therefore, a fixed contact member is placed on this path of movement, it is possible to obtain a condition of make-and-break between the contacts which is controlled by the thermal energy supplied by element 44 when energized.

Reference is made to Fig. 7, which shows one means of accomplishing this effect. Therein is shown a fixed contact 50 carried by an insulating block 51 on a mounting bracket 52 affixed to end cap 22 by a foot 53 and screws 54 therethrough and into the body of end cap 22.

It is obvious that an electrical circuit of any desired type can be controlled by the positioning of contacts 39 and 50 as determined by the heat applied by thermal conduction to the bi-metallic strip 35 through heating element 44. By virtue of the pre-stress or torsion applied to the torsion bar 20 shown by lines A and B, the contacts 39 and 50 when in engaged position will not be disturbed by vibrational forces and therefore the structure used can be used in environments subject to vibration without disturbing the contacts.

Furthermore, as the moving contact 39 closely approaches or recedes from the fixed contact 50, any vibrationary forces will be prevented from causing premature make or break of the contacts since the pre-set condition of torsion applied to the torsion bar will damp out such tendencies. Furthermore, since the movement of the moving contact 39 relative to the fixed contact 50 is in a non-circular path, namely, in a portion of a helical path, there will be a wiping or tangential action involved which will make for better contact pressures, more positive action and prevent the tendency to arc over and weld.

It should be realized that in a relay of the type illustrated in Fig. 7 the contact gap between contacts 39 and 50 at the beginning of the timing period, namely, the initial setting, would only remain constant at the particularly ambient temperature pertaining. Therefore, as is conventional, a compensating bi-metallic strip is needed in the present invention where variations in ambient temperature are extreme or where the timing to be performed is critical.

To this end, as shown in Figs. 1 and 2, a secondary bi-metallic strip 55 is provided of the same type, metals and construction as the primary bi-metallic strip 35. Strip 55 is mounted to surround torsion bar 20 and lay

parallel and in line with strip 35 but is spaced away therefrom to preserve a thermally insulating air or like gap to minimize and reduce direct heating of the strip 55 by strip 35 when this latter is heated by element 44.

Compensator strip 55 is mounted on end cap 22 by means of a post 56 to which it is welded as at 57, the lower end of post 56 being fixedly supported to the cap 22 by a bracket 58 secured to the cap by screws 59 and to the post by welding 60.

The free end of strip 55 supports an insulating bar 61 fastened thereto by screws 62 at one end and carrying at its other end a contact point 63. The contact 63 is equivalent for all purposes to contact 50 of Fig. 7, but differs therefrom in that it is also carried by a metallic bi-metal strip, namely strip 55, whereby ambient temperatures will be compensated for, as is obvious. When a pre-selected gap is established between contacts 63 and contact 40, this will be maintained under non-heating conditions of coil or heating element 44 whatever ambient conditions exist and even great changes in temperatures will not affect the initial or pre-established gap since the two bi-metallic strips 35 and 55, being of common form, will change and react equally to such temperature changes.

The support 56 for the contact 63 will be relatively rigid and since the primary bi-metallic strip 35 and contact 40 are mounted on torsion bar 20, when this is placed under the pre-set torsion, as hereinbefore described, the system comprising both strips 35 and 55 and contacts 40 and 63 will be relatively free of disturbances from vibration likely to be encountered in the use of such a device.

Thus, the relay shown in Fig. 2 is one which is sturdy, vibration-proof, compact, and efficient while possessing the additional advantage of being compensated for changes of ambient temperature over an extremely wide range.

The device disclosed in Figs. 1, 2 and 7, hereinbefore described, may be mounted in its can or container in such manner as to permit evacuation of air therefrom whereby it may operate in vacuo. Alternately, the interior of the casing may be filled with a suitable gas. Such procedures are conventional in the art and are used to give different times of delay action to suit specific purposes.

Hereinbefore, the thermal time delay relay has been only provided with a pre-set contact gap which must be pre-established. If the unit is then sealed, no further adjustment can be made to the torsion bar to vary the contact gap and thus change the timing of the relay. In some uses, it is desirable to permit of changing the calibration after the unit has been assembled and sealed.

