Dec. 26, 1961

J. F. HOWARD

THERMAL DEVICE

3,015,007

Filed Dec. 8, 1959

4 Sheets-Sheet 1

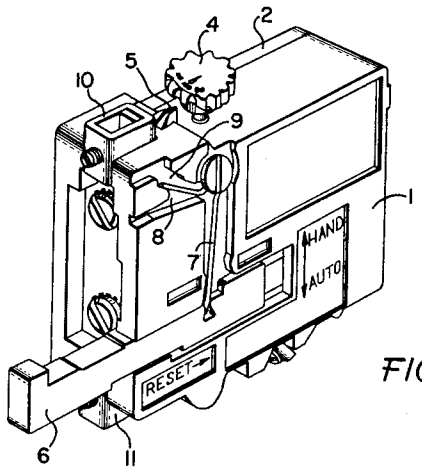


FIG. 1

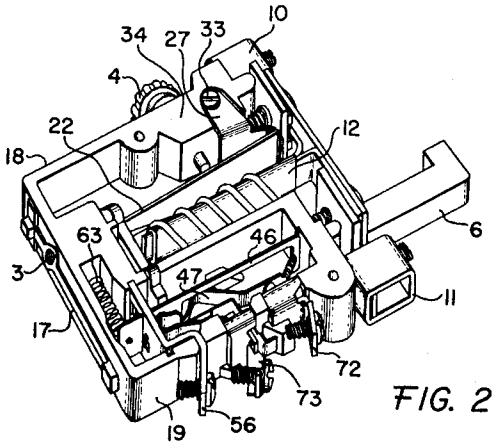


FIG. 2

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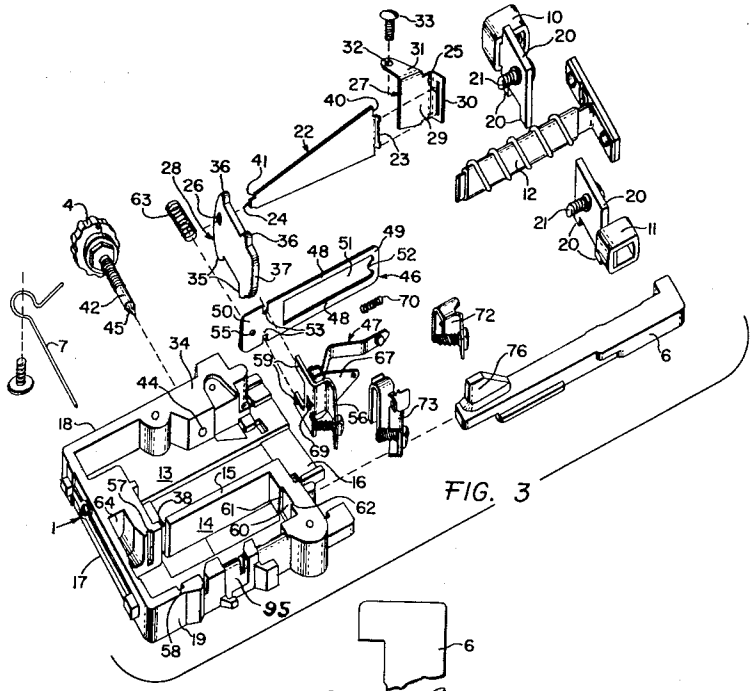


FIG. 3

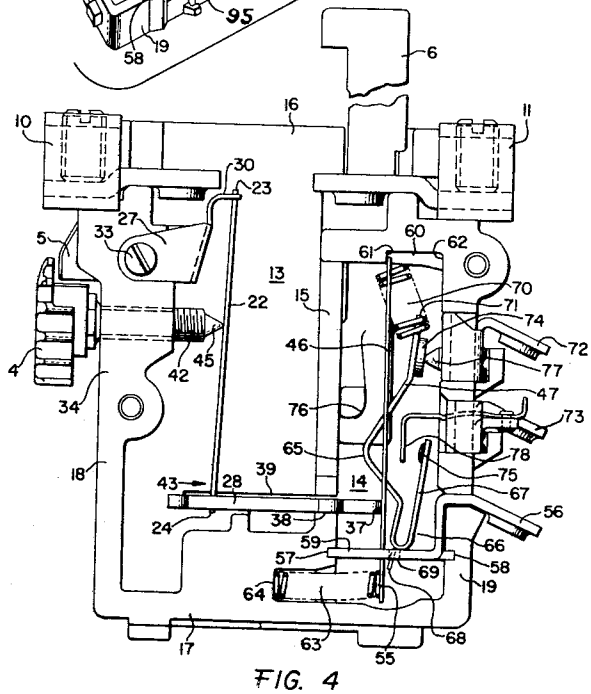


FIG. 4

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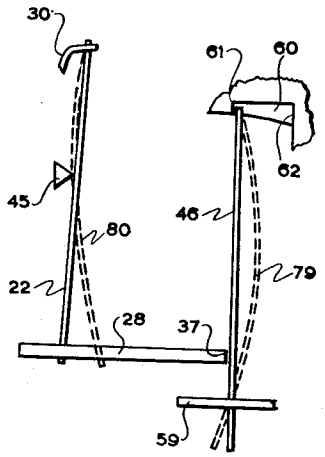


Fig. 5

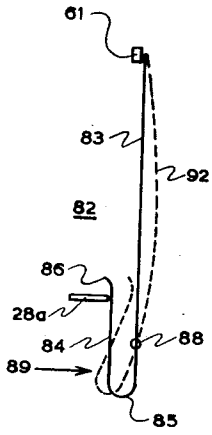


Fig. 8

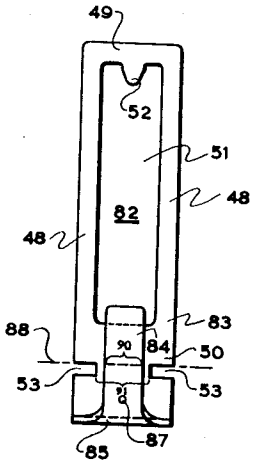


Fig. 6

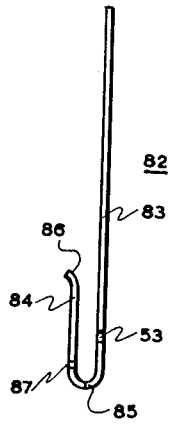


Fig. 7

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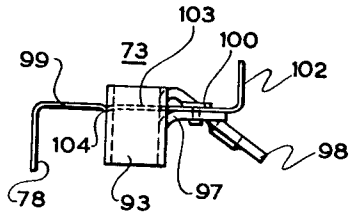


