July 13, 1937. C. J. WERNER 2,086,755

CONTROL DEVICE

Original Filed Aug. 22, 1934 4 Sheets-Sheet 1

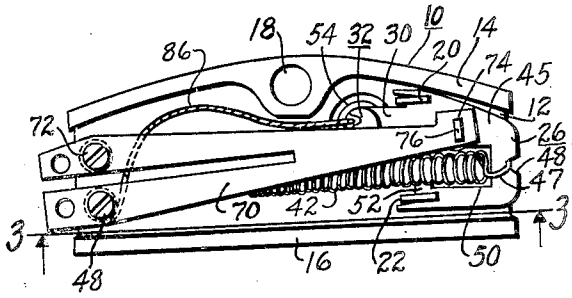


Fig. 1

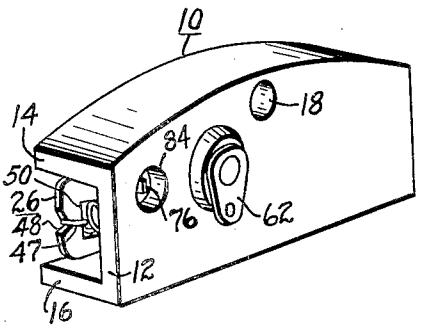


Fig. 2

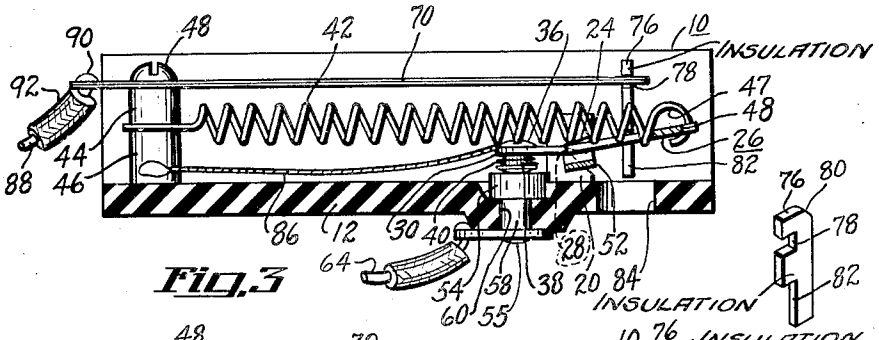


Fig. 3

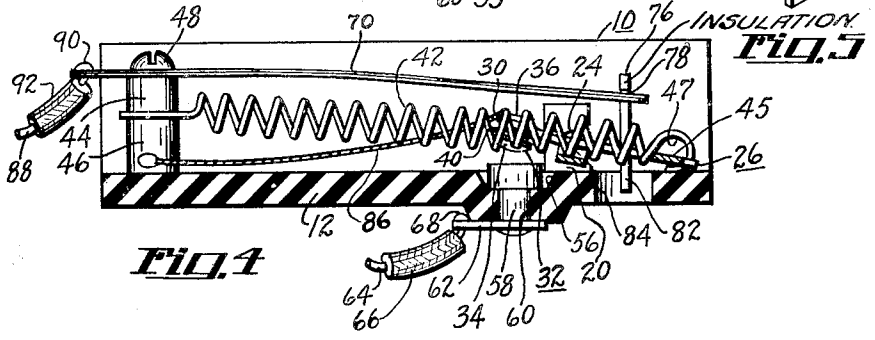


Fig. 4

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CONTROL DEVICE

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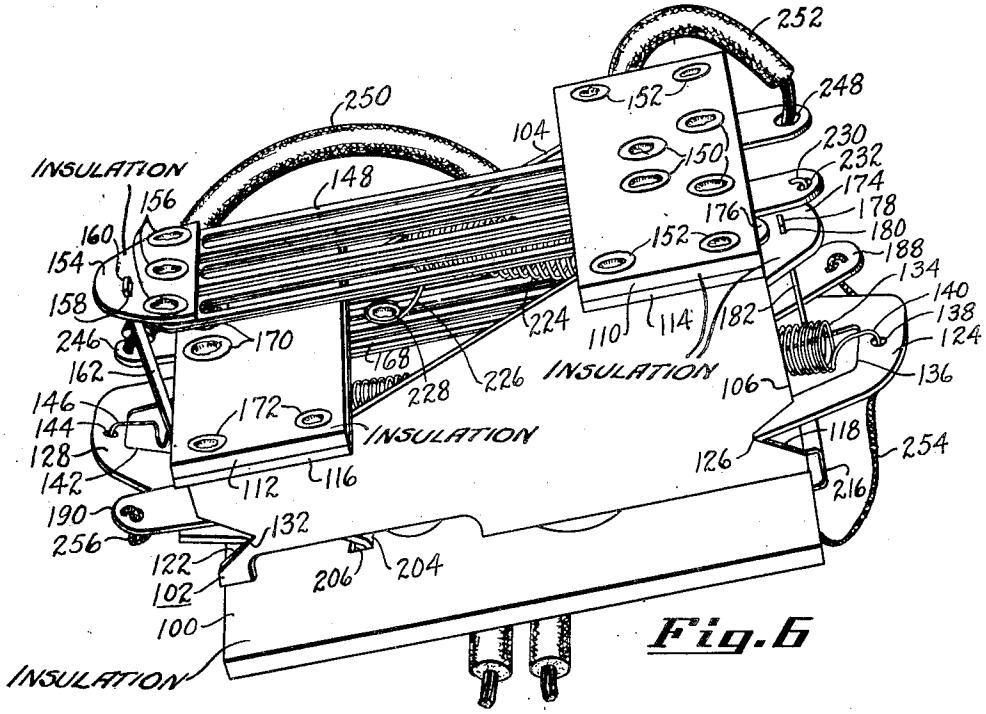