It is a further feature of the present invention to provide means for permitting calibration of the unit at any time after it has been assembled and sealed. The unit according to this feature of the invention is shown in Figs. 3, 4, 5, and 6. Referring to Figs. 3, 4, and 5, there is disclosed a cylindrical can 65 having a lower circular end cap 66 and an upper circular lid 67. The parts 65, 66, and 67 are adapted to be associated together in conventional manner to form an enclosure for the thermal time delay unit to be described and to be hermetically sealed, in any usual way. The lower cap 66 has a plurality of hermetically sealed-in terminal pins 68 whereby the lower cap becomes a terminal feed-through header and can be used in connection with a conventional socket. Mounted upon the inner face of lower cap 66 is an angle bracket 69, this being attached to the cap by any suitable means such as brazing. Supported by the upright leaf of bracket 69 and brazed thereto, to project upwardly through the body of can 65 and substantially centrally thereof is a channel-shaped member 70 comprising the torsion bar of the present invention. Bar 70 is formed of stainless steel, preferably, because of

the inherent low thermal conductivity factor of that metal, and is channel-shaped to give greater rigidity per unit weight, particularly when placed under torsion, as is the essence of the present invention, while keeping the bar of small mass to thus provide a small compact and light-weight unit. The upper lid 67 is a deep cylindrical cylinder with one end closed and is adapted to be removably connected or nested with the body of the can 65.

The upper end of can 65 is sealed by means of a flexible diaphragm 71 which extends over the complete area of the upper end of the can at a point slightly below the terminal edge thereof. Diaphragm 71 is of well known construction for such devices and basically comprises a thin membrane which can be sealed and presents an airtight closure end while permitting a flexing or distortion of its body in a generally radial plane. Thus, the inherent function of a diaphragm is used in the present invention to permit of variations of torsional stress applied to the torsion bar 70.

To this end, centrally mounted on the underside of diaphragm 71 and projecting into the can is an end bearing 72 made of rigid structure and affixed to the central area of the diaphragm by brazing or soldering if a metal bearing is used or by adhesive if a plastic or insulating bearing is used, such as nylon. Bearing 72 has a semi-circular seat and is suitably blind and serves to mount and support non-frictionally a ball or glass bead 73, said ball being carried on a stem 74, which stem in turn is attached to the inside wing of torsion bar 70. The attachments will depend on the materials used for the parts. Thus, the upper end of torsion bar 70 is anti-frictionally supported by blind bearing 72 and ball 73 and the lower end of bar 70 is fixedly held by cap 66. By this means of support and suspension of bar 70 it is possible to apply extremely small variations of torsional force to bar 70, to vary the torque thereon in very small increments. To accomplish this, there is provided an angle bracket of Z-shape 75 brazed to the back of torsion bar 70 using one leaf 76 and projecting as shown in Figs. 3 and 8 with the major section 77 of the angle bracket presenting a bearing surface angularly arranged relative to the channel-shaped torsion bar 70. Suitably mounted in the central area of section 77 is a ball or glass bead 78 which acts as an anti-friction surface to be operated from externally of the can 65 and specifically diaphragm 71 to move bracket 75 around the torsion bar 70, as a fulcrum.

To this end, there is mounted an adjusting screw 80, the lower end of which passes through a tapped bore in one arm 82 of an L-shaped lever to cause it to follow angularly the movements of screw 80 which bears against diaphragm 71. The other arm 83 of the lever passes through diaphragm 71 and is brazed thereto to preserve the hermetical seal, the end of arm 83 resting on ball 73. Thus, when screw 80 is turned against the face of the diaphragm, the lever 82, 83 will move to cause bracket 75 to rotate the upper end of torsion bar 70, which is free to turn, thereby causing torsional stress throughout bar 70.

It is obvious that the amount of torque applied to bar 70 can vary minutely since the operational linkage permits of small increments of adjustment. It is a preferable feature of this invention that the torsion bar 70 shall have some torsional stress thereon at all times, so that the parts for adjusting the torsion will be so associated that there will be at all times some torque on the bar and this will be augmented at will by means of adjusting screw 80.

Torsion bar 70 is adapted to carry the bi-metallic operating strip and heating element hereinbefore defined. In Fig. 3, the primary strip 85 is shown as a C-shaped thin flat element mounted, as by brazing, by one of its ends to the other leaf 86 of Z-shaped bracket 75. The free end of strip 85 carries an insulating block 87 and a contact 88 thereon, said contact being connected by a wire 89 with one terminal pin 68, as shown.