Fig. 9

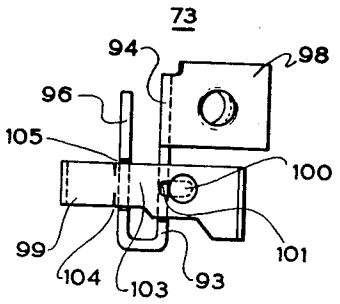


Fig. 10

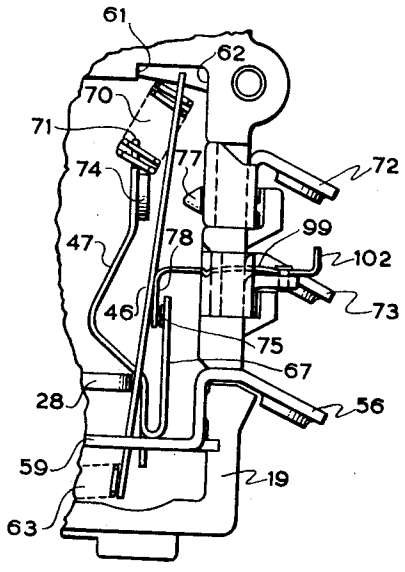


Fig. 11

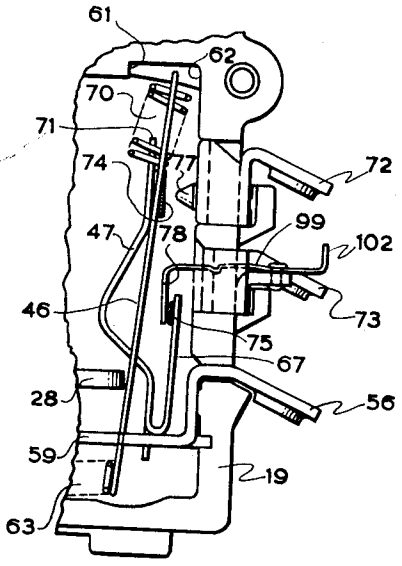


Fig. 12

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3,015,007

THERMAL DEVICE

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Claims priority, application Canada Nov. 19, 1959
13 Claims. (Cl. 200—114)

This invention relates to electric overload actuated devices and particularly to the electric switching mechanism used in such devices.

Overload devices are often incorporated into electromagnetic contactors to protect electric motors or like apparatus against excessive current flow thereto; the device contains some means for sensing abnormal current flow and in response thereto causes the contactor to disconnect the apparatus from its power source. Such overload actuated devices ordinarily utilize a bimetallic strip disposed to actuate at least one set of contacts and means for heating the bimetallic strip. The heating of the bimetal may be acomplished by passing some or all of the load current through either the bimetal or a separate heating element placed near or in direct contact with the bimetal. It is also possible to combine the direct and separate heating means.

In operation, a bimetal deflects in response to an increase or decrease in temperature thereof, the amount of deflection being related to temperature change. A bimetal is essentially a device calibrated to sense changes in temperature from a given temperature. The heat causing such changes may come from heating means provided or from other sources, i.e., an increase or decrease in the ambient temperature will influence a bimetal. When a thermal device is located in an environment such as outdoors where the ambient temperature usually varies greatly between night and day and also between seasons, the problem of providing a bimetallic type of thermal device which will consistently perform a satisfactory control function can become very difficult indeed. For example, if an electrically heated bimetal is calibrated at 70° F. to open a set of contacts in the device at 30 amperes, more than 30 amperes will be required when the ambient temperature falls below 70° F. and less than 30 amperes when the temperature rises above 70° F., the more the temperature deviates from 70° F. the greater the current deviation from 30 amperes. Therefore, if variations in the ambient temperature within which the device operates become great enough, the reliability of the device may be seriously impaired.

There are many known ways for compensating a bimetal for changes in the ambient temperature conditions surrounding it. Usually a second bimetal is provided, which bimetal cooperates with the first bimetal in such a way that the deflections of the two bimetals due to ambient conditions tend to cancel, thus leaving a net deflection of the first bimetal representing the current flow in the heating means. Generally, adding a second bimetal results in a more complex device due to added structure; such a device therefore tends to be larger, more costly to manufacture and to have more moving parts which are subjected to wear.

Accordingly, it is an object of this invention to provide a novel means for compensating the bimetallic strip in a thermally responsive device for changes in ambient temperature conditions, a means which is simple, reliable, inexpensive, avoids the use of additional parts and does not increase the physical dimensions of the device.

It is another object of this invention to provide a simple means for converting a bimetallic type of thermally responsive device which is uncompensated for ambient temperature conditions to a compensated device.

It is yet another object of this invention to provide a thermally responsive device which may be fully compensated, under compensated or over compensated for ambient temperature conditions.

After the power line to a piece of apparatus has been disconnected by an electromagnetic contactor due to an overload condition sensed by an overload device in the contactor, the circuit must be re-established either manually or automatically when it is desired to place the apparatus into service again. The operator in attendance may reclose the circuit manually by actuating a reset mechanism in the device. Manual reclosing will generally take place after the abnormal conditions which caused the contactor to open have been corrected. When an overload device is set to automatically reclose its electromagnetic contactor, reclosing will take place after a time delay sufficient to allow the bimetal in the device to cool down to normal.

In some applications employing electromagnetic contactors, it is desirable to signal the operator automatically whenever a contactor opens the power line to a piece of apparatus due to excessive current flow thereto. A light, bell, buzzer, etc., may be employed as the signal means. The signal alerts the operator to the fact that a certain piece of equipment may be overloaded, defective, or otherwise operating improperly, thereby directing his attention to the need for remedial action. Where a number of electromagnetic contactors are grouped and set for manual reclosing, the signal will immediately indicate to the operator which contactor requires his attention.

