Nov. 19, 1946. G. C. ARMSTRONG 2,411,351

OVERLOAD RELAY

Filed April 1, 1942 4 Sheets-Sheet 1

Fig. 1.

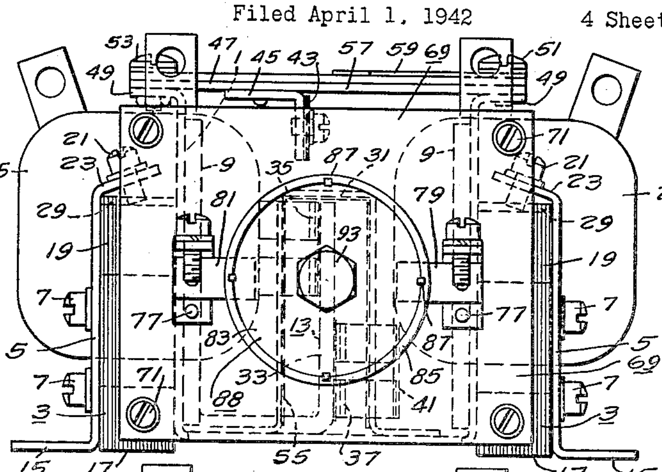


Fig. 2.

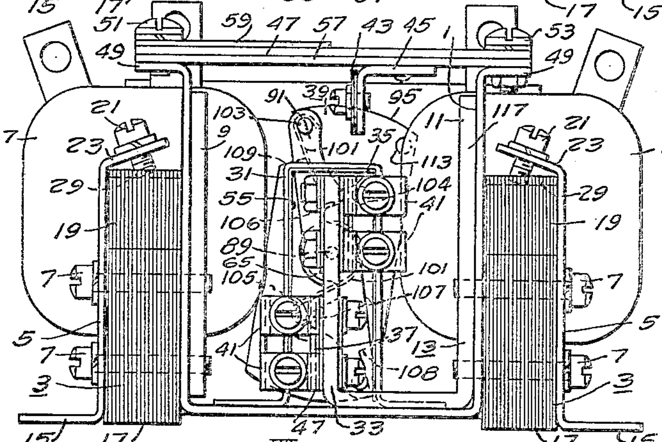
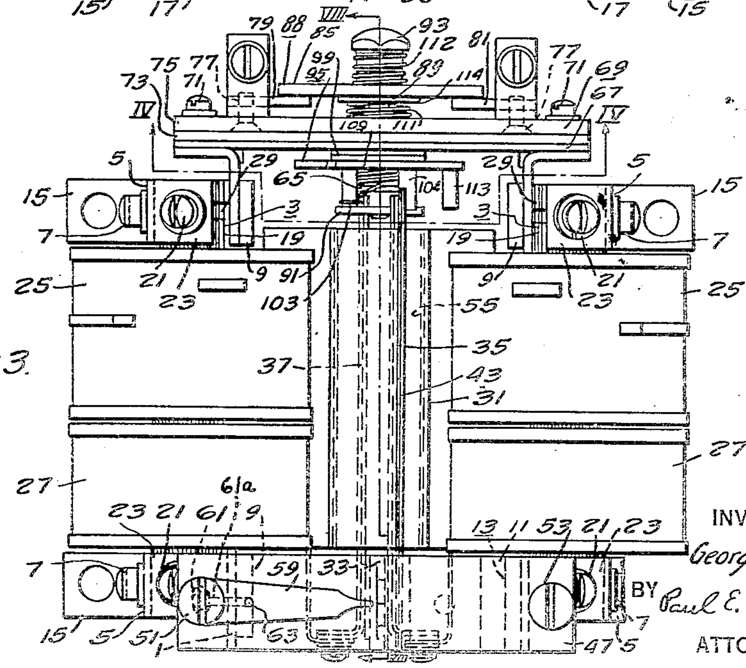


Fig. 3.



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2,411,351

OVERLOAD RELAY

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Fig. 4.

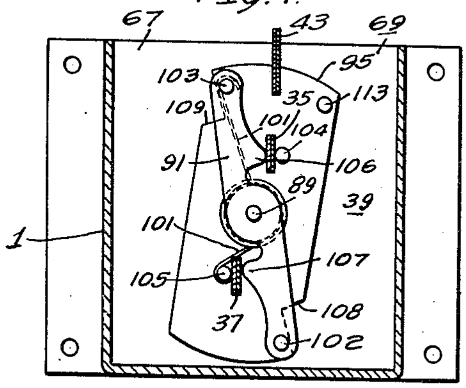


Fig. 5.

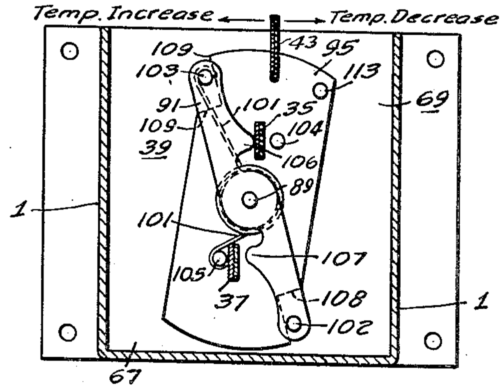


Fig. 6.

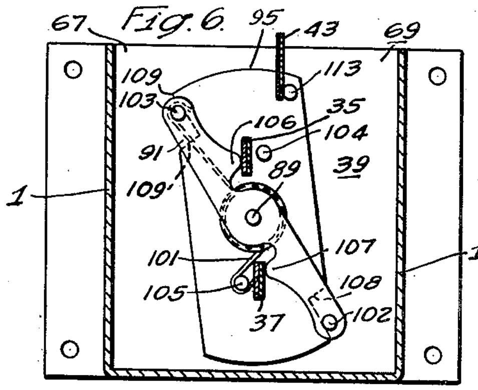
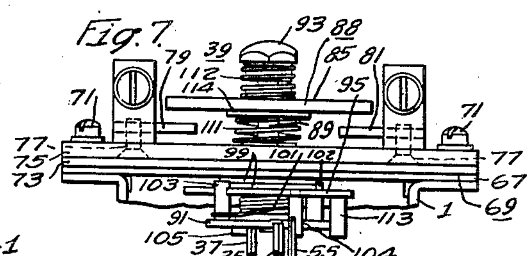


Fig. 7.



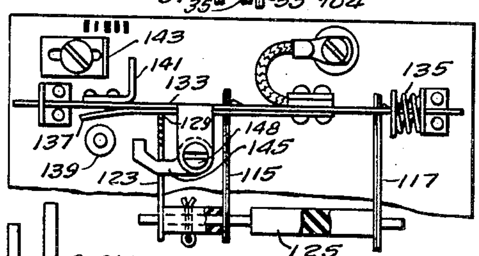


Fig. 13.