Surrounding a large part of the perimeter of primary strip 85 is a heating element 90 which comprises conventional thermal wire 91 upon an insulating form 92 (Fig. 5) and element 90 is connected with two other terminal pins 68 by wires 93 and 94, as shown in Fig. 3.

Since it is desired specifically to provide a thermal relay of the type where there is compensation provided for changes in ambient temperatures, there is used a secondary bi-metallic strip 95 which is of identical size, shape and characteristics as bi-metallic strip 85. Strip 95 is mounted to surround torsion bar 70 and lie the same vertical plane and in a parallel horizontal plane as the strip 85 to minimize direct heating of strip 95 from strip 85 when heating element 90 is energized. By arrangement of the two strips as C-shaped there is thus obtained the necessary length of bi-metallic material by arrangement in a circular path so that the overall size of the device is reduced, while the spacing between strip 85 and 95 can be effectively large enough to provide an adequate isolation of the heated or primary strip 85 from the compensator strip 95.

Strip 95 is fixedly held in position by suitably mounting one end thereof to a post 96. Post 96 is affixed to the inside face of lower cap 66, but suitable means, whereby strip 95 is mounted upon the lower cap in fixed position with its free end capable of movement under urge of temperature changes inside or outside the can.

Carried by the free end of strip 95 is an upright arm 97 to which is attached a resilient finger 98 carrying at its upper end a contact 100. Contact 100 is connected electrically to a terminal pin 68 through a wire 99 attached to a point 101 on spring finger 98.

Finger 98 and arm 97 are attached together and arm 97 is supported on strip 95 by any conventional means depending on the material from which they are made.

Throughout this description where metal-to-metal connections are made, these may be welded, spot soldered, brazed or other known manner used in this art for a permanent connection of good thermal and/or good electrical continuity. Where insulating materials are used, these can be riveted on, glued or otherwise affixed as known in the art.

It is obvious that some parts described hereinbefore as metallic can be of insulating material without departing from the essence of the invention.

The operation of the device of Fig. 3 is best shown in the detail drawings of Figs. 5 and 6. Figure 5 is a simplified view of the plan of Fig. 3 and shows the vital parts of the relay in initial position namely before installation in a circuit. Ball 78 is in contact with leaf 77 of bracket 75 and the channel bar 70 will thus be under a pre-set torsional stress which may represent maximum timing, for example. Contacts 88 and 100 are thus set at a gap G of Fig. 5. This gap will be maintained under all ambient conditions between a very wide range because contact 100 is carried by compensator strip 95 which will vary equally under ambient conditions with strip 75.

Upon energizing heating element 90, the contact 88 will move toward contact 100 until actual electrical contact is made but the movement though small, will be in a portion of a helical path, or otherwise stated, it will be eccentric to the center of ball 73, so that there will be a tangential component of force in the contact pressure, causing a desired wiping action between contacts. Due to the isolation of compensator strip 95 from strip 85, the effect of convection of thermal energy will not be material enough to introduce any large delay factor when the temperature of element 90 is reduced, as by deenergizing, so that a quick break of contacts 88 and 100 will occur upon deenergizing and the parts will quickly return to the normal or initial position of Fig. 5. Direct conduction of thermal energy is also minimized by forming the torsion bar 70 of a low thermal conductivity metal, such as

stainless steel, and providing a relatively long path of metal between the two bi-metallic strips 85 and 95.

Furthermore, since torsion bar 70 is under an initial stress, the parts connected thereto will be vibration-damped, particularly the contact 88 which is projected in cantilever construction and therefore liable to fluctuate and follow external or environmental vibrations, if undamped.

Fig. 6 shows the method of calibrating the device and is a similar simplified view to that of Fig. 5. When the adjusting screw 80 (Fig. 3) is turned, this rocks lever 83, the diaphragm 71 permitting the movement without disturbing any other function of the device. This moves ball 78 to the left of Fig. 5 into the position shown in Fig. 6, thus turning bracket 77 about its fulcrum and adding more twisting motion or torsion onto torsion bar 70. This carries contact 88 with it into a position closer to fixed contact 100 as shown by new position or contact gap *g* of Fig. 6. The device can operate exactly as before described but now the timing has been lessened. Fig. 6 may well represent the minimum time delay of the relay, so that any position can be assumed between Figs. 5 and 6 namely, any gap obtained betwen G and *g* for the particular device. The value of time delay is determined for the unit by other factors such as size and type of bi-metallic used, heating element capacity and the like but between the maximum and minimum setting inherent in any relay according to the invention there can be a calibration made at any time without disturbing any other function or characteristic of the device.