Fig. 6

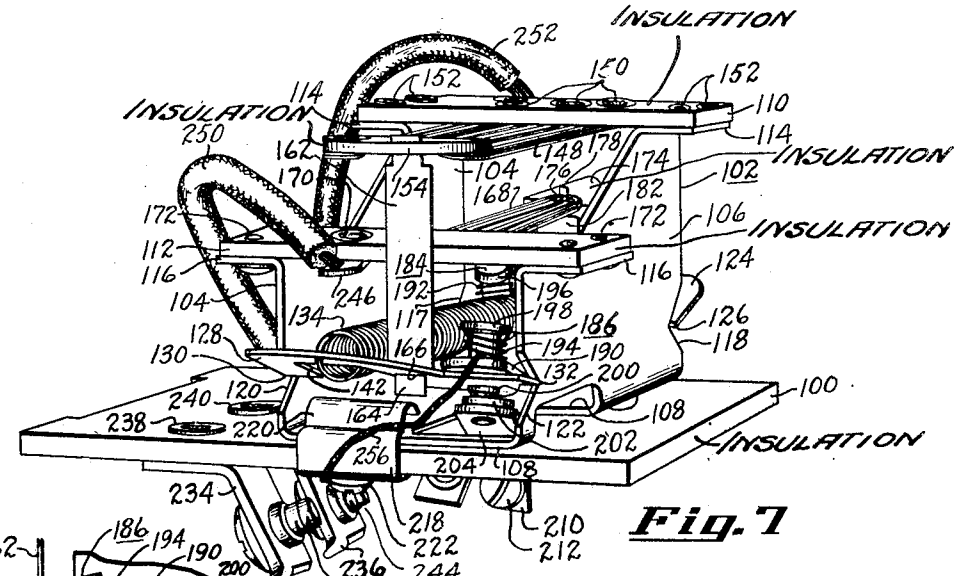


Fig. 7

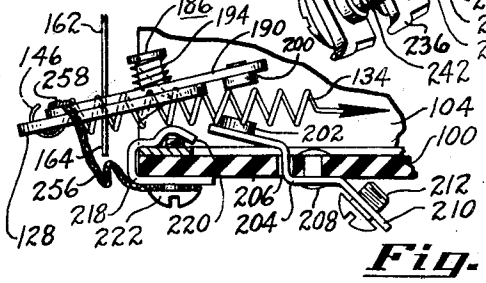


Fig. 8

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CONTROL DEVICE

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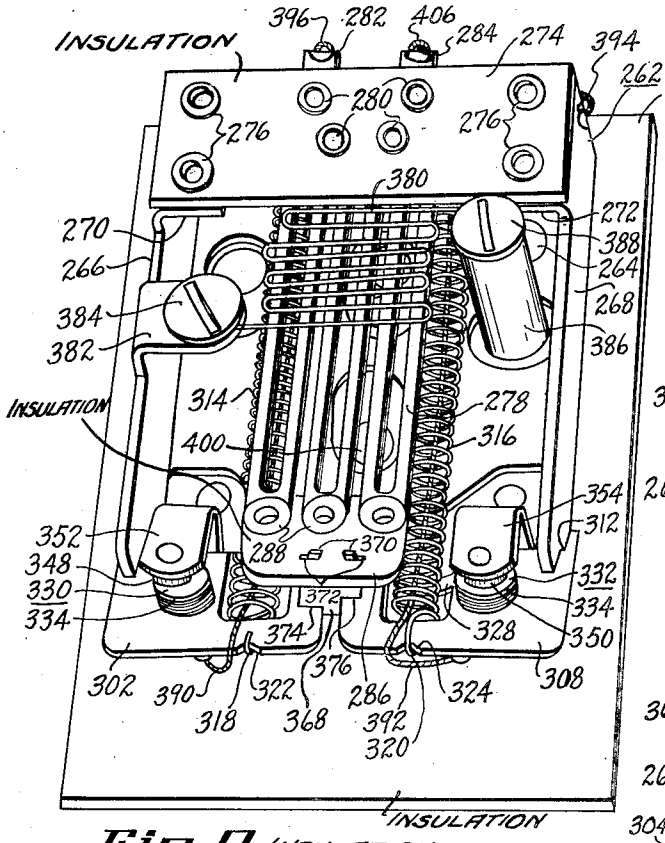


Fig. 9

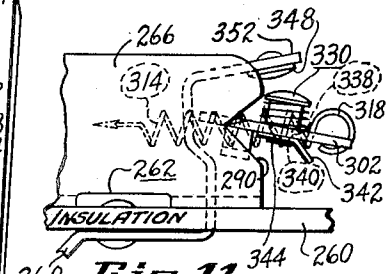


Fig. 11

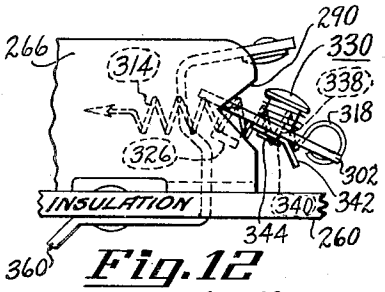


Fig. 12

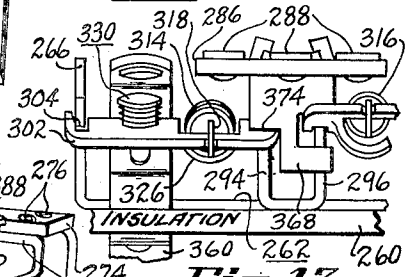


Fig. 13

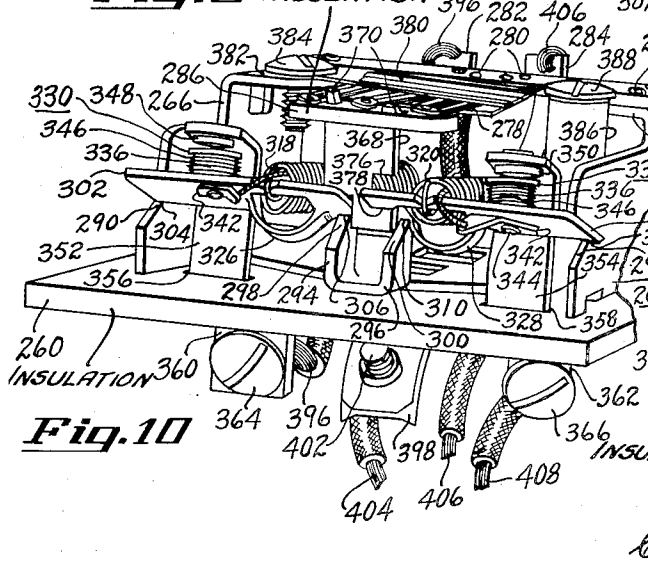


Fig. 10

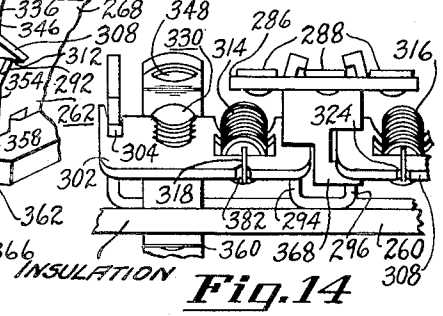


Fig. 14

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CONTROL DEVICE

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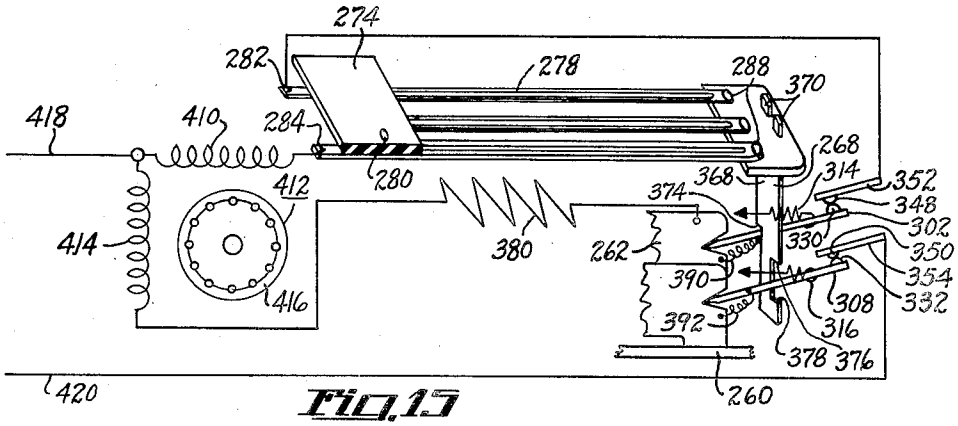