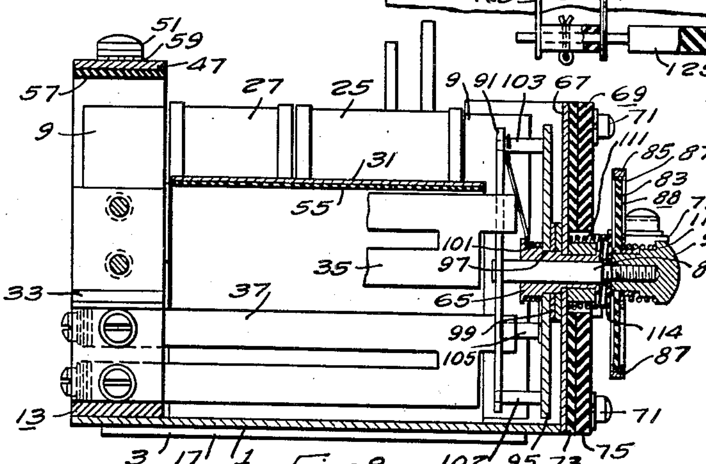


Fig. 8.

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Fig. 9.

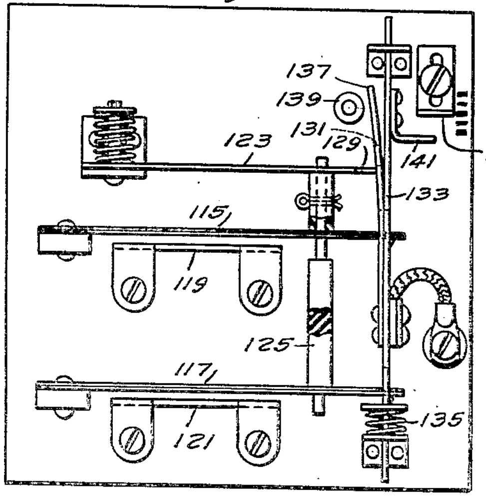


Fig. 10.

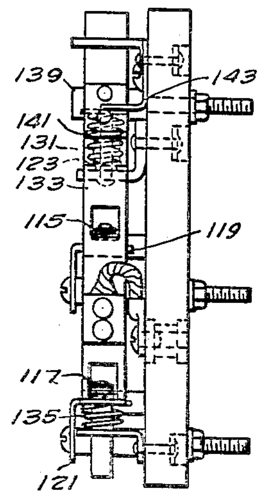


Fig. 11.

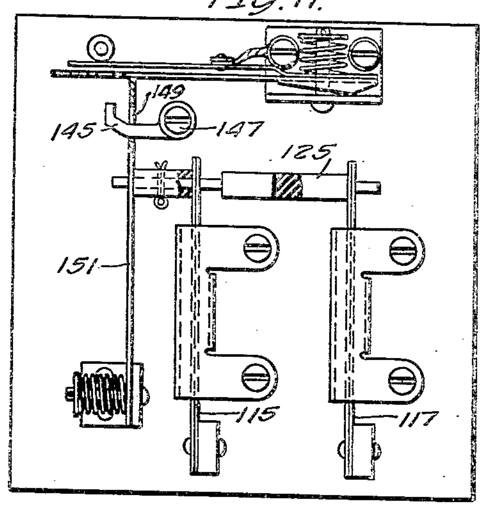


Fig. 12.

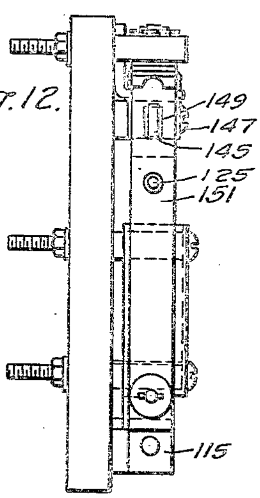
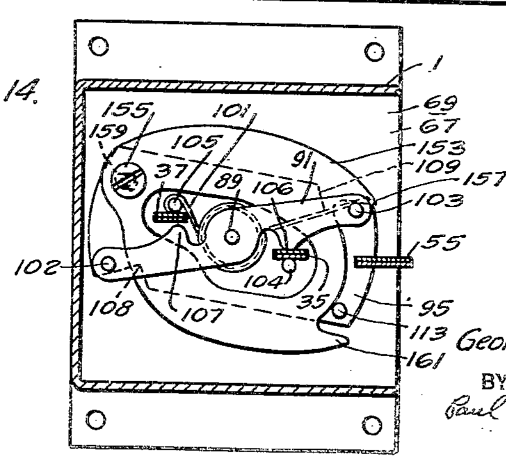


Fig. 14.



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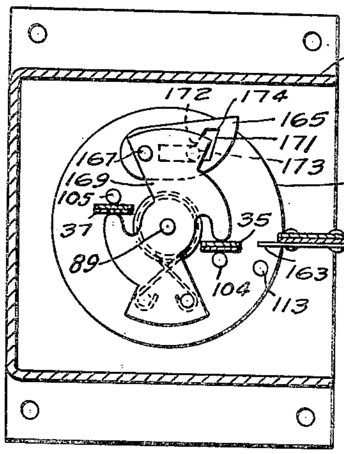

Fig. 15.

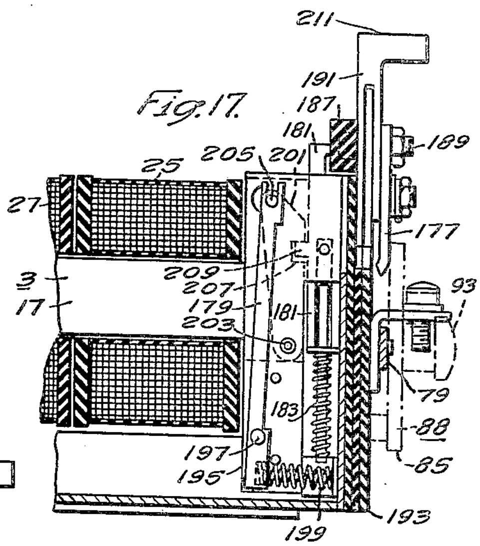

Fig. 17.

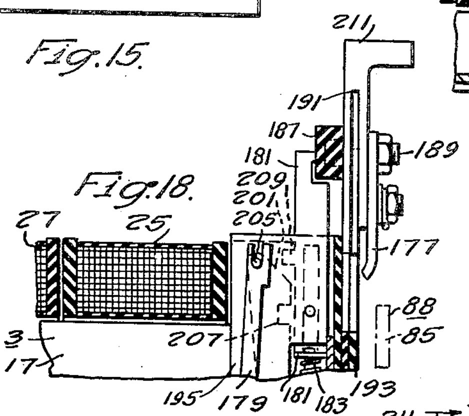

Fig. 18.