Therefore, it is a further object of this invention to provide auxiliary contact means in a thermally responsive device, which contact means are employed with electric signal means to indicate whether the line contacts in an electromagnetic contactor are open or closed.

It is another object of this invention to provide auxiliary contact means in a thermally responsive device, which contact means are employed in suitable circuitry to initiate auxiliary control functions.

It is yet another object of this invention to provide in a thermally responsive device auxiliary contact means which may be used to set the device for manual or automatic operation, and reset the contacts in the device when it is set for manual operation.

In accordance with the invention a thermally responsive device includes a thermally responsive bimetallic element coupled to a switching mechanism so as to provide for the actuation of the switching mechanism. The switching mechanism comprises a frame supported at one end thereof for pivotal movement on an axis transverse to the longitudinal axis of the frame and a contact arm supported at one end thereof for pivotal movement of its other end through a window in the frame on an axis adjacent and substantially parallel to said first axis. A spring interconnecting the frame and the contact arm provides a resilient means for causing over center snap action pivotal movement of the arm in one direction upon pivotal movement of the frame in the opposite direction. When it is desired to compensate the main bimetallic strip in the device for change of ambient temperature conditions, the frame is formed from bimetallic strip and it is positioned in the device such that it and the main bimetal deflect independently in a way which maintains a predetermined relationship between them.

A further aspect of this invention provides for auxiliary contact means whereby it is possible to signal tripping of the thermally responsive device, i.e., opening of the main contacts in the device, and which means thereafter may be employed to reset the device manually. The movable contact arm carries at least one additional contact adapted to engage a fixed contact by means of which an elec-

tric circuit may be energized when the main contacts in the device open. This so-called fixed contact is movable manually so that it may be used to reset the device after the bimetallic element cools off, that is, reclose the main contacts.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a perspective view of an overload protective device embodying the invention;

FIG. 2 is another perspective view of the device, the side cover being removed to expose the operating mechanism of the device;

FIG. 3 is an exploded view of the parts used in the device of FIGS. 1 and 2;

FIG. 4 is a view of the device in elevation showing the parts assembled in the housing;

FIG. 5 is a view in elevation illustrating the way in which the main bimetal and the bimetallic frame deflect when the ambient temperature rises;

FIGS. 6 and 7 are side and end views respectively showing an alternate type of bimetalic frame;

FIG. 8 is a single line diagram of the bimetallic frame shown in FIGURES 6 and 7 illustrating the way in which the frame deflects when heated;

FIGS. 9 and 10 are elevation and plan views of the auxiliary fixed contact structure shown in FIGS. 3 and 4;

FIG. 11 is a segment of FIG. 4 illustrating the switching mechanism when the device is set for manual operation;

FIG. 12 is a view similar to FIG. 11 illustrating the switching mechanism when the device is set for automatic operation.

Referring now to FIGS. 1 and 2, the invention is shown as incorporated in an overload actuated device comprising an insulating housing 1 and a side cover 2 cooperating with the housing to retain the parts in mounted condition. The device is adapted to be mounted by means of a screw threaded into a tapped hole 3 in the bottom of the housing. External operating members are provided, including knob 4 which cooperates with the molded projection 5 on the housing 1 as a stop, and reset lever 6 which may be positioned for either manual or automatic operation through the positioning of spring 7 either in slot 8 for automatic operation or in slot 9 for manual reset operation. When the novel auxiliary contact means to be described later is employed reset lever 6 may be used as an alternate means to reset the device manually when the auxiliary contact means is positioned for manual operation of the device, and the lever may be dispensed with altogether when the auxiliary contact means is positioned for automatic operation of the device. Terminals 10 and 11 are provided for connecting suitable conductors to resistance heater 12.

Referring particularly to FIG. 3, the cavity in housing 1 is partitioned into two separate compartments 13 and 14 by a wall 15 molded integral with side wall 16 and bottom wall 17 and disposed generally parallel to end walls 18 and 19. Terminals 10 and 11 are trapped in the molded housing by the engagement of projections 20 with mating slots provided in side wall 16 and cover 2. Heater 12 is secured in position inside compartment 13 near wall 15 but spaced therefrom by means of screws 21 threaded into apertures in terminals 10 and 11 whereby a circuit is completed through the heater between the terminals.

A bimetallic strip 22 disposed in compartment 13 generally parallel to wall 15 between heater 12 and end wall 18 is loosely retained in this position by means of tongues 23, 24 on the ends of the strip received into mating apertures, 25, 26 respectively, as a loose sliding fit, aperture 25 being in fixed support 27 and aperture 26 in movable support 28. Fixed support 27 is a sheet metal member having a flat body portion 29 formed with a bent-up portion 30 containing aperture 25 and an ear 31 bent in the opposite direction from an adjacent edge. The ear is apertured at 32 to receive screw 33 which secures the support to a boss 34 on the inside of wall 18. Movable support 28 is spaced from fixed support 27 a distance slightly less than the overall length of the bimetal and consists of a rigid strip, preferably insulating material, formed with projections 35 integral with one longitudinal edge of the strip and similar projections 36 integral with the other longitudinal edge. Projections 35 are adapted to fit loosely into groove 39 (FIG. 4) in side wall 16, a groove which runs generally parallel to bottom wall 17, and projections 36 into a similar groove in cover 2 whereby support 28 is mounted for limited sliding movement lengthwise through slot 38 in partition 15. The length of support 28 is such that the end 37 thereof projects into compartment 14 while the other end containing aperture 26 remains in compartment 13. It is thus seen that the bimetallic strip spans supports 27 and 28 and is loosely retained therebetween for pivotal movement only along the line of contact between shoulders 40 and fixed support 27 and shoulders 41 and movable support 28.