Fig. 15

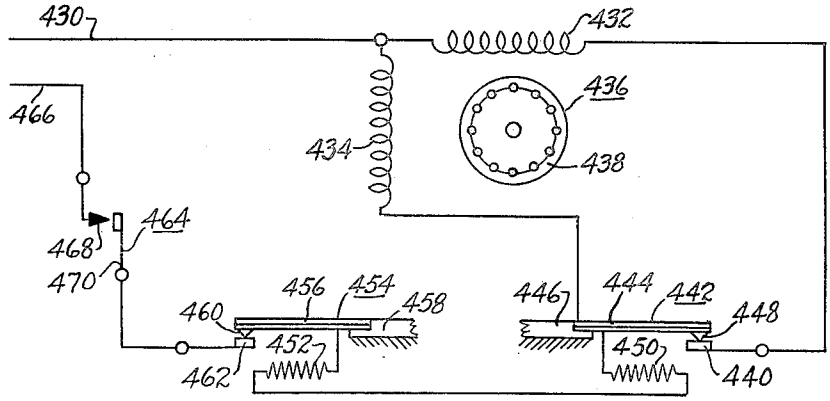


Fig. 16

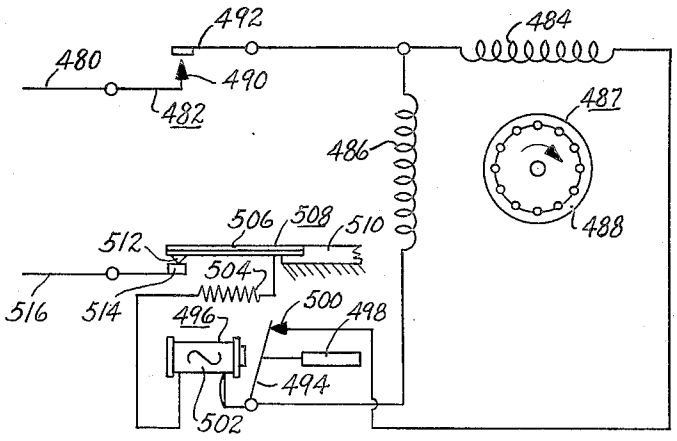


Fig. 17

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UNITED STATES PATENT OFFICE

2,086,755

CONTROL DEVICE

Calvin J. Werner, Dayton, Ohio, assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application August 22, 1934, Serial No. 740,961
Renewed September 2, 1936

15 Claims. (Cl. 200—113)

This invention relates to a control device, and more particularly to controlling an electrical circuit in response to a control device for a thermal-responsive device.

An object of this invention is to provide a thermal-responsive switch that is inexpensive to build, durable, and efficient in operation.

Another object of this invention is to provide a thermal-responsive switch having more than one set of contacts controlled by a thermal-responsive element, so that a plurality of circuits are controlled in a predetermined sequence by the thermal-responsive element. Such a switch is particularly adapted, for example, to the control of the starting and running circuits of an electic motor and to providing overload protection for the motor. In the disclosed embodiment of the invention, this object is accomplished and such a switch provided in one aspect of the invention by the combination incorporating a support, stationary contacts secured to the support, movable contacts adapted to engage the stationary contacts and carried by separately electrically insulated pivotally mounted contact carrying members, a thermal responsive actuating element anchored at one end and operatively connected to the contact carrying members through an intermediate member in such a way that the contact carrying members are actuated at different times, and springs each anchored at one end and having their other ends connected to the contact carrying members.

Another object of this invention is to provide a switch for controlling an electrical circuit, which switch is actuated by a thermal-responsive element and has means for effecting quick make and break of the contacts. An example of a use to which such a switch is particularly adapted is that of controlling the starting and running circuits of an electric motor. In the disclosed embodiment, one aspect of the invention is provided by a combination incorporating a support, a stationary contact secured to the support, a movable contact adapted to engage the stationary contact, which movable contact is mounted on a pivotally supported contact carrying member and insulated from the stationary contact, a spring anchored at one end and having its other end connected to the contact carrying member, a thermal responsive element anchored at one end near the anchored end of the spring, said thermal responsive element and spring being substantially parallel to each other, the pivotal mounting for the contact carrying member being nearer the end of the spring that is fastened thereto than to the other end of the spring, and said spring exerting a continuous force against the movement of the thermal responsive element in one direction, the magnitude of which force diminishes after movement is started and continues to diminish until after the contacts are broken.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is an elevation of a switch embodying a preferred form of the present invention.

Fig. 2 is a perspective view of the back of the switch shown in Fig. 1.

Fig. 3 is a sectional view of the switch shown in Fig. 1 with the switch contacts closed, and is taken substantially on the line 3—3 and in the direction of the arrows, as indicated in Fig. 1.

Fig. 4 is a sectional view of the switch shown in Fig. 1, with the switch contacts open, and is taken substantially on the line 3—3 and in the direction of the arrows, as indicated in Fig. 1.

Fig. 5 is a perspective view of a link utilized in a preferred form of the switch shown in Figs. 1, 2, 3 and 4.

Figs. 6 and 7 are perspective views of a modified form of the switch combining two switches similar to that shown in Figs. 1, 2, 3 and 4 into a single unit.

Fig. 8 is a fragmentary view of a portion of the switch shown in Figs. 6 and 7, with the contacts in the open position.

Fig. 9 is a perspective view of a preferred form of switch having a plurality of contacts actuated by a single thermal-responsive element.

Fig. 10 is an end view of the switch shown in Fig. 9.

Figs. 11, 12, 13 and 14 are fragmentary views showing positions of the contacts in the operation of the switch shown in Figs. 9 and 10.

Fig. 15 is a preferred form of motor control circuit embodying the switch such as that shown in Figs. 9 and 10.

Figs. 16 and 17 are modified forms of motor control circuits embodying the present invention.

With particular reference to Figs. 1 to 4 inclusive, a support or housing 10 is preferably made of insulating material such as molded phenol fiber and has a base or back portion 12 and side walls 14 and 16. In the particular form illustrated, the switch is particularly adapted to be utilized for the control of an electric motor,

and altho it is not at all limited to that use, the side wall 14 is shown as curved, so that the switch fits inside of the motor housing. An opening 18 is provided in the support for the accommodation of suitable mounting means.