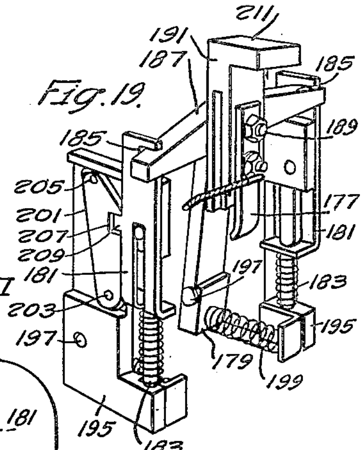

Fig. 19.

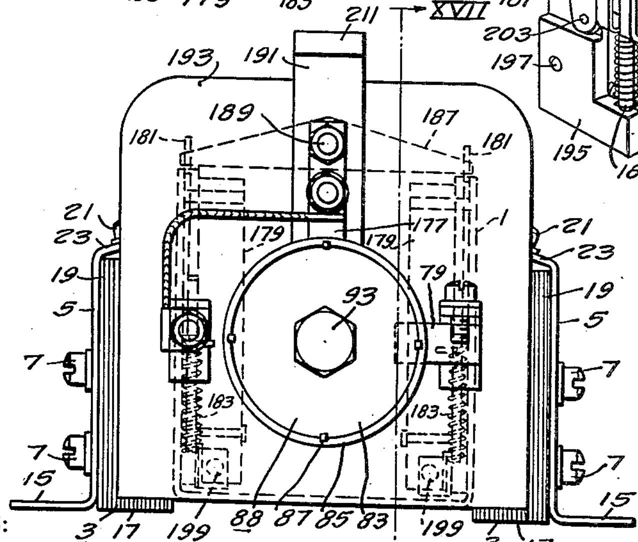

Fig. 16

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UNITED STATES PATENT OFFICE

2,411,351

OVERLOAD RELAY

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Application April 1, 1942, Serial No. 437,235

24 Claims. (Cl. 175—294)

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My invention relates to shock resisting overload relays particularly those useful in protecting motors from excessive currents and which say, a given relay is, responsive to the motor current through selectively operable thermal and magnetic operating means.

More specifically my invention relates to an overload relay having therein a tripping element unaffected by a shock of predetermined value, which involves, by way of example, a plurality of current carrying bimetals which, upon determined heating due to excessive currents passing therethrough, will actuate the tripping element to trip the relay, and a pair of armatures either of which in the event of excessively high currents will trip the relay.

An object of my invention is to provide a solidly constructed relay capable of withstanding heavy shock.

Another object of my invention is to provide a thermal overload relay which will not trip under heavy shock when carrying a large percentage of rated current.

Another object of my invention is to provide a thermal overload relay which shall be compensated for ambient temperature.

A specific object of my invention is to provide a thermal overload relay solidly constructed on a steel frame and having a balanced tripping mechanism requiring a relatively great travel for tripping, thereby reducing the effect of mechanical shock.

Another object of my invention is to provide a thermal overload relay having therein a plurality of poles for protecting each phase of the system in which the relay is used.

A specific object of my invention is to provide a thermal overload relay having therein a plurality of poles for protecting each phase of the system in which the relay is used and having therein means for quickly tripping the relay in case of an open phase and after a predetermined time delay during normal overload conditions.

Another object of my invention is to provide a thermal overload relay having therein an inertia element or latch to prevent tripping of the relay when subjected to mechanical shock.

Another object of my invention is to provide an overload relay having therein tripping means responsive either to thermal or magnetic effects, both caused to operate by the motor armature current.

A specific object of my invention is to provide a thermal and magnetically actuated overload relay solidly constructed on a steel frame, having

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therein a balanced tripping mechanism designed to reduce the effect of mechanical shock, a plurality of bimetallic elements heated by excessive currents which selectively actuate the tripping mechanism to quickly trip the relay in case of an open phase in the system which it protects. But the bimetallic elements also provide a predetermined time delay during normal overload conditions. Further tripping means magnetically controlled are provided to instantly trip the relay in the event of excessively high currents due to a short circuit, and means are included for automatically compensating for changes in ambient temperature as well as means adjustably fixing the rating of the relay above and below 100% of rated current.

Other objects and advantages will become more apparent from a study of the following specification when considered in conjunction with the accompanying drawings, in which:

Figure 1 is an end view of an overload relay embodying the principles of my invention;

Fig. 2 is a view of the end opposite to that of Fig. 1;

Fig. 3 is a plan view of the overload relay;

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 3;

Fig. 5 is a sectional view similar to Fig. 4, but with the tripping mechanism shown as tripped by one actuating bimetal;

Fig. 6 is a sectional view similar to Fig. 4 but with the tripping mechanism shown as tripped by both actuating bimetals;

Fig. 7 is a top view of the tripping mechanism as shown in the open phase tripped position in Fig. 5;

Fig. 8 is a sectional view taken on the line VIII—VIII of Fig. 3;

Fig. 9 is a plan view of a relay embodying certain principles of my invention having plane movement for its tripping action;

Fig. 10 is an end view of Fig. 9;

Fig. 11 is a plan view of a relay having plane movement of its tripping mechanism and an inertia latch for resisting shock;

Fig. 12 is an end view of Fig. 11;

Fig. 13 is a fragmentary plan view of the tripping mechanism shown in Figs. 9 and 10 having an inertia element for resisting shock.

Fig. 14 is a plan view of the tripping mechanism shown in Figs. 1–8, inclusive, having an inertia element for resisting shock;

Fig. 15 is a modified form of tripping mechanism having rotary movement for tripping and an inertia latch for resisting shock;

Fig. 16 is a view of the contact end of a relay embodying a magnetic tripping means;

Fig. 17 is a sectional view taken on the line XVII—XVII of Fig. 16 with the relay contacts closed;

Fig. 18 is a fragmentary sectional view in the same section plane as Fig. 17 but with the relay contacts opened by action of the magnetic tripping means.

Fig. 19 is a perspective view of the magnetic tripping assembly.

Referring more particularly to Figures 1, 2 and 3 of the drawings, numeral 1 denotes a U-shaped frame member to which are fastened the transformer cores 3 and mounting brackets 5 by means of screws 7 extending through the brackets, transformer cores and the side walls of the U-frame 1 to thread into tapped holes in the strengthening strip 9 and one leg 11 of U-member 13, all of which are mounted against the inner wall of the frame 1, to clamp the assembly rigidly in position. The outwardly bent bottom portion 15 of the brackets 5 having holes drilled therethrough, provide means for mounting the relay.