It is obvious that various modifications can be made to the parts and association thereof within the spirit and scope of the invention herein defined.

For example, instead of the calibrating and adjusting means operating directly on the torsion bar 70 to vary its torsion, instead the adjustment could be made to move the contact 100 (Fig. 3) toward and away from contact 88 by having ball 78 and lever 83 directly act on spring finger 98, in which case, the pre-set torsion would be established in the device by the method shown in Fig. 2, namely, by setting the torsion bar in the can under loaded conditions.

Referring now to Figs. 9 and 10, there is shown another form of the present invention wherein instead of a C-shaped strip, there is provided an elongated flat primary strip.

Casing 109 has a terminal header 110 of insulating material and has plurality of metal pins 111 therethrough. Across the diagonal pins 111 is a metal plate 112 carrying the torsion bar 113 which has at its upper end a peg 114 carrying an insulating bead 115 preferably made of glass. A metal angle bracket 116 is soldered to the upper part of torsion bar 113 carrying on one leaf a contact member 117 and on the other leaf an upwardly projecting metal peg 118 terminating in an insulating bead 119 such as a glass bead.

Bead 115 bears against a bushing 120 in the cap 121 nested over of casing to form a bearing surface for the torsion bar 113. An angle bracket 122 is mounted on the underside of cap 121 being brazed thereto and has one leaf 123 bearing against bead 119. Since cap 121 is nested over the end of casing 109, if this is rotated thereon leaf 123 will cause bead 119 to move and will thus twist or rotate torsion bar 113. The cap thus forms a means to exert torsion on bar 113 and/or to adjust the position of contact 117 relative to another contact to be hereinafter described. Cap 121 when rotated to desired position can be held in place, for example by soldering.

Mounted on a further pair of pins 111 is an elongated strip 125 formed of bi-metallic material forming a primary strip and carrying at its upper end a contact 126 which is arranged in a common plane with contact 117. A heater coil 127 surrounds the major portion of strip 126 having wires 128 connecting same to two more pins 111.

The unit may be hermetically sealed as previously mentioned.

The operation is similar to that previously described: Upon energizing the heater coil 127, the strip 125 will be deflected to cause contact 126 to move toward and into contact with contact 117. Adjustment between the contacts by varying the gap may be made by turning cap 121 to move bead 119 and twist torsion bar 113 on its axis.

The unit of Figs. 9 and 10 is not compensated for ambient temperatures. Such compensation would be readily achieved, as previously described, by mounting contact 117 on a secondary bi-metallic strip and supporting this to move rotatively with the torsion bar 113.

In the various modifications hereinbefore described there is provided at all times a torsion bar, which can be pre-stressed, and which can have varying degrees of torsion applied thereto by rotating it upon its longitudinal axis or twisting it along its length, said torsion bar carrying one contact of a pair of cooperating contacts. The other contact is relatively fixed whereby adjustment of torsion on the bar varies the gap between contacts. Operation of the contact closing and opening is by virtue of at least one bi-metallic strip suitably influenced by thermal energy from an associated heating coil. A compensator or secondary bi-metallic may be provided to compensate for ambient temperature changes in which case the relatively fixed contact will be moved with the compensator strip.

By practicing the present invention while there is provided a compact, small mass, vibration resistance, rugged relay for use for providing varied time delays under thermal control for many purposes and one wherein small or large increments of time delay can be calibrated for in the device quickly, accurately and at any time without disturbing any other characteristic or function of the device.

What is claimed is:

1. A thermal time delay relay comprising in combination, a primary bi-metallic C-shaped strip, a torsion bar, a lever between said bar and said strip, supporting said strip at one end, a compensating C-shaped strip spaced apart from said primary strip but in the same vertical plane and in a parallel horizontal plane and supported at one end, an electrical contact member carried by the free end of each strip and normally spaced apart by a pre-set selected distance, a heating element associated with and surrounding said primary strip to cause the free end thereof and its contact to move in an eccentric path toward said free end and contact of the compensating strip, when said heating element is energized, and means to apply and maintain a pre-selected torsion on said torsion bar at all times, to dampen the effects of environmental vibrations.