A stop 42 on end wall 18 is disposed in compartment 13 intermediate supports 27 and 28 and adapted to engage the high expansion side of the bimetal such that it cooperates with fixed support 27 to restrain movement of the bimetal upon being heated to deflection of the end thereof supported on movable support 28. As clearly shown in FIG. 4 fixed support 27 restrains the upper end of the bimetal while movable support 28 allows the lower end of the bimetal to deflect to the right as indicated by arrow 43; the deflection of the lower end of the bimetal moves support 28 to the right. Preferably, stop 42 is made adjustable and may be a threaded shank screwed into a threaded aperture 44 in boss portion 34 of end wall 18 such that point 45 of the shank engages the high expansion side of the bimetal on or near the longitudinal center line thereof. After assembly of the bimetal to its supports 27 and 28, threaded shank 42 is driven into threaded apertures 44 until its point 45 is positioned to provide the desired calibration of the bimetal; after which knob 4 is permanently fixed to the outer end of the shank. Knob 4 cooperates with projection 5 to limit turning movement of the shank to something less than one turn whereby the position of point 45 may be altered slightly to provide for limited adjustment of the bimetal. Indicia may be provided with which a pointer on the knob cooperates to indicate bimetal settings.

End 37 of movable support 28 actuates a switch mechanism located in compartment 14 when the support is moved towards end wall 19 by deflection of the bimetal from a normal undeflected position thereof. The switch mechanism is best illustrated in FIGS. 3 and 4. The switch mechanism consists essentially of a frame 46 adapted to cause movement of contact arm 47 between "contact make" and "contact break" positions. Preferably, frame 46 is formed from a thin strip of resilient spring-like material into a pair of spaced legs 48 integral with spaced end portions 49 and 50, the legs and end portions defining window 51. End portion 49 has an inwardly projecting tip 52, and the other end portion 50 has a pair of notches 53 extending inward from opposite edges of the frame along an axis transverse to the longitudinal axis of the frame. There is also a small projection 55 raised from the flat surface of portion 50. A terminal 56 trapped in recesses 57, 58 in walls 15, 19 respectively at the lower end of compartment 14 has a pair of spaced legs 59, one of which is positioned along side wall 16 and the other along cover 2. The spacing between legs 59 is such as to allow each leg to fit freely into a corresponding notch 53 and thereby support frame 46 in an upright position for pivotal movement on the axis of

the notches. The upper end portion 49 of the frame rests in recess 60 whose sides 61, 62 serve as spaced stops to limit pivotal movement of the frame, and a coil spring 63 retained in recess 64 by means of projection 55 biases the frame for counter-clockwise rotation against stop 61. It is to be noted with respect to FIG. 4 that spring 63 acts on frame 46 at a point below its pivotal axis while movable support 28 has its end 37 butting against the side of the frame above this axis. Movement of support 28 in the direction indicated by arrow 43 will cause the frame to pivot clockwise toward stop 62 against the bias of spring 63. It is therefore apparent that by biasing the frame counter-clockwise toward stop 61 spring 63 also biases bimetallic strip 22 for clockwise rotation about fixed support 27 against stop 42 when the strip is heated by means of heater 12. When heater 12 is de-energized, the lower end of the bimetallic strip assumes a position far enough to the left to be free from the action of spring 63 because the upper end of frame 46 now rests against stop 61. Hence when the bimetal deflects upon being heated, it does so against the bias of spring 63.

Contact arm 47 is formed with a humped back 65 and stands on a rounded base 66 which also supports a second upstanding arm 67. The contact arms are supported on terminal 56 for rocking movement on rounded base 66 on an axis adjacent and substantially parallel to the axis on which frame 46 pivots; a tongue 68 struck out from rounded base 66 fits freely into aperture 69 in terminal 56 to prevent sliding movement of the arm assembly along terminal 56. A coil spring 70 compressed between the free end 71 of contact arm 47 and tip 52 on end portion 49 of frame 46 completes an over-center snap action mechanism involving contact arm 47, frame 46 and coil spring 70.

In one position of the contact arms, i.e., that illustrated in FIG. 4, a contact 74 on the free end of arm 47 makes with a fixed contact 77 on terminal 72 and in the other position of the arms a contact 75 on the free end of arm 67 makes with contact surface 78 mounted on terminal 73, terminals 72 and 73 being clipped to end wall 19 of housing 1. Terminal member 73 is constructed such that its contact surface 78 is manually movable in the same general directions as those followed by movable contact 75, the movement of contact surface 78 being limited to two definite positions. The construction of member 73 will be described in detail later.

In actual use of the overload device heater 12 is connected into a power supply conductor by means of terminals 10 and 11 such that the current flowing in the conductor passes through the heater to cause heating thereof. Under normal load conditions the heat produced by heater 12 is insufficient to operate the device, but if the current flow rises above a predetermined value, sufficient heat will then be produced to cause bimetallic strip 22 to deflect. As best illustrated in FIG. 4 deflection of the bimetal in the direction indicated by arrow 43 slides support 28 to the right whereby frame 46 rotates clockwise. As frame 46 rotates clockwise spring 70 is compressed and its axis brought towards alignment with the plane of the frame, i.e., the spring enters window 51 in the frame. When contacts 77, 74 are made as shown in FIGURE 4, spring 70 exerts a component of force tending to keep them closed, but continued rotation of the frame clockwise finally reverses this component of force thereby causing arms 47, 67, to rotate counterclockwise with over center snap action thus separating contacts 77, 74 and closing contacts 75, 78. The construction of the switch mechanism is such that after actuation thereof due to deflection of the bimetal, frame 46 is free to rotate clockwise a considerable distance before striking stop 62 thus allowing for overtravel of the bimetal. After end potrion 49 of frame 46 strikes stop 62 further overtravel of the bimetal is possible because the frame preferably is formed from resilient material which will flex readily when urged to do so by movement of support 28. When the device is set for manual reset as illustrated in FIG. 4, the contact arms may take one of two stable positions, that is, one where contacts 74, 77 are closed and one where contacts 75, 78 are closed, the contacts 77 and 78 serving as stops to limit the travel of the arms. During each complete over center switching operation arm 47 and spring 70 pivot through window 51 in the frame.