The transformer cores 3 are of laminated construction and are assembled in two pieces. The lower sections 17 are secured to the frame 1 by the screws 7 while the upper section 19 are of the form of straight bars and seat upon the ends of upwardly extending portions of the lower core sections 17. Clamping screws 21 threading through tapped holes in the inwardly bent top portion 23 of the brackets 5 clamp the upper sections 19 of the transformer cores 3 in position. This construction facilitates the assembly of the primary coils 25 and the secondary coils 27 about the upper sections 19, said assembly being accomplished by positioning the coils in their respective positions and sliding the upper core sections through openings in the centers of the coils. Once in place the upper core sections 19 are held in accurate location by seating the screws 21 in the slots 29.

An internally thermally and electrically insulated shielding member 31 open at its ends is fastened to the frame 1. At one end of said shielding member is the leg 33 of U-member 13 to the right top side of which leg as seen in Fig. 2 is insulatedly secured at its open end a hairpin shaped or bifurcated current carrying bimetal 35. To the lower left side of said leg is insulatedly secured a second bimetal 37 similar to the first. Both bimetals are of sufficient length to extend through the shield 31 and engage cooperating parts of the tripping mechanism indicated generally at 39 which they actuate. A pair of leads or connections 41 extending from each of the secondary coils are fastened to the open ends of the bimetals thus completing a current path from a secondary coil through a bimetal and back again to the coil. The primary coils are connected to the motor circuit.

A third bimetal 43 is fastened to an angle 45 insulatedly mounted on the bottom of a laminated cross member 47 which bridges the frame 1 and is fastened in position on turned out portions 49 of frame 1 by screws 51 and 53. The bimetal extends longitudinally of the relay similarly to the hairpin bimetals and is of sufficient length to intercept a cooperating part of the tripping mechanism. As viewed in Fig. 2 this bimetal is disposed directly above the shield 31 through which the current carrying bifurcated bimetals pass and is protected from heat transfer from said bimetals by said shield, the inner walls of which are coated with a heat resisting material 55, and thermally insulated from the frame by the insulating element 57 of the laminated cross member 47. Ambient temperature changes produce deflections in bimetal 43 in the same direction relative to rotation of the tripping element as produced in the bifurcated bimetals.

The shield 31 serves several purposes. It decreases loss of heat from the activating bimetal elements, thereby decreasing the power input required to operate the device. It decreases heat transfer to the compensating bimetal; inasmuch as the effective tripping temperature of the actuating bimetals is the difference between their temperature rise and the temperature rise due to heat transfer to the compensating or ambient temperature bimetal, such heat transfer reduces the sensitivity and affects the tripping time characteristics. So shielding the actuating bimetals from the compensating bimetal increases the tripping time on small overloads. The shield also acts to increase the tripping time at small overloads in another way. Restrictions of ventilation about the bimetals results in the gradual heating of the air so enclosed within the shield. It restricts circulation of air to the adjacent surfaces of the coils and the frame. Consequently upon the relatively rapid heating of the bimetals due to internal heating is superimposed, first the reactive heating due to the increase of air temperature within the shield, second the reactive heating due to internal heat absorption of the shield and finally reactive heating due to the more gradual heating of the coils and the frame. The compensating bimetal is so ventilated and its mounting so insulated as to isolate it as much as possible from these secondary temperature changes. The cross section of the transformer iron and the resistance of the secondary circuits are carefully selected to cause a certain degree of magnetic saturation at high overloads. All of these effects are utilized to give the relay highly advantageous time characteristics, namely a long tripping time at small overloads which the protected motor can carry for an hour or more without attaining an excessively high temperature and a tripping time at current equivalent to locked-rotor currents which are sufficiently long to allow the motor to accelerate high inertia loads yet short enough to protect the motor if it fails to start. The tripping time at high overloads can be easily modified to meet special requirements by changing the number of laminations in the transformers removable core assembly.

The rating of the relay is adjustable within predetermined limits above and below 100% rating, said adjustment being accomplished as shown in Fig. 3. A pointer 59 shown in the 100% rating position is pivoted about the screw 51 extending through a slot 61 through one end of the cross member 47 and threadedly engaging a turned out portion 49 of the frame 1. A pin 63 rigidly fastened in the pointer rotatably engages the cross member 47 in the slot 61*a*. The entire assembly is locked in any of its positions by tightening the screw 51. If the pointer 59 is rotated clockwise it will be seen that the pin 63 will rotate the cross member 47 counterclockwise about screw 53 within limits imposed by the slot 61. With the bimetal 43 fastened to said cross members as hereinbefore described, counterclockwise rotation of its mounting will move the free end of the bimetal to the left thereby increasing the travel of the tripping mechanism before tripping takes place and increasing the rating of the relay. Rotation of the pointer counterclockwise will move the free end of the bimetal **43** to the right to decrease the rating of the relay.

Referring now to Figs. 4 to 8, inclusive, of the drawings, in which the tripping mechanism has been particularly shown, said tripping mechanism is denoted generally at **39** and is pivotally mounted in a sleeve bearing **65** secured in a metal plate **67** of the laminated plate assembly **69** secured to outwardly bent portions of the frame **1**, by a plurality of screws **71**. Said laminated plate assembly comprises the metal plate **67** and a pair of insulating plates **73** and **75**. The outer insulating plate **75** has holes drilled therethrough and countersunk in its inner face to receive screws **77** of a corresponding shape in a manner to present a flush surface on its inner face. To its outer face is fastened by means of said screws a pair of stationary contacts **79** and **81**. Insulating plate **73** forms an insulating barrier between the screws **77** and the frame **1**.

An insulating disc **83** having fitted on its periphery a metal ring **85** which is secured thereon by pressed over portions **87** forms a movable contact **88** which bridges the stationary contact elements **79** and **81**.

In Fig. 8, I have shown a sectional view through the center line of the tripping mechanism **39**. A shaft **89** having riveted to its one end a latch element **91** and its other end reduced in diameter and threaded to receive a nut **93** is pivotally and slidably mounted within the sleeve bearing **65**. A catch element **95** which cooperates with the latch **91** is pivotally mounted about the sleeve bearing **65** and prevented from traveling axially by the shoulder **97** on the one side and washers **99** disposed between the catch element and the plate **67** on the other. A torsion spring **101** positioned about the end of the sleeve bearing **65** has one end secured about a pin **103** in the latch element **91** and its other end secured to a pin **105** in the catch element **95** which will, as seen in Fig. 4, bias the latch element **91** clockwise and the catch element **95** counterclockwise to contact the pins **104** and **105** against one side of the ends of the bifurcated or hairpin bimetals **35** and **37** and the projections **106** and **107** of the latch element against the other side when the movable contact **88** is in engagement with the stationary contacts **79** and **81**.