Support members 20 and 22 are secured to the back 12 of the support or housing 10, preferably by being molded into the insulating material. The support members 20 and 22 have notches such as 24 therein. A contact carrying member 26 has knife edges such as 28 that cooperate with the notches 24 to provide a pivotal mounting for the contact carrying member. The contact carrying member 26 has an arm portion 30, near the end of which arm portion a contact 32 is mounted.

The contact 32 has head portions 34 and 36 and a stem portion 38, which stem portion is slidably mounted in an opening, not shown, in the arm portion 30. A spring 40 is interposed between the arm portion 30 and the head portion 34 to resiliently urge the head portion 34 away from the arm portion 30. The spring 42 is anchored at one end, preferably by clamping that end between suitable spacers 44 and 46 on a screw 48, which screw is threaded into the support or housing 10. The other end of the spring 42 is connected to a lever portion 45 of the contact carrying member 26, preferably by a loop portion 47 of the spring 42 that is disposed in a notch 48 in the end of the contact carrying member. The end of the spring 42 near the loop portion 47 is disposed within an opening 50 in the contact carrying member, and a curved portion 52 of the contact carrying member provides a stop that contacts the spring intermediate the extremities thereof when the contact carrying member is moved in one direction.

The spring 42 normally urges the contact 32 into engagement with a stationary contact 54, which stationary contact is secured to the back or base 12 of the housing by riveting as at 55, or by other suitable fastening means. The contact 54 is preferably mounted in a recess 56 in the base or back 12, and has a stem portion 58 that extends through an opening 60 in the base or back 12. A lug 62 is preferably secured to the contact 54 for making electrical connection to a conductor of an electrical circuit such as 64, which conductor is shown as insulated at 66 and connected to the lug 62 by soldering as at 68.

A thermal-responsive element 70, preferably a substantially V-shaped bi-metallic member, has one of the legs of the V anchored between the head of the screw 48 and the spacer 44, while the other leg of the V is similarly anchored by a screw 72 and similar spacers, not shown. The thermal-responsive element extends along the spring 42, and is substantially parallel thereto. The free end of the substantially V-shaped thermal-responsive element has a slot 74 therein. A link 76 has a notch 78 therein, which link is inserted into the slot 74. As best shown in Fig. 5, a corner 80 is preferably rounded so that the link may be easily inserted into the slot 74. The link 76 is also notched at 82, and fits into a slot in the contact carrying member 26 to effect an actuating connection between the end of the thermal-responsive element and the contact carrying member, so that when the thermal-responsive element flexes toward the contact carrying member, the contact carrying member is actuated thereby. An opening 84 is provided in the back or base 12 thru which opening the end of the link passes when the thermal-responsive element flexes toward the base. A flexible wire 86 is connected to the contact 32 and to the spacer 46 so that a positive connection is provided between the movable contact 32 and the thermal-responsive element. The connection of an electrical circuit to the thermal-responsive element is made thru a wire such as 88 which is connected to the thermal-responsive element by soldering as at 90, or by other suitable connecting means. The wire 88 is indicated as insulated at 92.

With particular reference to Figs. 6 and 7, the switch support comprises an insulating base 100 that serves as a terminal strip, a substantially U-shaped metallic frame 102 having side walls 104 and 106 and a connecting portion 108, as well as strips of insulating material 110 and 112 that are preferably riveted to angularly extending portions 114 and 116 respectively, that are integral with the side walls 104 and 106. The side walls 104 and 106 have substantially V-shaped notches 117 and 118, in one end thereof, and substantially V-shaped notches 120 and 122 in the other ends thereof. A movable contact carrying member 124 has knife edges such as 126 disposed in the V-shaped notches 117 and 118 to provide a substantially frictionless pivotal mounting for the contact carrying member 124. A movable contact carrying member 128 has knife edges at 130 and 132 that are disposed in the V-shaped notches 120 and 122 to provide a pivotal mounting for contact carrying member 128. The contact carrying members 124 and 128 are connected by a tension spring 134, which spring holds the contact carrying members in position so that the knife edges rest in their respective notches and provides a component of force that tends to maintain engagement of the contacts. The contact carrying member 124 has a slot 136 therein in which one end of the spring 134 is disposed, and has a hole 138 thru which a hook portion 140 of the spring passes to connect the spring to the contact carrying member. The contact carrying member 128 has a slot 142 therein in which the other end of the spring is disposed, and has a hole 144 thru which another hook portion 146 of the spring passes to connect that end of the spring to the contact carrying member 128.

One of the thermal-responsive elements 148 is secured to the insulating strip 110 by rivets 150, or other suitable fastening means; and the insulating strip 110 is secured to the frame 102 by means such as rivets 152. The thermal-responsive element 148 is preferably cut so that it comprises adjacent substantially-parallel strips connected in zig-zag fashion to increase the electrical resistance thereof. The free ends of the thermal-responsive element 148 are connected together by a member 154 that is preferably made of insulating material, and are secured to the member by rivets 156, or other suitable fastening means. The member 154 has an opening 158 therethrough through which an end portion 160 of a link 162 extends. Another end portion 164 of the link 162 extends through an opening 166 in the contact carrying member 128, so that the link provides an actuating connection between the end 154 of the thermal-responsive element 148 and the contact carrying member 128 to effect actuation of the contact carrying member in one direction responsive to movement of the end of the thermal-responsive element. Another thermal-responsive element 168, similar to the element 148 has one end anchored to the insulating strip 112 by means such as rivets 170, and the insulating strip 112 is secured to the frame 102 by rivets 172, or other suitable fastening means.

The other end of the thermal-responsive element 168 is secured to an insulating member 174 by means such as rivets 176. The insulating member 174 has an opening 180 therein through which an end portion 178 of a link 182 extends to provide an actuating connection between the thermal-responsive element 168 and the contact carrying member 124 similar to the actuating connection between the thermal-responsive element 148 and the contact carrying member 128.

Pins 184 and 186 are secured to contact carrying members 124 and 128 respectively, upon which pins contact arms 188 and 190 respectively, are slidably mounted. The contact arms 188 and 190 are resiliently urged toward the contact carrying members 124 and 128 by springs 192 and 194 respectively, which springs surround the pins and are intermediate head portions 196 and 198 on the ends of the pins, and the contact arms. Contact points such as 200 are mounted on each of the contact arms 188 and 190.

Stationary contacts such as 202 are secured in position for engagement with the movable contacts 200 by brackets such as 204, which brackets preferably extend through openings such as 206 in the insulating base 100, the brackets are secured to the base 100 by rivets such as 208, or other suitable fastening means. The brackets 204 preferably have portions 210 projecting from the base, which portions have threaded holes therein for the accommodation of terminal screws such as 212.

Similar stop members 216 and 218 are secured to the ends of the base 100 and have portions such as 220 near the ends of the spring 134 against which the spring strikes when moved toward the stops by the movement of a thermal-responsive element. When the spring strikes one of these stops, its effective length is reduced, and with continued movement of the thermal-responsive element, the spring is bent over the portion 220 of the stop. Screws such as 222 project through the stop members 216 and 218 and the base 100 beneath the portion 220 to provide a screw adjustment for regulating the height of the portion 220.