After a switching operation where the contact arms have changed from the stable position shown in FIG. 4 to a second stable position where contacts 74, 77 are open and 75, 78 closed, the contacts may be reset to their former FIG. 4 position by manually depressing lever 6 which is slidably mounted in the casing and biased to its extended position by spring 7. In depressing lever 6 a cam surface 76 thereon engages hump 65 on arm 47 and forces the arm to rotate clockwise until it passes the over center point where spring 70 takes over to complete the movement of the arm with snap action thus closing contacts 74, 77 and returning the frame to stop 61. This type of reset operation has been previously referred to as "manual reset," and it is possible when contact surface 78 is in its extreme left position as shown in FIG. 4. When contact surface 78 is positioned to the extreme right, the device is set for so called "automatic operation." During automatic operation, surface 78 acts as a stop in the path of travel of contact 75 thus preventing complete over center switch action to the second stable position. Hence when the bimetal deflects upon being heated and moves frame 46 clockwise, contacts 74, 77 separate and remain open only as long as held that way by the bimetal. When the bimetal cools, contacts 74, 77 reclose automatically. It is to be noted that contact surface 78 limits arm 67, and hence arm 47 as well, in its movement counter clockwise when the device is set for either manual or automatic operation.

The novel means employed to compensate the main bimetal in the device for changes in ambient temperature will now be discussed. Normally, frame 46 is cut from a strip of relatively thin spring material, such as steel or brass, into the shape illustrated in FIG. 3, but when it is desirable to provide compensation for ambient temperatures, this frame may be replaced with a frame of identical shape formed from a strip of bimetal. This bimetal frame is positioned in the device with its low expansion side facing in the direction of the main bimetal 22. Since the frame has its lower end pivotally supported on legs 59 of terminal 56 and its upper end biased against stop 61 by means of spring 63, it warps when heated in the manner illustrated by dashed lines 79 in FIG. 5, i.e. the frame bends in a direction away from end 37 of actuator 28. It has already been pointed out that bimetal 22 has its low expansion side facing in the direction of the frame, and consequently upon being heated it warps in the manner illustrated by dashed lines 80, i.e., its lower end deflects toward the frame. FIG. 5 shows the same arrangement of bimetal and switch frame as shown in FIG. 4 and also illustrates in exaggerated form the manner in which each deflects when heated. When the temperature inside the device housing rises due, for example, to a rise in room temperature, bimetal 22 and bimetallic frame 46 absorb some of this heat and in response thereto deflect as illustrated in FIG. 5. This rise in ambient temperature causes the bimetallic frame to deflect in a direction away from end 37 of actuator 28 and the lower end of bimetal 22 to deflect to the right, whereby actuator 28 is moved to the right towards the frame. A fall in ambient temperature causes these two members to deflect in the opposite direction.

Any deflection of the lower end of the main bimetal due to temperature changes in the bimetal moves the actuator in the same direction. When the ambient tem-

perature in which the device operates increases, the actuator is moved to the right by the main bimetal, and simultaneously frame 46 curves to the right away from the oncoming end 37 of the actuator. A fall in the ambient temperature causes the movements of the bimetallic members to reverse. As the frame curves to the right as illustrated in FIG. 5 the greater the distance the actuator must travel to rotate the frame clockwise (FIG. 4) to the point where contacts 74, 77 snap apart. When, over a given range of ambient temperatures, the distance which the frame must be moved by the actuator for over-center action of the switch mechanism is equal to the distance which the actuator must be moved by the bimetal in response to an overload condition, the device is said to be fully compensated for this temperature range. In other words, an overload device is said to be fully compensated for operation in a range of ambient temperatures when substantially the same overload is required to actuate the device regardless of the specific ambient temperature in the range to which the device may be subjected. When fully compensated, the device requires a substantially constant overload for actuation thereof over a given range of ambient temperature conditions; an under-compensated device requires a decrease in overload with increase of ambient and vice versa for over-compensation.

A carefully selected degree of under-compensation is of special significance when applied to electric motors because overload devices so designed may be used to protect the motors in a variety of ambient temperature conditions by making use of the increased motor load capacity in cold weather. It is possible to match the characteristics of the overload device described herein with the characteristics of the motor to be protected by the device in such a way that the motor output increases as the ambient temperature decreases and at the same time afford adequate protection against an undue rise in the motor's "hot spot" temperature. The type of bimetallic frame described so far with reference to FIGS. 3, 4 and 5 has been found to be satisfactory for these purposes.

As those skilled in the art well know, a reasonable amount of skill must be exercised in the selection of a bimetal suitable for a particular application; in addition to length, the behaviour of a bimetal when heated depends upon such other factors as width, thickness, grade, composition, etc. Some of the factors which determine the amount of compensation required include design features of the device, apparatus to be protected and the difference in temperature between ambient and that of the time tripping of the device occurs.

There are also applications where it may be desirable to overcompensate the overload device, in which case the movement of actuator 28 by the main bimetal in response to a rise in the ambient temperature must be accompanied by an even greater movement of the frame away from end 37 of the actuator. Stated otherwise, an increase in ambient will be accompanied by the need for an increase in the overload current required to actuate the switching mechanism.

It is well known that the length of a bimetallic strip is the main factor which determines the amount of deflection possible. This invention includes a novel means for increasing the effective length of the bimetallic frame and yet retain a frame structure which is interchangeable with the previously mentioned frame 46. FIGS. 6 and 7 show a bimetallic frame construction 82 which provides for substantial overcompensation of the main bimetal.

Frame 82 may be formed from a single strip of bimetal into two spaced substantially parallel portions 83 and 84 standing on an integral semi-cylindrical base 85 as clearly illustrated in FIGS. 6 and 7. Portion 83 is similar to frame 46 in that it includes the same two legs 48, and portions 49 and 50, projection 52, window 51 and notches 53. However, the end portion 50 is extended and bent through 180° to provide the second upstanding portion 84 whose upper end 86 is curved slightly away from portion 83 as shown in FIG. 7. This bend is such that the low expansion side of the bimetal is on the inside, that is, the low expansion sides of portions 83 and 84 face each other. Frame 82 is supported on terminal 56 with its portion 84 nearest bimetal 22 by means of legs 59 thereon fitting loosely into notches 53 such that the frame is free to pivot on an axis 88 transverse to the longitudinal axis of the frame. It is clearly shown in FIG. 6 that width 90 of portion 84 is considerably less than spacing 91 between notches 53, hence portion 84 may be positioned between legs 59 in spaced relationship thereto. The mounting of frame 82 is identical to that described in connection with frame 46 and illustrated in FIGURES 3 and 4, and furthermore, frame 82 is fully interchangeable with frame 46. If frame 82 is used in the device shown in FIGS. 1 to 4, it is necessary to replace actuator 28 with a shorter actuator because the portion 84 is now located between end 37 of the actuator and the main portion 83 of the frame. This shortened actuator, which is designated 28*a* in FIG. 8, engages the upper free end of portion 84 of frame 82 and as a result any deflection of bimetal 22 upon being heated causes actuator 28*a* to apply to the upper end of 84 a force which tends to rotate the frame clockwise on axis 88. Continued rotation of frame 82 clockwise will force contact arm 47 to rotate counter-clockwise with over-center snap action. As with frame 46, frame 82 is also biased from counter-clockwise rotation by means of a coil spring similar to spring 63. This spring is positioned in recess 64 as before and compressed between the end wall of the recess and portion 84 of the frame in region 87. Arrow 89 in FIG. 8 illustrates the direction of the force applied by the spring to the frame to bias the upper end thereof against stop 61. In FIGS. 6 and 7, numeral 87 designates an aperture in portion 84 into which a rivet may be secured to provide a projection which fits into the end of the coil spring, thus retaining the end of the spring in position against the frame.