As may be seen in Figs. 4, 5 and 6, the latch **91** and catch element **95** of the tripping mechanism are positioned and balanced about the same axis of rotation. The torsion spring **101** biases the latch element **91** away from tripping position. As a result, reaction forces on these elements due to heavy vibrations of the relay will be equally distributed about their axis of rotation thereby greatly reducing the possibilities of tripping from this source.

Open phase protection

If one phase of the motor circuit is open so that only one of the actuating or bifurcated bimetals **35** and **37** is heated, the other actuating bimetal being cold and therefore stationary will so bias the catch element **95** of the tripping mechanism **39** as to prevent its moving. It will, therefore, be seen that counterclockwise movement of the latch element **91** being actuated by the heated bimetal will be relatively small before tripping is accomplished.

Assuming for the moment that the upper actuating bimetal **35** is in circuit with a phase of a motor which is closed, it will be apparent that excess-currents passing through the bimetal will cause heating which heating will deflect said bimetal to the left against the projection **106** of the latch element **91** to begin rotation of said latch element counterclockwise. During this time, however, the lower actuating bimetal **37** being in circuit with a phase which is open is not heated and remains stationary, and by its contact with pin **105** prevents the catch element from rotating with the latch element. As a result the pins **102** and **103** immediately clear the edges of the notches **108** and **109** in the catch element allowing the shaft **89** to be thrust axially to the right (Fig. 8) by the compression spring **111**, unseating the movable contact from the stationary contacts as shown in Fig. 7. The movable contact is biased by the compression spring **112** against the stationary contacts when the relay is closed and against a washer **114** of insulating material locked between a shoulder on shaft **89** and the nut **93** when the relay is open. This slidable mounting provides sufficient resilience that the movable contact may properly seat itself on the stationary contacts.

The small travel of the latch element **91** for single or open phase tripping is an important feature for the following reasons.

With any multipole relay in which the several poles act on a single tripping mechanism the current required to trip the relay with one pole only is greater than with all poles heating and acting because only one bimetal supplies the force necessary for tripping. Therefore the load on said bimetal is increased. In addition there is the absence of heat transfer between the poles which would ordinarily cause each to reach a higher temperature than if heated alone.

Also in case of an open phase the increase in current of a three phase motor running single phase in many cases is not greatly in excess of the minimum tripping current of the relay and unless the relay is accurately adjusted and applied it may fail to protect the motor. Further, in order to avoid tripping during starting, relays are often designed to have a tripping time which is as long as safety will permit if the load should jam and lock the rotor from turning. This is permissible because such occurrences are extremely unusual and is necessary to allow the motor to start heavy inertia loads without the relay opening. However, an open phase, due to an open fuse or connection, is much more usual, and in some cases the currents within the motor may be increased by a much greater percent from normal than the line currents. It is, therefore, more important for the relay to trip in case of single phase than for balanced operation. As a two pole relay, my inventive relay trips much more quickly in two out of the three possible phase openings in a three phase system, and in any case in a two phase system.

Normal tripping

In Fig. 6, I have shown the tripping mechanism **39** in its normally tripped position. During normal overload conditions both actuating bimetals **35** and **37** carry excess currents. The resulting heating deflects the upper bimetal **35** to the left and the lower bimetal **37** to the right against the projections **106** and **107** rotating the latch element **91** counterclockwise as here viewed.

In this instance the catch member **95** is rotated therewith by the torsion spring **101**, and by the friction of the pins **102** and **103**, there now being no obstruction to resist such rotation until the pin 113 in the catch element 95 is intercepted in its travel by the ambient temperature bimetal 43. The latch element continues to rotate until the pins 102 and 103 clear the notches 108 and 109 in the catch plate at which time tripping takes place as hereinbefore described for open phase protection. The ambient temperature bimetal 43 corrects for surrounding temperature changes. As the temperature changes the bimetal 43 is deflected in the same relative rotational direction and in proportion to deflections in the actuating bimetals 35 and 37 as produced by temperature variations and which will rotate the tripping mechanism accordingly. A uniform tripping travel for normal overload conditions is, therefore, maintained. This feature, of course, has no effect upon open phase tripping since the ambient temperature bimetal 43 plays no part in that action.

The relay can be modified to eliminate ambient temperature compensation by substituting a solid metallic strip for the compensating bimetal. In this case the element 43 can be made non-temperature-responsive.

For open phase protection my inventive overload relay may be of the form as shown in Figs. 9 and 10 wherein plane movement instead of rotational movement for tripping is used.

In this application the bimetals 115 and 117 do not carry current, although they may be readily so designed, but are heated by the heater elements 119 and 121. Here again either bimetal may actuate a latch member 123 to effect tripping. Assuming upward deflection of the upper bimetal 115 as caused by overheating due to an open phase, the actuating rod 125 being moved upwardly moves with it the latch 123 until a reduced end portion thereof 129 is adjacent a window or opening 131 in the catch element 133 at which time said latch quickly releases the catch 133 since the bottom bimetal being cold restrains the slidably mounted catch element 133 from moving upward under the influence of the compression spring 135. Releasing of the catch permits its free end 137 normally biased to engage the contact 139 completing a circuit through a relay coil to open the motor circuit (not shown). Under normal overload conditions both bimetals 115 and 117 deflect upwardly. The slidably mounted catch element 133 is moved upwardly with the bimetals and latch by the compression spring 135 until a projection 141 on said slidable catch element engages a stop 143, adjustable for changing the relay's rating, thus stopping the catch. Continued movement of the bimetals will then release the catch 133 and complete the relay circuit as before described.

As may be readily seen the type of relay shown in Figs. 9 and 10 is not necessarily limited to two poles but may have any number of poles that may be required by the system which it protects. With this embodiment of my invention, a bimetallic element may be provided for each phase in a system thus providing quick single phase protection in any case.