A heater element 224 is disposed intermediate the thermal-responsive elements 148 and 168, and is preferably in the form of a coil having spaced turns. In the particular form shown in Fig. 6, the heater coil 224 has an end 226 connected to the thermal-responsive element 168 by a rivet 228 or other suitable fastening means. The other end 230 of the heater coil 224 is connected to a connecting lug 232 that is provided by one end of the thermal-responsive element 148. It is understood that this heater element may, however, be connected to any desired points in the circuit that provide control responsive to a particular current. The heater coil 224 is not shown in Fig. 7, and has been eliminated from that view so that the other parts of the switch may be more clearly shown.

Terminals 234 and 236 are secured to the base 100 by rivets 238 and 240 respectively, or other suitable fastening means. The terminals are preferably bent so that they project from the base, and they have screws 242 and 244 threaded therein to provide connecting terminals for making connections to an electrical circuit. The terminal 246 is provided for making connections to one end of the thermal-responsive element 168; and a terminal 248 is provided for making connections to an end of the thermal-responsive element 148. Insulated conductors 250 and 252 are connected to the terminals 246 and 248 respectively for making connections to an electrical circuit. Flexible conductors 254 and 256 are provided for making connections to the movable contacts through the contact arms 188 and 190 respectively. As shown in Fig. 8, the conductor 256 has one end soldered to the contact arm 190 at 258, and has its other end intermediate the screw 222 and stop 220.

With particular reference to Figs. 9 to 14 inclusive, a support comprises a base 260 and a substantially U-shaped frame 262 that is secured to the base by a rivet 264, or other suitable fastening means. The frame 262 has sides 266 and 268, which sides are provided with inwardly extending portions 270 and 272 to which a strip of insulating material 274 is secured by rivets 276, or other suitable fastening means. The thermal-responsive element 278 has one end anchored to the insulating strip 274 by means such as rivets 280. The thermal-responsive element 278 is preferably cut so that it has substantially parallel portions connected in zig-zag fashion to increase the electrical resistance thereof, and has terminal portions 282 and 284 integral with the ends thereof. The other ends of the thermal-responsive element 278 are secured to an insulating member 286 by means such as rivets 288.

The sides 266 and 268 have substantially V-shaped notches 290 and 292 in the ends thereof; and upwardly projecting portions 294 and 296, that are preferably integrally formed with the frame 262, have similar substantial V-shaped notches 298 and 300 respectively therein. A movable contact carrying member 302 has knife edges 304 and 306 that are disposed in the notches 290 and 298 respectively to provide a pivotal mounting for that contact carrying member. A movable contact carrying member 308 has knife edges 310 and 312 that, in cooperation with the notches 300 and 292 respectively, provide a pivotal mounting for the contact carrying member 308. Springs 314 and 316 have hook portions 318 and 320 at the ends thereof that are disposed in notches 322 and 324 of the contact carrying members 302 and 308 respectively, to connect the springs to the contact carrying members. The springs 314 and 316 are preferably tension springs and have their other ends anchored, so that they hold the contact carrying members in position. Curved stop portions 326 and 328 are preferably integrally formed with the contact carrying members 302 and 308 respectively. When the contact carrying members 302 and 308 are moved downwardly, as viewed in the drawings, the springs 314 and 316 strike the stop portions 326 and 328 respectively, so that the effective lengths of the springs are decreased, and the springs are bent over the stop portions as the downward movement progresses.

Contacts 330 and 332 are mounted on the contact carrying members 302 and 308 respectively, and are movable therewith. Each of the contacts 330 and 332, has a head portion 334, a stem portion 336 and a smaller stem portion 338. The smaller stem portions 38 are slidably mounted in openings 340 in the contact carrying members 302 and 308, and are long enough to permit some axial movement of the contacts. Connecting lugs 342 are secured to the smaller stem portions 338 of the contacts by soldering or riveting as at 344. Springs 346 surround the stem portions 336 intermediate the head por-

tions 334 and the contact carrying members to urge the head portions 334 away from the contact carrying members. Cooperating stationary contacts 348 and 350 are secured to brackets 352 and 354 respectively, which contacts are in alignment for engagement with the contacts 330 and 332 respectively. The brackets 352 and 354 extend through openings 356 and 358 respectively, in the base 260 and have portions 360 and 362 that project from the base to provide terminals into which terminal screws 364 and 366 are threaded.

A link 368 has projecting tips 370 that extend through holes 372 in the insulating strip 286, and are bent to secure the link 368 to the insulating strip 286. The link 368 is notched so that it has a shoulder 374 that engages one side of the contact carrying member 302 to effect movement of the contact carrying member in one direction in response to flexure of the thermal-responsive element 278. The link is also notched so that it has shoulders 376 and 378 that engage the contact carrying member 308 to effect movement of that contact carrying member in either direction in response to flexure of the thermal-responsive element. A heater element 380 that preferably comprises a resistance wire formed in zig-zag fashion is closely associated with one surface of the thermal-responsive element 278. One end of the heater element 380 is secured and electrically connected to a terminal 382 that is preferably integrally formed with the side 266, which terminal has a screw 384 threaded therein for securing the end of the heater element to the terminal. The other end of the heater element 380 is secured and electrically connected to the binding post 386 by a screw 388 that is preferably threaded into the binding post. The binding post 386 is preferably insulatingly secured to the base 260.

The contacts 330 and 332 are preferably positively connected to the frame 262 by leads 390 and 392 that are connected to the lugs 342, preferably extend through the springs 314 and 316 respectively, and are connected to the frame 262 as by soldering at 394. The terminal 360, and the particular switch shown in the drawings, is connected to the end 282 of the thermal-responsive element through an insulated wire 396. A terminal 398 that is secured to the base 260 by a rivet 400 and preferably has a screw 402 threaded therein, as well as insulated wires 404, 406 and 408 are provided for making electrical connections to the circuit to be controlled by the switch.

With particular reference to Fig. 15, the thermal-responsive switch shown is a diagrammatic representation of the switch shown in Figs. 9 to 14 inclusive, and reference numerals similar to those previously used in describing that switch refer to similar parts that perform similar functions. The end 284 of the thermal-responsive element is connected to one end of an auxiliary or starting field winding 410 of a motor 412, which motor also has a main field winding 414 and a rotor 416 that is preferably of the squirrel-cage type. The other end of the starting or auxiliary field winding 410 is connected to one end of the main field winding 414 and to a power supply line wire 418. The other end of the main field winding 414 is connected to one end of the heater element 380; while the other end of the heater element is connected to the frame 262 of the switch, and thence through the conductors 390 and 392 to the movable contact carrying members 302 and 308, respectively. The other end 282 of the thermal-responsive element is connected to the stationary contact 348, and the other power supply line wire 420 is connected to the other stationary contact 350.