2. A thermal time delay relay comprising in combination, a primary bi-metallic C-shaped strip, a torsion bar, a lever between said bar and said strip, supporting said strip at one end, a compensating C-shaped strip spaced apart from said primary strip but in the same vertical plane and in a parallel horizontal plane and supported at one end, an electrical contact member carried by the free end of each strip and normally spaced apart by a pre-set selected distance, a heating element associated with said primary strip to cause the free end thereof and its contact to move toward said free end and contact of the compensating strip, when said heating element is energized, means to apply and maintain a pre-selected torsion on said torsion bar at all times, to dampen the effects of environmental vibrations and means to vary the torsional force to adjust the pre-set position of said contacts.

3. A thermal time delay relay of the type described comprising in combination an enclosure having two end

caps, a torsion bar therewith having its ends firmly held by said end caps, means to affix said end caps to said enclosure so that said torsion bar will be twisted to apply a selected torsional force thereto, a bi-metallic strip having one end fixedly mounted and the other end free to move relative to said torsion bar, a heating element associated with said strip, to cause said movement, when energized, a first contact carried by said free end of said strip to move therewith and a second fixed contact in the path of movement of said first contact and carried by said torsion bar.

4. A thermal time delay relay comprising in combination an elongated enclosure, caps for each end of said enclosure, a torsion bar extending longitudinally and centrally of said enclosure, affixing means in said caps for the ends of said torsion bar, means, at least at one end of said enclosure, for fixedly mounting one cap rotationally displaced from the other cap, to apply torsion to said bar, a primary bi-metallic strip of C-shaped construction within said enclosure mounted at one end on said bar and surrounding same, whereby the free end thereof may have eccentric movement thereabout, a heating element surrounding part, at least, of said primary strip, to cause said eccentric movement when energized, a compensating bi-metallic strip within said enclosure longitudinally spaced apart from said primary strip fixedly mounted at one end upon one of said caps concentrically with said primary strip and parallel thereto, a first contact carried by the free end of said primary strip, and a second contact carried by said compensating strip in a position to be contacted by said first contact when moved with the free end of said primary strip by energizing said element.

5. The relay according to claim 4 having means operating externally of said enclosure for increasing the torsional force on said bar, whereby to alter the initial positioning of said contacts relative to each other.

6. A thermal time delay relay of the type defined, a fixed contact, a moving contact, a primary bi-metallic strip, a heating element for causing operational movements of said strip and moving contact to closed and opened positions relative to said fixed contact, and a compensating bi-metallic strip isolated from said primary strip and acting to move said fixed contact in accordance with changes in ambient temperatures, wherein said primary bi-metallic strip is C-shaped and is carried on a pre-stressed torsion bar, to dampen environmental vibrations and calibrating means are provided to vary the amount of torsional force on the pre-stressed torsion bar, to alter the initial position of the moving with respect to the fixed contact.

7. A thermal time delay relay of the type described comprising in combination an open casing, a terminal cap for one end thereof, a nesting lid for the other end thereof, a diaphragm at the lid end of the casing, a bearing in said diaphragm, an antifriction ball in said bearing, a flat elongated bar of channel contour, attached at its upper end to said ball to pivot in said bearing, a bracket fixedly mounting the lower end to said cap, whereby said bar may be placed under torsional load by turning the upper end, a linkage from said bar at its under end to a member projecting through said diaphragm including a lever attached to said bar normal thereto, a ball mounted thereon, one arm of a rocking lever pressing on said ball and an adjuster screw pressing on the other end of the rocking lever, said adjusting screw being external of said casing, a normally fixed contact within said casing, a moving contact within said casing adapted to move toward said fixed contact for electrical contact therewith and away therefrom for electrical discontinuity, a first bi-metallic strip mounted on one end to move with said torsion bar and operating to cause its free end to move said moving contact, a heating element in operating association with said first strip, to thermally induce movements thereof, and a second bi-metallic strip mounted at one end and operating under ambient temperature changes to cause its free end to modify the position of said normally fixed contact.