Relays of the type shown in Figs. 9–12 are not inherently shock resisting. In order that this type may not trip during periods in which it is subjected to mechanical shock an inertia type of latch 145 has been added. This latch is pivotally mounted at 147 to the relay base and projects through a window or opening 149 in the trip latch 151. The end projecting through the window is bent upwardly at right angles a sufficient distance

that its upper end projects above the opening 149 in the trip latch. As may be seen in the drawings, the latch is first bent upwardly at an angle then finally at a right angle to the portion of the latch extending through the window. During normal tripping when the trip latch is deflected to the left, the lower surface of the inertia latch 145 follows the window edge upon which it rests dropping the upwardly extending portion of the latch down until it will clear the window and no longer obstruct travel of the trip latch to the tripping position. If, however, the relay were subjected to sudden shock from such a direction that the trip latch 151 would suddenly be deflected to the left, the inertia latch 145 in this instance due to the instantaneously high velocity of trip latch movement will not move a substantial distance from its normal horizontal position and its upwardly extending edge will not clear the upper window edge in the trip latch thus preventing the trip latch from reaching its trip position. In this embodiment of my invention quick single phase protection is not to be had because the catch element is not slidably mounted. The distance the trip latch must travel before tripping takes place is, therefore, fixed for both single phase and normal overload tripping. Quick single phase tripping could be accomplished if, as shown in Fig. 13, the inertia latch 145 were pivotally mounted at 148 to a slidably mounted catch member 133 similar to that of Figs. 9 and 10. The inertia latch 145 in that case would move with the catch member 133 and the trip latch 123 and thereby maintain a fixed position with respect to the trip latch.

Should the resistance to shock of the particular embodiments of my invention as illustrated in Figs. 1 to 8 be insufficient, a shock absorbing weight or inertia element 153 as shown in Fig. 14 may be used as an additional safeguard. It is pivotally mounted to the catch element 95 by the screw 155 and supported on its opposite side by its projection 157 which rests upon pin 103 on the latch element 91. Forces exerted by the inertia element through the above mechanical couple will rotate the catch element counterclockwise and the latch element clockwise. In other words torques will be developed about the rotation axis of the latch and catch elements opposite to those necessary for tripping. Clearance in the hole 159 around 155 is offset so that movement of the inertia element 153 by shock to the left rotates catch element 95 counterclockwise away from tripping position by reason of its couple with the catch element at 155. Shock from any direction which will move the inertia element to the right will rotate the inertia element counterclockwise about its pivot axis 155 engaging projection 161 of the inertia element with pin 113 on the catch element to rotate said catch element counterclockwise about its pivot axis which rotation is opposite to tripping rotation. From the foregoing it may be seen that regardless of the direction of shock forces to which the relay may be subjected torques will be developed about the pivot axis of the latch and catch elements by the inertia element opposite to torques necessary for tripping.

In Fig. 15 an inertia latch 165 of the type used in the relay which employs plane movement of the tripping elements is applied to a relay having rotational movement of its tripping elements. In this instance, the inertia latch is pivotally mounted at 167 to the trip latch 169 and is carried therewith during its rotative movement.

Said inertia latch 165 is provided with a substantially L-shaped slot 171 which surrounds a pin 173 in the disc 175 and spaces the trip latch 169 from the disc 175 when the trip elements are in the closed position as shown. Said pin supports the inertia latch 165 in a substantially horizontal position.

The function of the tripping elements in this modification of my invention is identical with that shown in Figs. 1–8, inclusive. The bimetallic elements disposed between the projections on the trip latch and pins secured to the disc actuate the trip latch in single or open phase and normal overload conditions in a manner identical with that of the previously described embodiment. The ambient temperature bimetal also performs the same function as before by automatically maintaining a fixed distance between the projection 163 therefrom and the pin 113 in the disc with which it cooperates during normal overload tripping.

Assuming rotative movement of the trip latch either by normal overload or single phase tripping it is readily seen that the right-hand end of the inertia latch 165 will drop downwardly when the edge 172 of the slot 173 passes beyond the pin allowing the trip latch 169 to be rotated through an angle sufficient for tripping before the rotative movement is checked by the pin contacting the end of the slot. If, however, the relay is subjected to forces due to shock which are of a nature to cause rotation in the direction of tripping of the trip latch the inertia latch 165 due to the instantaneously high angular velocity of the trip latch will be maintained in the position shown. The length of the slot 171 in this instance being of insufficient length to permit full tripping travel of the trip latch will, therefore, prevent tripping.

In the embodiment of my invention as shown in Figs. 16 to 19, the type of thermal overload relay shown in Figs. 1 to 8 has been modified to provide instantaneous tripping in response to short circuit currents.

With contactors now available capable of interrupting short circuit currents to extremely high values for use in controllers for power house auxiliaries, and for other applications in which the motors are located close to a supply source of high capacity, it is necessary to have a relay which will trip instantaneously on such currents, to deenergize the contactor magnet. An overload relay to protect the motor from excessive loading or from stalled currents is also necessary. This embodiment of my invention combines these functions, thereby reducing cost, size and complications. The usual thermal overload relay must have its heating elements protected by quick acting fuses or back-up breaker and, for circuits capable of delivering more than 5,000 amperes, must also have same means of limiting the current which flows through the heaters, such as saturating transformers or shunts. This device uses saturating transformers as integral parts of the relay, so that the heating elements are automatically protected, even with the relatively long opening time of a contactor.

The thermal tripping operation is identical to that of the hereinbefore described relay but the contacts are modified to substitute for one of the stationary contacts a sliding contact 177 normally latched in position to contact the ring or movable contact 88. The movable contact 85 is normally latched by the tripping mechanism (not shown) to form a bridge circuit between the sliding contact 177 and the stationary contact 179. The movable butt contact 85 is thermally tripped while the sliding contact 177 is magnetically tripped.

The two transformers, having primary coils 25 energized by the current to the protected motor, and secondary coils 27 connected to the relay bimetallic elements are designed to have appreciable magnetic flux at locked rotor currents. At higher currents magnetic leakage flux rapidly increases, and actuates the magnetic armatures 179, there being one for each pole, at 12 to 15 times the thermal rating. Movement of either armature will trip the sliding contact.

The description of construction and operation is as follows. A pair of latch bars 181 (see Fig. 19) are biased upwardly by the coil springs 183. Their upper ends 185 are notched to receive the extremities of the cross arm 187 which has pivotally mounted at its center 189 a reset member 191 slidably mounted in the laminated plate assembly 69 and which serves to support and actuate the movable or sliding contact 177, thus providing independent tripping for either pole. The tripping details are assembled on a pair of plates 195, one mounted on either side of the relay, replacing the stiffening strips 11 adjacent to the primary coils 25, and secured by the two screws 7 holding the transformer to the frame. The steel armatures 179 are pivoted about the pins 197 and biased clockwise away from the primary coils by the coil springs 199. The catches 201 are pivoted at 203 and carry pins 205 which engage slots in the upper ends of the armatures. Notches 207 in the catches 201 normally engage lugs 209 on the latch bars 181 when the latter are in their downward position, with the contacts closed. When the magnetic force in either pole is sufficient to overcome the bias of either of springs 199, an armature 179 will rotate counterclockwise about its pivot disengaging the latch bar and tripping the sliding contact 177. Resetting after tripping magnetically is accomplished by pressing upon the button 211 formed on the top end of the sliding contact carrying or reset member 191 which action by means of the cross-arm 187 forces the latch bars 181 down against the bias of the coil springs 183 until the lugs projecting therefrom are reengaged by the notches in the catches 201. The sliding contact carrying member 191 is grooved to slide in a guiding slot in the insulating front plate of the relay.