With particular reference to Fig. 16, a power supply line wire 430 is connected to one end of a starting or auxiliary field winding 432 and to one end of a main field winding 434 of a motor 436 having a rotor 438 that is preferably of the squirrel cage type. The other end of the auxiliary field winding is connected to a stationary contact 440 of a thermal-responsive switch 442; while the other end of the main field winding is connected to one end of a thermal-responsive element 444 that has one end anchored at 446 and has a contact 448 actuated by the other end and in alignment for engagement with the contact 440. A heater element 450 has one end connected to the thermal-responsive element 444 and its other end connected to a heater element 452 of a switch 454, either of which heater elements may be separate resistance units or the inherent resistance of the thermal-responsive elements themselves. The other end of the heater element 452 is connected to a thermal-responsive element 456 of the switch 454, which thermal-responsive element has one end anchored at 458 and a contact 460 actuated by its other end. The contact 460 is in alignment for engagement with a stationary contact 462, which stationary contact is connected through a main control switch 464 to the other power supply line wire 466. The main control switch 464 has a contact 468 and a cooperating movable contact arm 470.

With particular reference to Fig. 17, a power supply line wire 480 is connected through a main control switch 482 to one end of a starting or auxiliary field winding 484 and to one end of a main field winding 486 of a motor 487 having a rotor 488 that is preferably of the squirrel cage type. The main control switch 482 has the contact 490 and a cooperating movable contact arm 492. The other end of the main field winding 486 is connected to a movable contact arm 494 of an electromagnetically actuated switch 496, and the movement of the contact arm 494 is preferably controlled by a dash-pot 498. The other end of the auxiliary field winding 484 is connected to a stationary contact 500 that is in alignment for engagement with the contact arm 494. An electromagnet 502 is magnetically associated with the movable contact arm 494 to actuate the arm, and has one end connected to the contact arm 494 and its other end connected to one end of a heater element 504. The other end of the heater element 504 is connected to an end of a thermal-responsive element 506 that is part of a thermal-responsive switch 508. The heater element 504 may be either a separate resistance unit or the inherent resistance of the thermal-responsive element itself. One end of the thermal-responsive element 506 is anchored at 510, and the other end actuates a contact 512 that is in alignment for engagement with a stationary contact 514. The stationary contact 514 is connected to another power supply line wire 516.

The thermal-responsive switches shown in Figs. 16 and 17 are preferably similar to those shown in Figs. 1 to 4 or Figs. 9 and 10.

In the operation of the switch shown in Figs. 1 to 4 inclusive, the contacts 32 and 54 are normally biased into engagement by a component of the force exerted by the spring 42 that is connected

to the movable contact carrying member **26**. With the particular switch illustrated, the thermal-responsive element **70** is connected in series with an electrical circuit, in response to the current in which circuit the switch is controlled. It is understood, however, that the thermal-responsive element may be controlled by the temperature of any desired surrounding medium or heater element. When the thermal-responsive element flexes toward the contact carrying member **26**, that contact carrying member is actuated through the link **76** to open the contacts. When the switch is in the contact closed position, as shown in Fig. 3, the spring **42** exerts its maximum force to hold the contacts in engagement. Hence, before movement of the contact carrying member **26** can be effected by the thermal-responsive element **70**, sufficient energy must be built up in the thermal-responsive element to overcome the force of the spring **42** and start movement of the contact carrying member. When movement of the contact carrying member is begun, the component of the force of the spring **42** that resists such movement of the thermal-responsive element diminishes as the movement of the contact carrying member progresses. Since the contact **32** is resiliently mounted, the contacts **32** and **54** remain in engagement for a short interval of time after movement of the contact carrying member is started, and since the speed of movement of the contact carrying member increases with the distance of movement, a quick or snap break of the contacts is effected.

As the motion of the end of the thermal-responsive element progresses toward the contact carrying member, the end of the spring **42** that is connected to the contact carrying member moves in the same direction. After a predetermined movement of the end of the spring in that direction, and after the contacts are disengaged, the stop portion **52** of the contact carrying member engages the spring intermediate the extremities thereof and acts as a fulcrum about which the spring is bent upon further movement of the contact carrying member in the same direction. This engagement of the stop portion **52** and the spring decreases the effective length thereof, so that the spring resists further movement of the contact carrying member in a manner similating a constant load or resisting force. The stop portion **52** prevents the axis of the spring **42** from crossing the pivotal axis of the contact carrying member, so that the spring **42** continually resists the movement of the contact carrying member in one direction, and effects movement of the contact carrying member in the other direction when the thermal-responsive element flexes in the reverse direction.

In the operation of the dual switch shown in Figs. 6 to 8 inclusive, the separate switch units operate in substantially the same manner as that described for the switch shown in Figs. 1 to 4 inclusive. In this dual switch, however, a single frame is utilized for supporting the two switches and a single spring **134** biases the movable contact carrying members of both switches. In the switches of this dual unit also, the stops **220**, against which the biasing spring strikes, are mounted on the base **100** and are adjustable, instead of being integral with the movable contact carrying members.

In the dual switch shown in Figs. 9 to 14 inclusive, both movable contact carrying members are actuated by a single thermal-responsive element. The link that provides the actuating connection between the thermal-responsive element and the contact carrying members is preferably notched to provide shoulders **374** and **376** that are not in alignment so that the actuation of the contact carrying members is effected at different time intervals, or at different points of flexure of the thermal-responsive element. It is understood, however, that the link can be so notched that it provides a different sequence of operation of the contacts, or so that they operate at substantially the same time.

In the particular form shown, the contact carrying member 302 is actuated by the thermal-responsive element 278 in substantially the same manner as described for the switch shown in Figs. 1 to 4 inclusive. That is, the contact carrying member 302 is actuated to a position such as that indicated in Figs. 11 and 13 without actuating the contact carrying member **308**. Continued flexing of the thermal-responsive element in the same direction moves the contact carrying member 302 to a position such as that indicated in Figs. 12 and 14, and also actuates the contact carrying member **308** to a position such as that indicated in Fig. 14. After the contact carrying member 302 has been moved to the position indicated in Fig. 13, the thermal-responsive element must build up sufficient energy to overcome the resisting force of the spring **316** before movement of the contact carrying member **308** is started. Since, in the form shown, it is desirable that the contacts **330** and **348** engage prior to the contacts 332 and **350**, the stop portion 326 engages the spring **314** before the axis of that spring crosses the pivotal axis of the contact carrying member **302**; while the stop **328** preferably engages the spring **316** at or slightly beyond the point at which the axis of the spring crosses the pivotal axis of the contact carrying member **308**. Hence, the shoulder **378** is provided on the link **368** to start the return movement of the contact carrying member **308**.

Fig. 15 diagrammatically illustrates the application of the dual switch shown in Figs. 9 to 14 inclusive, to the control of an electric motor. In this circuit, the movable contact carrying member **302** and the contacts **330** and **348** control the starting and running circuits of the motor; while the contact carrying arm **308** and the contacts **332** and **350** protect the motor against overload, or some such abnormal condition that might be harmful to the motor. As illustrated, the circuit shows a split phase type of single phase alternating current motor; although it is understood that a similar control circuit might be applied to other types of motors.