Since the low expansion side of the bimetal is on the inside of bend 85, frame 82 upon being heated deflects in the manner illustrated in exaggerated form by dashed lines 92 in FIG. 8. When frame 82 deflects its upper end and pivotal axis 88 remain stationary while portion 83 curves to the right thereby causing base 85 to shift slightly to the left along a circular path, which shift tends to move the upper end 86 of portion 84 to the right. The movement of the upper end of portion 84 to the right when combined with the deflection of portion 84 to the right results in appreciable movement of the frame away from actuator 28*a*. When bimetal 22 and frame 82 are subjected to an equal rise in temperature, the deflection of bimetal 22 moves switch actuator 28*a* to the right while simultaneously frame 82 deflects in the same direction. Frame 82 may be constructed such that its region of contact with actuator 28*a* can deflect to the right at a rate greater than that at which the main bimetal moves the actuator, and hence over-compensation of the main bimetal for ambient temperature conditions is possible. By a proper selection of the bimetal used in frame 82 (i.e., thickness, grade, composition, etc.) a significant degree of over-compensation is possible. When over or full compensation is desirable, frame 82 is preferred, but frame 46 may also be used to provide full compensation as well as under compensation.

It is believed to be evident from FIG. 4 that hump 65 on contact arm 47 oscillates through window 51 in frame 46 or 82 when the switch mechanism is actuated. Window 51 serves another purpose; it reduces the width of bimetal in the frame and thereby reduces the tendency of the frame to warp in a direction transverse to the longitudinal axis thereof.

It has already been pointed out in this disclosure that many applications of electromagnetic contactors require

some means for signalling the operator in attendance whenever a contactor disconnects the power line from a piece of electrical apparatus. Auxiliary contact means such as that illustrated by numerals **73**, **78**, **75**, **67** and **56** in FIG. 4 may be employed with either the compensated or uncompensated thermally responsive device to complete a signal circuit whenever the device's main contacts **74**, **77** open and thereby alert the operator by sounding an alarm or illuminating an indicator lamp. The auxiliary contact structure consists of movable contact arm **67** integral with the main movable contact arm **47** and fixed terminal structure **73** clipped onto end wall **19** and retained in position thereon by means of jaws **94** and **96** grasping a recessed wall portion **95** on housing **1** (FIGS. 3, 4 and 10). Arm **67** is provided with contact **75** which is adapted to make with contact surface **78** on the fixed terminal structure after the main contact arm **47** has swung over center with respect to frame **46** or **82** from the position shown in FIG. 4 where contacts **74**, **77** are made to a second position where contacts **74**, **77** are separated.

The construction of the auxiliary fixed contact is shown in FIGS. 9 and 10, and comprises a body portion **93** and a contact strip **99** movably mounted thereon. The body portion may be formed from a single sheet of metal into a U-shape which includes jaws **94** and **96**, and jaw **94** has an integral terminal **98** and lug **97** projecting outwardly from the U-shaped portion. Lug **97** is apertured to receive rivet **100** which secures contact strip **99** to the lug and cooperates with recess **105** in jaw **96** for retaining the strip in a position transverse to the jaws. The strip contains slot **101** adapted to receive the shank of rivet **100** such that the strip is free to slide over the jaws a distance slightly less than the length of the slot. An upturned end **102** on the strip provides a means whereby the strip can be moved manually transversely of the jaws with the aid of a screw driver or similar tool. The contact strip may be formed from spring-like material such as Phosphor bronze sheet, and the central portion of the strip may be curved upward slightly as indicated at **103** to provide spring contact of the strip with lug **97** and jaw **96** whereby movement of the strip causes wiping action between the strip and contact body thus maintaining a path of low electrical resistance between contact surface **78** and terminal **98**. Dent means **104** in the strip cooperates with jaw **96** to restrain movement of the strip between two definite positions, i.e., the dent on either side of the jaw. The left hand end of the strip is bent downwardly to provide contact surface **78** which makes with contact **75** in one position of movable contact arm **47**.

Referring now to FIG. 4, it will be seen that portion **78** of strip **99** may also serve as a stop to limit counterclockwise rotation of contact arm **47**. Furthermore, it is possible to completely eliminate reset lever **6** and utilize the auxiliary contact means for the normal functions of the lever. When contact surface **78** is in its extreme left position as shown in FIGS. 4 and 11, it stops arm **67** and hence the main movable contact arm in a second stable position where end **71** thereof rests on the left side of the frame as illustrated in FIG. 11, the arm being biased for counterclockwise rotation by spring **70**. After such a switching operation the switch must be reset manually. Resetting can be effected manually by means of lever **6** in the manner described earlier on or by engaging end **102** on contact strip **99** with a suitable tool, such as a screw driver, and pulling the end away from the device housing thus moving contact surface **78** to the right, which surface in turn drives contact **75** to the right, thus rotating arm **47** clockwise until spring **70** takes over to reclose contacts **74**, **77** with snap action. After contacts **74**, **77** close, the device may be reset to its former position for "manual operation" by pushing end **102** of strip **99** toward end wall **19** of the housing as far as it will go. It is to be understood that after such a switching operation, the main bimetal must be allowed sufficient time to cool to near normal before manual resetting is attempted, otherwise actuator **28** may continue to exert on the switch frame a force which tends to rotate the frame clockwise thus positioning the upper end of the frame far enough to the right to prevent contacts **74**, **77** from remaining closed.