Because the magnetic force does not attain effective magnitude until the transformer saturates, no adjustment is necessary, the springs being designed to trip at 12 to 15 times coil thermal trip rating. The instantaneous trip rating is changed simultaneously with the thermal rating by changing the primary coils.

The shielding effect of the frame and the properly limited size of the armature, prevent the development of magnetic forces above the strength of the parts. The light masses and strong tripping springs give very high speed action at high currents.

I am, of course, aware that others, particularly after having had the benefit of the teachings of my invention, may devise other devices embodying my invention and I, therefore, do not wish to be limited by the specific showing made in the drawings or the descriptive disclosure hereinbefore made, but wish to be limited only by the scope of the appended claims.

I claim as my invention:

1. A thermally responsive device comprising, in

combination, a pair of thermally responsive elements which deflect when heated, pivotally mounted tripping means actuated by the deflections of said thermally responsive elements, movable contacting means slidably disposed about the pivot axis of said tripping means, spring means disposed about said pivot axis between said movable contact and said tripping means for effecting snap-action of said movable contact, and a bimetallic element exclusively responsive to ambient temperature for effecting uniform tripping travel of the tripping means during surrounding temperature changes.

2. Apparatus as recited in claim 1, together with means for adjustably supporting said bimetallic element responsive to ambient temperature to provide an adjustment of its fixed position within predetermined limits to effect predetermined variation of the travel of the tripping means necessary for tripping.

3. A thermal overload device comprising, in combination, a pair of bimetallic elements of the form of bifurcated strips, means for passing electric current therethrough for heating the same, pivotally mounted tripping means balanced about its pivot axis and spring means for biasing the same away from tripping position thereby reducing the relative effect of vibrations or mechanical shock due to impact of large magnitude imposed upon the relay, said tripping means being actuated by deflections of said bimetallic elements being heated, resiliently mounted movable contact means slidably disposed about the pivot axis of said tripping means, spring means disposed about said pivot axis between said movable contacting means and said tripping means for effecting snap action of said movable contact, a bimetallic element of the form of a flat strip exclusively responsive to ambient temperature for effecting uniform tripping travel of the tripping means during surrounding temperature changes.

4. A thermally and magnetically responsive device comprising, in combination, a plurality of bimetallic elements, transformer means for heating the same, tripping means, a movable contact operated by said tripping means in response to deflections of said bimetallic elements being heated by said transformer means, separate tripping means responsive to magnetic effects operable upon magnetic saturation of said transformer, and a sliding contact engageable with said movable contact and actuated by said magnetically responsive tripping means.

5. A thermally and magnetically responsive device comprising, in combination, a pair of bimetallic elements, a pair of poles, each pole comprising primary and secondary coils, thus forming, in effect, on each pole, a transformer, one of said secondary coils being in circuit with one of said pair of bimetallic elements, the other of said secondary coils being in circuit with the other of said pair of bimetallic elements, for heating the same, tripping means actuated by said bimetallic elements being heated, movable contacting means actuated by said tripping means, a bimetallic element responsive to surrounding temperature changes for effecting uniform tripping travel of the tripping means during surrounding temperature changes, separate tripping means responsive to the magnetic field surrounding said poles, and a sliding contact engageable with said movable contacting means and actuated by said magnetically responsive tripping means.

6. Apparatus as recited in claim 5, in which said tripping means responsive to magnetic effects comprises a pair of armatures disposed in proximity to said poles, spring means for biasing said armatures away from said poles, catch means controlled by either of said pair of armatures, latch means, said latch means being releasably engaged by said catch means, spring means for biasing said latch means to tripped position, said sliding contact being actuated by said latch means for disengaging the sliding contact from said movable contacting means.

7. Apparatus as recited in claim 5, in which said tripping means responsive to magnetic effects comprises a pair of armatures, a pair of springs for biasing each of said armatures into normal or latched position, a pair of catches, each engaging one of said pair of armatures to be controlled by movements thereof, a pair of latches, each of said catches releasably engaging one of said pair of latches, a cross-arm or bridging member engaged at its ends in cooperating notches in said pair of latches, said sliding contact being pivotally mounted centrally of said bridging member and guided for travel in a fixed line for effecting disengagement thereof with said movable contacting means upon release of either of said latches when one of said armatures is actuated and upon release of both of said latches when both of said armatures are actuated.

8. In a relay, a stationary contact, a movable contact mounted for movement back and forth between positions engaging and disengaging said stationary contact, and having a bias to one of said positions, tripping means for holding said movable contact against movement under its bias comprising a pair of members movable relative to each other to tripping position for releasing said movable contact for movement under its bias, and a pair of temperature responsive elements, each of said elements having a connection to both of said members for effecting simultaneous movement thereof without movement therebetween when both elements are heated, one of said elements being effective to anchor one of said members and the other being effective to move the other of said members to tripping position when only one of said elements is heated.

9. In a relay, a stationary contact, a movable contact mounted for movement back and forth between positions engaging and disengaging said stationary contact, and having a bias to one of said positions, tripping means for holding said movable contact against movement under its bias comprising a pair of members movable relative to each other to tripping position for releasing said movable contact for movement under its bias, and a pair of temperature responsive elements, each of said elements having a connection to both of said members for effecting simultaneous movement thereof without movement therebetween when both elements are heated, a stop engageable with one of said members for arresting movement thereof after a predetermined movement of both of said members, each of said elements through said connections functioning as a stop when only one of said elements is heated, operation of said stop or one of said elements as a stop being effective to cause relative movement between said members to trip said tripping means.

10. In a relay, a stationary contact, a movable contact mounted for movement back and forth between positions engaging and disengaging said stationary contact, and having a bias to one of said positions, tripping means for holding said movable contact against movement under its bias

comprising a latch member and a catch member, said members being mounted for movement in the same direction and for relative movement with respect to each other to tripping position, a pair of temperature responsive elements, each of said elements having a connection with said members for effecting movement thereof in the same direction when both of said elements are heated, a stop engageable with one of said members for arresting movement thereof after a predetermined movement of both of said members, each of said elements functioning as a stop through said connections when only one of said elements is heated.