8. A thermal time delay relay of the type described comprising in combination an open casing, a terminal header cap for one end thereof, a nesting lid for the other end thereof, a diaphragm at the lid end of the casing, a bearing in said diaphragm at the lid end of the casing, a bearing in said diaphragm, an antifriction ball in said bearing, a flat elongated bar of channel contour, attached at its upper end to said ball to pivot in said bearing, a bracket fixedly mounting the lower end to said cap, whereby said bar may be placed under torsional load by turning the upper end, a linkage from said bar at its under end to a member projecting through said diaphragm including a lever attached to said bar normal thereto, a ball mounted thereon, one arm of a rocking lever pressing on said ball and an adjuster screw pressing moving the rocking lever, said adjusting screw being external of said casing, a normally fixed contact within said casing, a moving contact within said casing adapted to move toward said fixed contact for electrical contact therewith and away therefrom for electrical discontinuity, a first bi-metallic strip mounted on one end to move with said torsion bar and operating to cause its free end to move said moving contact, a heating element in operating association with said first strip, to thermally induce movements thereof, and a second bi-metallic strip mounted at one end and operating under ambient temperature changes to cause its free end to modify the position of said normally fixed contact, said bi-metallic strips being C-shaped and of like form and arranged in the same vertical plane and parallel, each of said strips surrounding said bar and being concentric thereof, and carrying the contacts on their free ends, whereby movement of the contacts relative to each other is eccentric of said bar and in a helical path.

9. A thermal time delay relay of the type described comprising in combination an open casing cap for one end thereof, a nesting lid for the other end thereof, a diaphragm at the lid end of the casing, a bearing in said diaphragm, an antifriction ball in said bearing, a flat elongated bar attached at its upper end to said ball to pivot in said bearing, a bracket fixedly mounting the lower end to said cap, whereby said bar may be placed under torsional load by turning the upper end, a linkage from said bar at its under end to a member projecting through said diaphragm, a normally fixed contact within said casing, a moving contact within said casing adapted to move toward said fixed contact for electrical contact therewith and away therefrom for electrical discontinuity, a first bi-metallic strip mounted on one end to move with said torsion bar and operating to cause its free end to move said moving contact, a heating element in operating association with said first strip, to thermally induce movements thereof, and a second bi-metallic strip mounted at one end and operating under ambient temperature changes to cause its free end to modify the position of said normally fixed contact, said bi-metallic strips being C-shaped and of like form and arranged in the same vertical plane and parallel, each of said strips surrounding said bar and being concentric thereof and carrying the contacts on their free ends, whereby movement of the contacts relative to each other is eccentric of said bar and in a helical path, said casing when assembled with its lower cap and diaphragm being hermetically sealed.

10. A thermal time delay relay comprising in combination a casing, a lower cap therefor adapted to be hermetically sealed thereon, a removable lid nested over the upper end of said casing, a top member extending across the upper end of said casing, a diaphragm extending across said casing at the upper part thereof and spaced below said member, said diaphragm being hermetically sealed to said casing, a bearing block mounted on the underside of said diaphragm within said casing, a bracket

affixed to the underside of said cap inside said casing, an elongated channel-shaped bar extending longitudinally of said casing with the lower end affixed to said bracket to form a rigid connection and having at its upper end an antifriction member mounted within said bearing block, whereby said bar may be readily placed under a torsional load, an angle bracket fixed on said torsion bar at its upper end and normal thereto, an L-shaped lever having one arm bearing on said bracket and the other arm extending through said diaphragm and sealed thereto, a threaded bushing in said top member, an adjusting screw mounted in said bushing to contact the portion of said arm of the lever projecting externally of said diaphragm and rock same, the upper and externally projecting portion of said screw being capable of being rotated, a primary C-shaped bi-metallic strip around said bar and attached at one end to said angle bracket, whereby it shares movements with said torsion bar when same is caused to rotate by said adjusting screw, a heating element wound upon said primary strip, a compensating strip horizontally parallel to and spaced apart from said primary strip and

in concentric alignment, a mounting member rigidly supporting one end of said compensating strip and attached to said lower cap, a first electrical contact on the free end of said primary strip, a second electrical contact projecting from the free end of said compensating strip, into the path of movement of the first contact, the gap between said contacts being initially maintained, despite changes in ambient temperature, and the gap being variable in width by adjustment of the torsional load on said torsion bar.

References Cited in the file of this patent

UNITED STATES PATENTS

1,523,505	Barnett	Jan. 20, 1925
1,647,336	Bradshaw	Nov. 1, 1927
1,753,945	Replogle	Apr. 8, 1930
2,235,779	Van Dusen	Mar. 18, 1941
2,249,582	Strobel	July 15, 1941
2,340,158	Theisen	Jan. 25, 1944
2,700,084	Broekhuysen	Jan. 18, 1955