In the operation of the circuit shown in Fig. 15, the starting or auxiliary field winding current flows through the thermal-responsive element to directly effect heating of the thermal-responsive element; while the main field winding current flows through the heater element **380** that is closely associated with the thermal-responsive element so that the heating of the heater element **380** also heats the thermal-responsive element. When the motor is not running, the switch contacts are normally in the position illustrated in Fig. 15. When a source of current is connected to the motor through the power supply line wires **418** and **420**, the circuits are closed to both the main and auxiliary field windings. However, as the rotor speed increases in the starting of the motor, the thermal-responsive element is heated to a sufficient degree that by the time the rotor has reached a predetermined speed, the thermal-

responsive element has flexed sufficiently to effect disengagement of the contacts **330** and **348** to open the circuit to the auxiliary field winding, thus switching from the starting to the running circuit of the motor. The heater element **380** is preferably so designed and positioned that the normal main field winding current at full load, or less than full load, does not cause flexure of the thermal-responsive element an amount sufficient to cause disengagement of the contacts **332** and **350**, but it does provide sufficient heat so that the thermal-responsive element remains sufficiently flexed to maintain the contacts **330** and **348** in their disengaged position. Such an abnormal condition as a sufficient overload on the motor causes an increase in the main field winding current that in turn increases the temperature of the heater element **380**, which increase in temperature flexes the thermal-responsive element to effect disengagement of the contacts **332** and **350**. The disengagement of these latter contacts opens the circuit between the main field winding **414** and the power supply line wire **420** to stop the motor. The circuit will then remain open until the thermal-responsive element has cooled sufficiently that the thermal-responsive element flexes back to its normal position to permit the contacts to close. If the overload or abnormal condition still remains, the motor will again be started and stopped in a similar manner. It is desirable that the contacts **330** and **348** close prior to or simultaneously with the contacts **332** and **350**, so that the main field winding alone will not be connected across the power supply line wires **418** and **420** when the motor is stopped.

The circuit shown in Fig. 16 operates in a manner similar to that described for Fig. 15, except that separate control switches having separate thermal-responsive elements are utilized to accomplish the starting and overload control. In this instance, the thermal-responsive elements differ in characteristics so that the thermal-responsive element **444** and the heater element **450** effect control of the starting and running circuits, while the switch **454** remains closed until some abnormal condition such as an excessive overload on the motor occurs. Switches such as that illustrated in Figs. 1 to 4 inclusive, having thermal-responsive elements with different operating characteristics are adapted to be used in a system such as illustrated in Fig. 16.

The circuit illustrated in Fig. 17 operates in a manner similar to that of the circuit of Fig. 16, except that a dashpot controlled magnetic switch is utilized for controlling the circuit to the starting or auxiliary field winding **484**.

From the foregoing description of the construction and mode of operation of the present control device, it will be apparent that the unit comprises chiefly a support **10** to which is secured a stationary contact **54**, a movable contact **34** adapted to engage the stationary contact **54**, which movable contact **34** is mounted on a pivotally supported contact carrying member **26** and insulated from the stationary contact **54**, a spring **42** anchored at one end and having its other end **47** connected to the contact carrying member **26**, a thermal responsive element **70** anchored at one end near the anchored end of the spring **42**, said thermal responsive element **70** and spring **42** being substantially parallel to each other, the pivotal mounting **24** for the contact carrying member **26** being nearer the end **47** of the spring **42** that is fastened to the contact carrying member **26** than to the other end of the spring, and said spring **42** exerting a continuous force against the movement of the thermal responsive element **70** in one direction, the magnitude of which force diminishes after movement is started and continues to diminish until after the contacts **54** and **34** are broken.

In an embodiment of the dual switch, it will be apparent that the device comprises chiefly a support **260**, stationary contacts **348** and **350** secured to the support **260**, movable contact carrying members **302** and **308** pivotally mounted at **290** and **298** and **300** and **292** respectively and having contacts **330** and **332** mounted thereon for engagement with the stationary contacts **348** and **350** respectively, said contacts **330** and **332** being electrically insulated from the contacts **348** and **350**, a thermal responsive actuating element **278** anchored at one end at **280** and operatively connected to the contact carrying members **302** and **308** by an intermediate member **368** so that the contact carrying members **302** and **308** are actuated at different times responsive to the thermal responsive element **278**, and springs **314** and **316** each anchored at one end and having their other ends connected to the contact carrying members **302** and **308**.

These combinations possess the following advantages:

1. Quick breaking of the contacts responsive to a thermal responsive element.
2. Capability of control responsive to current in a circuit or the temperature of a surounding medium, or both.
3. Control of a plurality of contacts in a predetermined sequence responsive to a thermal responsive element.
4. Compactness of the assembly.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A switch comprising, in combination, a support, a stationary contact secured to the support, a pivotally mounted movable contact carrying member insulatingly mounted with respect to the stationary contact and having a contact mounted thereon for engagement with the stationary contact; a spring anchored at one end and having its other end connected to the contact carrying member, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying member so that actuation of the contact carrying member in one direction is effected by the thermal-responsive element, and a stop engaging the spring intermediate the extremities thereof to shorten the effective length of the spring after predetermined movement of the contact carrying member and spring.

2. A switch comprising, in combination, a support, a stationary contact secured to the support, a pivotally mounted movable contact carrying member insulatingly mounted with respect to the stationary contact and having a contact mounted thereon for engagement with the stationary contact, a spring anchored at one end and having its other end connected to the contact carrying member, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying member so that actuation of the contact carrying member in only one direction is effected by the thermal-responsive ele-

ment, and a stop engaging the spring intermediate the extremities thereof so that the spring substantially continuously urges the contact carrying member toward the thermal-responsive element.

3. A switch comprising, in combination, a support, a stationary contact secured to the support, a pivotally mounted movable contact carrying member insulatingly mounted with respect to the stationary contact and having a contact mounted thereon for engagement with the stationary contacts, a spring anchored at one end and having its other end connected to the contact carrying member, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying member so that actuation of the contact carrying member in one direction is effected by the thermal-responsive element, and a stop integral with the contact carrying member for engaging the spring intermediate the extremities thereof to shorten the effective length of the spring after predetermined movement of the contact carrying member and spring.

4. A switch comprising, in combination, a support, a stationary contact secured to the support, a pivotally mounted movable contact carrying member insulatingly mounted with respect to the stationary contact and having a contact mounted thereon for engagement with the stationary contact, a spring anchored at one end and having its other end connected to the contact carrying member, a bimetallic thermal-responsive element anchored at one end near the anchored end of the spring, said thermal responsive element and spring being substantially parallel to each other, the pivotal mounting for said contact carrying member being nearer the end of the spring that is fastened thereto than to the other end thereof, and said spring exerting a continuous force against the movement of the thermal-responsive element in one direction, the magnitude of which force diminishes after movement is started and continues to diminish until after the contacts are broken.