11. In a thermal overload relay, a pair of contacts movable to and from engaged and disengaged positions, and means for operating said contacts to one of said positions comprising a pair of thermostats respectively comprising a temperature responsive element, and means intermediate said elements and contacts for operating said contacts upon a predetermined movement of said thermostats when both of said elements are heated, and upon a smaller movement of said thermostats when only one of said elements is heated.

12. In a thermal overload relay, a pair of contacts movable to and from engaged and disengaged positions, and means for operating said contacts to one of said positions comprising a pair of thermostats respectively comprising a temperature responsive element, and means intermediate said elements and contacts operative upon travel thereof a predetermined distance in response to heating of both of said elements for operating said contacts, and operative upon a travel thereof a shorter distance in response to heating of only one of said elements for operating said contacts.

13. In a thermally and magnetically operated overload relay, the combination of, a contact assembly including a pair of movable contacts, movement of either of said movable contacts being effective to open the contact assembly, core members, inductively related windings on each of the core members, tripping means for one of said movable contacts; thermally responsive means electrically associated with the inductively related windings for operating the tripping means, an inertia member forming a part of the tripping means for biasing said tripping means against movement to tripping position, second tripping means for operating the other of said movable contacts, and a magnetically operated member adjacent each of said core members for operating said second tripping means.

14. In a thermally and magnetically operated overload relay, the combination of, a stationary contact, a slidably mounted contact, a movable contact for bridging the stationary and slidably mounted contacts, a pair of core members, a primary and a secondary winding on each of said core members, a bimetallic element connected across each of said secondary windings, tripping means for operating said movable contact, said bimetals engaging cooperating parts of said tripping means for operating the tripping means, an inertia latch forming a part of the tripping means for preventing tripping of said tripping means as a result of mechanical shock, tripping means for operating the sliding contact, and a magnetically operated member disposed in proximity to each of said core members for operating said second mentioned tripping means.

15. In a thermally and magnetically operated relay, the combination of, a contact assembly including a pair of movable contacts, movement of either of said contacts opening said contact assembly, tripping means for one of said movable contacts, a plurality of bimetallic elements having connections to cooperating parts of the tripping means for operating the tripping means, a plurality of pole assemblies including inductively related windings, each of said bimetallic elements being electrically associated with a winding of one of said pole assemblies, a bimetallic element exclusively responsive to ambient temperature changes for regulating operation of the tripping means, an inertia latch forming a part of the tripping means for biasing said tripping means against movement to tripping position as a result of mechanical shock, second tripping means for operating the other of said movable contacts, and means associated with each of said pole assemblies and responsive to the magnetic field about each of said pole assemblies for operating the second tripping means.

16. In an overload relay, the combination of a plurality of transformers each forming a pole assembly of the relay, a contact assembly comprising a pair of movable contacts each constructed and arranged to open the contact assembly upon movement thereof, thermally responsive tripping means controlled by the electrical outputs of each of said transformers, for operating one of said movable contacts; an inertia latch forming a part of the thermally responsive tripping means for biasing said tripping means against movement to tripping position as a result of mechanical shock, and magnetically responsive tripping means controlled by the magnetic fields about each of the transformers for operating the other of said movable contacts.

17. In an overload relay, the combination of, a plurality of transformers each forming a pole assembly of the relay, a contact assembly comprising a pair of movable contacts each constructed and arranged to open the contact assembly upon movement thereof, thermally responsive tripping means controlled by the electrical outputs of each of said transformers, for operating one of said movable contacts; and magnetically responsive tripping means controlled by the magnetic fields about each of said transformers for operating the other of said movable contacts.

18. In a thermally operated tripping mechanism, the combination of, a latch member, a catch member, and a plurality of thermally responsive elements which deflect when heated, each of said elements being disposed in operative relation with respect to both said members, for effecting simultaneous movement of said members without movement therebetween when both said elements deflect, one of said elements being effective to anchor one of said members and the other of said elements being effective to move the other of said members to tripping position when only one of said elements deflects.

19. In a thermally operated tripping mechanism, the combination of, a pair of movable tripping members, each operatively related to the other and adapted for simultaneous movement without movement therebetween and relative movement to tripping position, means for limiting the movement of one of said members, and means including a plurality of thermostatic elements which deflect when heated, each being operatively related to both said members for effecting simultaneous movement of both said mem-

bers when both said elements deflect, one of said elements being operative to anchor one of said members and the other of said elements being operative to move the other of said members when only one of said elements deflects.

20. In a thermally operated tripping mechanism, the combination of, a pair of frictionally engaged movable tripping members constructed and arranged for simultaneous movement without movement therebetween and relative movement to tripping position, and a pair of independently movable control elements disposed between said members.

21. In a thermally operated tripping mechanism, the combination of, a pair of frictionally engaged movable tripping members constructed and arranged for simultaneous movement without movement therebetween and relative movement to tripping position, a pair of independently movable control elements disposed between said members, and a control device constructed and arranged to engage but one of said members.

22. A thermally responsive device comprising, in combination, tripping means comprising a catch element and a latch element each rotatably mounted about the same axis, means for axially biasing the latch and catch elements together, spacing means disposed between the latch and catch elements for providing a predetermined axial spacing of said elements throughout a limited range of relative rotational movement thereof and thereafter permitting relative axial movement of said elements under the influence of the axial biasing means, thermally responsive means for rotatably actuating said latch element, means for limiting the rotational movements of the catch element, and means responsive to relative axial movement of the latch and catch elements.

23. A thermally responsive device comprising, in combination, tripping means comprising a

catch element and a latch element each rotatably mounted about the same axis, spring means for rotatably biasing said elements together, means for axially biasing the latch and catch elements together, spacing means disposed between the latch and catch elements for providing a predetermined axial spacing of said elements throughout a limited range of relative rotational movement thereof and thereafter permitting relative axial movement of said elements under the influence of the axial biasing means, thermally responsive means for rotatably actuating said latch element, means for limiting the rotational movements of the catch element, and means responsive to relative axial movement of the latch and catch elements.

24. A thermally responsive device comprising, in combination, tripping means comprising a catch element and a latch element each rotatably mounted about the same axis, spring means for rotatably biasing said elements together, means for axially biasing the latch and catch elements together, spacing means disposed between the latch and catch elements for providing a predetermined axial spacing of said elements throughout a limited range of relative rotational movement thereof and thereafter permitting relative axial movement of said elements under the influence of the axial biasing means, thermally responsive means for rotatably actuating said latch element, means for limiting the rotational movements of the catch element, an inertia element pivotally connected to said catch element and having projections thereon for engaging cooperating parts of said latch and catch elements, said inertia element rotatably biasing said latch and catch elements together, and means responsive to relative axial movement of the latch and catch elements.

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