When contact surface **78** is positioned to the extreme right by pulling end **102** of strip **99** as far away from the housing as it will go as shown in FIG. 12, the device is set for automatic operation. During automatic operation, movement of actuator **28** to the right drives the frame clockwise to the point where the force component of spring **70** urging contact **74** against contact **77** reverses and thereby snaps the contacts apart to the position illustrated in FIG. 12. As the main bimetal cools, the force applied by the actuator to the frame diminishes thus allowing spring **63** to rotate the frame counterclockwise until contacts **74**, **77** remake.

It is to be noted that counterclockwise rotation of the switch arms is limited by contact **75** striking contact surface **78** when the device is set for either automatic or manual closing of its main contacts. Hence every time thaat the main contacts in the device open, the auxiliary contacts close thus permitting an alarm circuit to be energized through the auxiliary contact means. The elements which cooperate to complete such a circuit through the device include terminal **56**, arm **67**, contact **75**, contact surface **78**, contact strip **99**, body portion **93** and terminal **98** (FIGS. 4, 9 and 10).

Although both the ambient temperature compensation means and the auxiliary contact means of this invention have been described with reference to the bimetal arrangement shown in FIGS. 2, 3 and 4, it is believed to be obvious to those skilled in the art that other arrangements of the bimetal will serve equally well, as for example, that described in United States Patent No. 2,897,-319 issued July 28, 1959 to E. R. Wolff.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electric switch comprising a frame having a pair of spaced legs joined together by a pair of spaced end members, said legs and end members defining a window in the frame; means for supporting said frame on a pivotal axis transverse to and adjacent one end of the frame whereby the other end of the frame can oscillate between first and second spaced stops; means for applying a force to said frame at a point adjacent said axis for biasing said other end of the frame against said first stop; a contact arm supported at one end thereof for pivotal movement on an axis adjacent and substantially parallel to said other axis whereby the other end of said arm can oscillate through said window between first and second position; spring means interconnecting said frame and arm and urging them in opposite directions whereby said arm can be moved with over-center snap action from said second to said first position by movement of the other end of said frame from said first toward said second stop; automatically actuated means for moving the other end of said frame from said first toward said second stop; means for moving said arm from said first to said second position whereby the contact arm may be reset manually or adapted for automatic resetting; and fixed contact making with a first contact on said arm when the arm is in said second position.

2. A switch as defined in claim 1 wherein said reset means comprises a second contact on said arm; and an auxiliary contact movable manually between third and fourth positions and through movement from said third to said fourth position moving said contact arm therewith from said first to said second position, said auxiliary contact when in said fourth position acting as a stop to cause automatic resetting of said arm to said second position.

3. A thermally responsive device compensated for ambient temperature comprising a bimetallic strip, an over-

center switch mechanism comprising a bimetallic frame spaced from said strip in side by side relationship and supported for pivotal movement on a transverse axis adjacent one end of the frame; an arm supported for pivotal movement on an axis adjacent and substantially parallel to said first mentioned axis; means interconnecting said arm and frame whereby pivotal movement of said frame in one direction causes pivotal movement of said arm in the opposite direction; and an actuator for transmitting deflection of said strip to said frame to cause pivotal movement thereof, the arrangement of said strip relative to said frame being such that upon being heated both deflect in the same general direction in at least the vicinity of said actuator.

4. A thermally responsive device compensated for ambient temperature comprising a bimetallic strip supported for deflection such that one end thereof can move; an overcenter switch mechanism comprising a frame spaced from said strip in side by side relationship and supported for pivotal movement on a transverse axis adjacent one end of the frame, said frame consisting of a pair of spaced bimetallic legs joined together at the ends thereof; an arm supported at one end thereof for pivotal movement of its other end between said legs on an axis adjacent and substantially parallel to said first mentioned axis; spring means supported by said frame and arm urging pivotal movement thereof in opposite directions whereby pivotal movement of said frame in one direction causes over center snap-action pivotal movement of said arm in the opposite direction; and an actuator for transmitting movement of said one end of the bimetallic strip to said frame to cause pivotal movement thereof, the arrangement of said strip relative to said legs being such that upon being heated both deflect in the same general direction in at least the vicinity of said actuator.

5. A thermally responsive switch compensated for ambient temperature comprising a bimetallic strip supported for deflection such that one end thereof can move; a frame spaced from said strip in side by side relationship and supported for pivotal movement on a transverse axis adjacent one end of the frame, an overcenter switch mechanism comprising said frame being formed from bimetallic strip into a pair of spaced legs with a pair of spaced end members; a contact arm supported at one end thereof for pivotal movement of its other end between said legs on an axis adjacent and substantially parallel to said first mentioned axis; spring means supported between the free end of said frame and arm urging pivotal movement thereof in opposite directions whereby pivotal movement of said frame in one direction causes over-center snap action pivotal movement of said arm in the opposite direction; a slidably mounted actuator for transmitting movement of said one end of the bimetallic strip to said frame to cause pivotal movement thereof; and means biasing said frame against movement by said actuator, the arrangement of said strip relative to said frame being such that upon being heated the strip and frame tend to warp in opposite directions.

6. A thermally responsive switch compensated for ambient temperature comprising an insulating housing; a bimetallic strip positioned upright in said housing; means for supporting said strip for deflection of the lower end thereof; an overcenter switch mechanism comprising a frame positioned upright in said housing and spaced from said strip in side by side relationship, said frame being formed from bimetallic strip into a pair of spaced legs integral with a pair of spaced end members defining a window; means for supporting said frame at the lower end thereof for pivotal movement on an axis transverse to the frame; a contact arm positioned upright in said housing; means for supporting said arm at the lower end thereof for pivotal movement on an axis adjacent and substantially parallel to said first mentioned axis; spring means supported between the upper end of said frame and arm urging pivotal movement thereof in opposite directions whereby pivotal movement of said frame in one direction causes over-center snap action pivotal movement of said arm in the opposite direction, the upper end of said arm moving along an arcuate path through said window; an actuator slidable in said housing and positioned between said strip and frame near the lower ends thereof, said actuator transmitting movement of the lower end of said bimetal to said frame to cause pivotal movement thereof; and means biasing said frame against pivotal movement by said actuator; the relative positioning of said strip and frame being such that the low expansion side of the strip faces in a direction opposite to that faced by the low expansion side of the frame.