5. A switch comprising, in combination, a support, a stationary contact secured to the support, a pivotally mounted movable contact carrying member insulatingly mounted with respect to the stationary contact and having a contact mounted thereon for engagement with the stationary contact, a spring anchored at one end and having its other end connected to the contact carrying member, a bimetallic thermal-responsive element anchored at one end near the anchored end of the spring, said thermal-responsive element and spring being substantially parallel to each other, the pivotal mounting for said contact carrying member being near the end of the spring that is fastened thereto, said spring exerting a substantially continuous force against the movement of the thermal-responsive element to open the contacts, the magnitude of which force diminishes after movement is started and continues to diminish until after the contacts are broken, and said contact being resiliently mounted on the contact carrying member so that the contacts remain in engagement until after movement of the contact carrying member is started.

6. A switch comprising, in combination, a support, a plurality of stationary contacts secured to the support, a plurality of pivotally mounted movable contact carrying members insulatingly mounted with respect to the stationary contacts and each having a contact mounted thereon for engagement with one of the stationary contacts, springs anchored at one end and each having its other end connected to one of the contact carrying members, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying members so that actuation of each of the contact carrying members in one direction is effected by the thermal-responsive element and a stop engaging one of the springs intermediate the extremities thereof so that the spring exerts a substantially continuous force on the contact carrying member toward the thermal-responsive element.

7. A switch comprising, in combination, a support, a plurality of stationary contacts secured to the support, a plurality of pivotally mounted movable contact carrying members insulatingly mounted with respect to the stationary contacts and each having a contact mounted thereon for engagement with one of the stationary contacts, springs anchored at one end and each having its other end connected to one of the contact carrying members, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying members so that actuation of each of the contact carrying members in one direction is effected by the thermal-responsive element said link effecting actuation of the contacts at different times, and a stop engaging each of the springs intermediate the extremities thereof to shorten the effective length of the springs after predetermined movement of the contact carrying members and springs.

8. A switch comprising, in combination, a support, stationary contacts secured to the support, first and second contact carrying members each insulatingly mounted with respect to one of the stationary contacts and each having a contact mounted thereon for engagement with one of the stationary contacts, first and second springs connected at one end to the first and second contact carrying members respectively and each having its other end anchored, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying members so that actuation of each of the contact carrying members in one direction is effected by the thermal-responsive element, the actuation of the first contact carrying member in the other direction being effected by the first spring and the actuation of the second contact carrying member in the other direction being effected by the second spring after being started by movement of the thermal-responsive element transmitted to the second contact carrying member thru the link.

9. A switch comprising, in combination, a support, a stationary contact secured to the support, a pivotally mounted movable contact carrying member insulatingly mounted with respect to the stationary contact and having a contact mounted thereon for engagement with the stationary contact, a spring anchored at one end and having its other end connected to the contact carrying member, a thermal-responsive element anchored at one end, a link operatively connecting the other end of the thermal-responsive element to the contact carrying member so that actuation of the contact carrying member in one direction is effected by the thermal-responsive element directly thru the link and actuation of the contact carrying member in the opposite direction is effected by the spring after being started by move-

ment of the thermal-responsive element transmitted thru the link, and a stop engaging the spring intermediate the extremities thereof to shorten the effective length of the spring after movement of the contact carrying member and spring in one direction.

10. A switch comprising, in combination, a support, stationary contacts secured to the support, pivotally mounted movable contact carrying members insulatingly mounted with respect to the stationary contacts and each having a contact mounted thereon for engagement with one of the stationary contacts, a thermal-responsive actuating element anchored at one end, an intermediate member operatively connecting the thermal-responsive element to the contact carrying members so that the contact carrying members are actuated at different times responsive to the thermal-responsive element, and springs each anchored at one end and having their other ends connected to the contact carrying members.

11. A switch comprising, in combination, a base, a thermal responsive element anchored at one end and having its other end movable due to flexure of said element in response to temperature changes; a tension spring anchored near the anchored end of the thermal responsive element; means connecting the movable end of the thermal responsive element to the other end of the spring; relatively movable cooperating contacts normally engaged, one of which is actuated by movement of the thermal responsive element; said thermal responsive element, spring and means being so disposed relative to each other that a component of the force of said spring continually urges the contacts toward their normally engaged position and such that said component of force of said spring diminishes as movement of the thermal responsive element progresses to effect acceleration of the movement of the thermal responsive element after the component of force is initially overcome by the thermal responsive element.

12. A switch comprising, in combination, a base, a thermal responsive element anchored at one end and having its other end movable from a normal position due to flexure of said element in response to temperature changes; a spring having one end fixedly anchored; means connecting the other end of the spring to the movable end of the thermal responsive element; said thermal responsive element, said spring and said means being so disposed with respect to each other that a component of the force of said spring opposes movement of the thermal responsive element from the normal position thereof; said thermal responsive element, said spring and said means also being so disposed with respect to each other that the said component of force diminishes to effect acceleration of the movement of the thermal responsive element after movement thereof starts; stop means for arresting movement of the thermal responsive element away from normal position and preventing said spring from aiding such movement; a pair of cooperating contacts, one of which is actuated by the thermal responsive element.

13. A switch comprising, in combination, a base, a thermal responsive element anchored at one end and having its other end movable from a normal position due to flexure of said element in response to temperature changes; a spring having one end fixedly anchored; means connecting the other end of the spring to the movable end of the thermal responsive element; said thermal responsive element, said spring and said means being so disposed with respect to each other that a component of the force of said spring opposes movement of the thermal responsive element from the normal position thereof; said thermal responsive element, said spring and said means also being so disposed with respect to each other that the said component of force diminishes to effect acceleration of the movement of the thermal responsive element after movement thereof starts; stop means for arresting movement of the thermal responsive element away from normal position and preventing said spring from aiding such movement; a pair of cooperating contacts, one of which is actuated by the thermal responsive element, and one of which contacts moves toward the other during initial movement toward disengagement.

14. A switch comprising, in combination, a base; a thermal responsive element; a spring means anchoring one end of the thermal responsive element and one end of the spring to the base; means connecting the other end of the spring to the other end of the thermal responsive element so that the spring is tensioned and exerts a component of force against the end of the thermal responsive element to which it is connected; a pair of cooperating contacts, engagement of which is controlled by the thermal responsive element; and stop means for preventing a reversal of direction of said component of spring force against the thermal responsive element.

15. A switch comprising, in combination, a base; a thermal responsive element; a spring; means anchoring one end of the thermal responsive element and one end of the spring to the base; means connecting the other end of the spring to the other end of the thermal responsive element so that the spring is tensioned and exerts a component of force against the end of the thermal responsive element to which it is connected; a pair of cooperating contacts, engagement of which is controlled by the thermal responsive element; and stop means for preventing a reversal of direction of said component of spring force against the thermal responsive element, and means urging one of said contacts toward the other during initial movement of the thermal responsive element against the said component of spring force.

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