7. A circuit interrupter comprising an arm movable between first and second positions, said arm closing main contacts in said second position; an over-center mechanism adapted to move said arm between said first and second positions with over-center snap action; a contact surface on said arm; an auxiliary contact manually movable between third and fourth positions, said auxiliary contact adapted to make with said contact surface in said third position and thereby stop said arm in said first position, said auxiliary contact also adapted when moved from said third to said fourth position to move said arm therewith to a position just over-center in said mechanism and thereafter allow unobstructed movement of said arm between said second position and said auxiliary contact; and means responsive to a predetermined condition for automatically moving said arm from said second position until stopped by said contact surface striking said auxiliary contact.

8. A circuit interrupter comprising a frame supported for pivotal movement on a transverse axis at one end thereof; spring means biasing said frame into a normal position; an arm supported on an axis adjacent and substantially parallel to said first mentioned axis for pivotal movement between first and second positions; means interconnecting said arm and frame whereby pivotal movement of said frame in one direction causes pivotal movement of said arm in the opposite direction with over-center snap action between said first and second positions, said arm closing main contacts in said second position; a contact surface on said arm; an auxiliary contact manually movable between third and fourth positions, said auxiliary contact adapted to make with said contact surface in said third position and thereby stop said arm in said first position; said auxiliary contact also adapted when moved from said third to said fourth position to move said arm therewith to a position just over-center with respect to the normal position of said frame and thereafter allow unobstructed movement of said arm between said second position and said auxiliary contact; and means responsive to a predetermined condition for automatically moving said frame whereby movement thereof will move said arm from said second position until stopped by said contact surface striking said auxiliary contact.

9. A circuit interrupter comprising a pair of integral arms supported on pivot means for movement of the end of each arm in an arcuate path to either a first, or second, or third position; main contact means carried by the first arm and adapted to make with fixed contact means in said second position; an auxiliary contact on the second arm, a reset device moveable manually between fourth and fifth positions; another contact on said reset device, said other contact adapted to make with said auxiliary contact and limit the movement of said arms to said first and third positions respectively; an over-center mechanism adapted to move said arms between said first and second positions with over-center snap action; said reset device adapted when moved from said fourth to said fifth position to move said arm therewith from first position over center in the mechanism to said third position and thereafter allow unobstructed movement of said arm between said second and third positions; and automatic means for actuating said over-center mechanism to move said arm from said second to either said first or third position.

10. A thermally responsive device compensated for changes in ambient temperature conditions comprising a bimetallic strip, an elongated bimetallic frame spaced from said strip and supported independently thereof for pivotal movement on an axis intermediate and transverse to its length, said frame having a first portion extending from said axis in one direction and a second portion extending from said axis in the other direction along a path which curves towards said bimetal such that the end of said second portion lies between the strip and the frame; switching means adapted to be actuated by movement of said first portion; and an actuator mechanically connecting said strip to said second portion for transmitting deflection of said strip into pivotal movement of said frame, the arrangement of said frame relative to said strip being such that upon being heated both deflect in the same general direction in at least the vicinity of said actuator.

11. A thermally responsive device compensated for changes in ambient temperature conditions comprising a bimetallic strip; an elongated bimetallic frame spaced from said strip and supported independently thereof for pivotal movement on an axis intermediate and transverse to its length, said frame having a first portion extending from said axis in one direction and the second portion extending from said axis in the other direction along a path which curves towards said strip such that the end of said second portion lies between the strip and first portion on the same side of said axis as said first portion; switching means adapted to be actuated by movement of said first portion; and an actuator mechanically connecting said strip to the free end of said second portion for transmitting deflection of said strip upon a rise of temperature thereof into pivotal movement of said frame, said deflection of the strip being in a direction towards said frame, the arrangement of said frame relative to said strip being such that upon being heated said frame deflects in a direction away from said actuator.

12. A circuit interrupter comprising a contact carrier movable between first and second position, said carrier closing main contacts in at least one of said positions; an over-center mechanism adapted to move said carrier between said first and second positions with over-center snap action; a contact surface associated with said carrier; an auxiliary contact manually movable between third and fourth positions, said auxiliary contact adapted to make with said contact surface in said third position and thereby stop said arm in said first position, said auxiliary contact also adapted when moved from said third to said fourth position to move said carrier therewith to a position just over-center in said mechanism and thereafter allow unobstructed movement of said carrier between said second position and said auxiliary contact; and means responsive to a predetermined condition for automatically moving said carrier from said second position until stopped by said contact surface striking said auxiliary contact.

13. A thermally responsive switch compensated for ambient temperature comprising an insulating housing, a bimetallic strip positioned upright in said housing, means for supporting said strip for deflection of its lower end, a frame positioned upright in said housing and spaced from said strip in side by side relationship, said frame being formed from bimetallic strip into a pair of spaced legs integral with a pair of spaced end members defining a window with the low expansion side of said frame facing the low expansion side of said strip; means for supporting said frame at the lower end thereof for pivotal movement on an axis transverse to the frame; the supported end of said frame extending well beyond its pivotal axis, said extension being bent from the plane of the frame in a direction of said strip so as to place the end of the extension between the other part of the frame and the strip; a contact arm positioned upright in said housing; means for supporting said arm at the lower end thereof for pivotal movement on an axis adjacent and substantially parallel to said first mentioned axis; spring means supported between the upper end of said frame and arm urging pivotal movement thereof in opposite directions whereby pivotal movement of said frame in one direction causes overcenter snap action pivotal movement of said arm in the opposite direction, the upper end of said arm moving along an arcuate path through said window; an actuator slidable in said housing and positioned between said strip and frame near the lower ends thereof, said actuator transmitting movement of the lower end of said bimetal to said extension to cause pivotal movement of said frame on said pivotal axis and means biasing said frame against pivotal movement by said actuator.

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