May 27, 1941. F. W. HOTTENROTH, JR 2,243,563

CONTROL DEVICE

Filed June 30, 1939

Fig. 1.

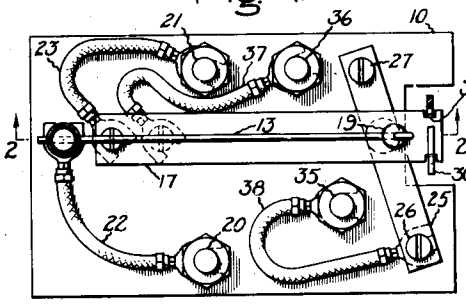


Fig. 2.

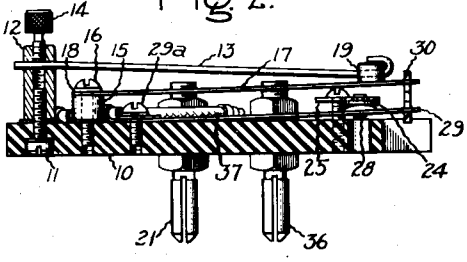


Fig. 3.

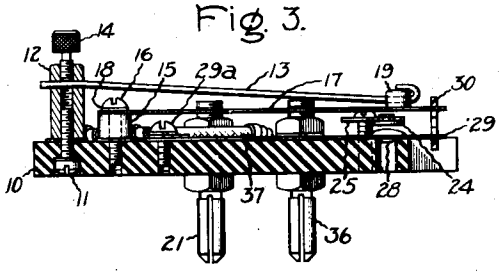


Fig. 4.

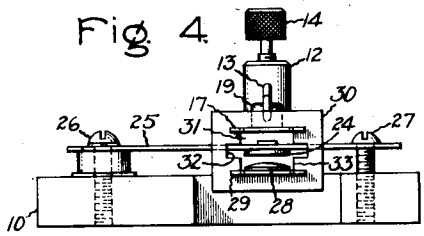


Fig. 5.

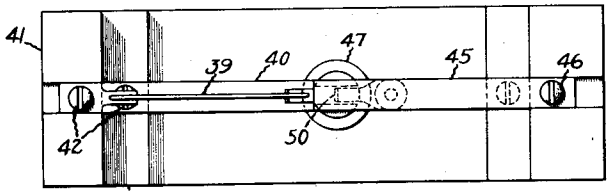


Fig. 7.

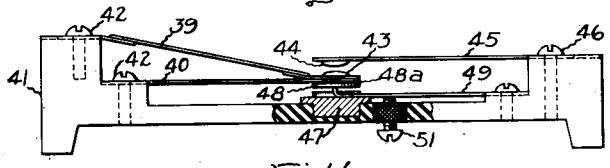
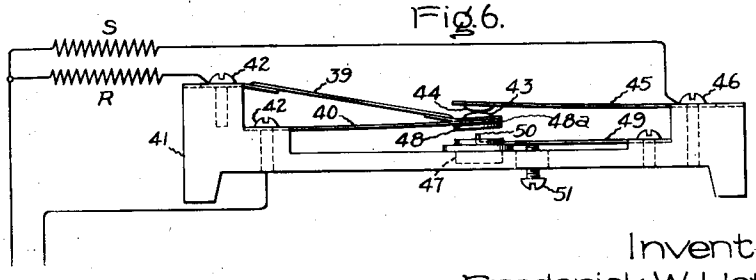


Fig. 6.



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His Attorney.

Patented May 27, 1941 2,243,563

UNITED STATES PATENT OFFICE

2,243,563

CONTROL DEVICE

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Application June 30, 1939, Serial No. 282,230

14 Claims. (Cl. 200—113)

My invention relates to a control device and more particularly to a thermal control device which may be used for example as a thermal cut-out, an overload relay, an accelerating relay, or a thermally operated time delay switch.

It is an object of my invention to provide a new and improved control device of the aforementioned type which is simple in construction, which may be manufactured at low cost, which avoids the use of a bimetallic temperature responsive member, and which is provided with simple, rugged means for adjusting the conditions under which the control device operates.

A still further object of my invention is to provide a control device having a new and improved construction and arrangement which responds quickly to thermal changes and which is particularly adapted for operation on short time intervals.

In accordance with my invention I provide a control device which is adapted to be actuated in accordance with changes in the magnitude of an electric current. The operating elements of my control device comprise a strip and a wire having substantially the same coefficient of thermal expansion but different resistances due to either their difference in cross-sectional area or to a difference in material. The wire and strip are firmly connected together at one end and separately fixed at their opposite ends. Current is arranged to pass through the wire and strip and the differential expansion of the two elements due to their different resistances causes a movement of the connected ends, which movement is utilized to perform a controlling function. In accordance with my invention I provide means varying the conditions under which the control device is actuated and also in one form of my invention I provide means for effecting movement of the control device with a snap action.

For a more complete understanding of my invention, reference should be had to the accompanying drawing in which Fig. 1 is a plan view of one form of my improved control device; Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1 showing the control device in one controlling position; Fig. 3 is a view similar to Fig. 2 showing the control device in a different controlling position; Fig. 4 is a partial end elevation of the construction shown in Fig. 1 showing the details of the connection between the contact strip and operating member; Fig. 5 is a plan view of a modified form of my invention; Fig. 6 is an elevation partly in section of the arrangement shown in Fig. 5 showing the control applied to an electric circuit and in one of its circuit controlling positions; and Fig. 7 is a view similar to Fig. 6 showing the control device in a different controlling position, the circuit shown in Fig. 6 being omitted and certain details being shown in section.

Referring to the form of my invention shown in Figs. 1–4, I have illustrated a control device which in the particular instance is arranged to be used as a time delay relay. It is understood, of course, that the arrangement shown in Fig. 1 could be employed equally well as an overload relay or as a thermal cut-out for an electrical circuit.

Referring to Figs. 1–4 in more detail, 10 is a support or base made from some suitable insulating material such as a phenolic condensation product. Firmly attached adjacent one end of the support by means of a screw 11 is a stud 12 having an opening therein which is adapted to receive one end of a wire 13. The wire 13 is firmly held in the stud 12 by means of a thumb-screw 14. Mounted on the support 10 adjacent the stud 12 is a second stud 15 which is firmly attached to the supporting base 10 by means of a screw 16. Attached to the stud 15 is a strip 17 which is insulated from the screw 16 by means of an insulating washer 18. Mounted on the end of the strip 17 opposite the fixed end thereof is a boss 19 which is provided with an opening through which the free end of the wire 13 is adapted to extend, the free end of the wire being reversely bent over the stud so as to form a rigid connection between the strip and the wire.

The wire 13 and the strip 17 form the principal elements of my improved control device. It will be observed that they are mounted in superposed relation and lie at an angle to each other. Due to the different shapes of the two elements, one being a substantially small wire and the other being a flat strip of substantial width, the resistances of the two elements are substantially different. Therefore, when an electric current is passed through the two elements, one will heat more than the other and the differential expansion of the two elements will cause a movement of the joined ends since the latter is free to move. In order to provide a control device which operates independently of ambient temperature changes, the two elements are made of the same material or of different materials having the same thermal coefficient of expansion. In this way variations in ambient temperature will affect both the operating elements of the control device in a similar manner and no auxiliary compensation means for ambient temperature is required. While in the preferred form of my invention the wire and strip will be selected so as to have the same thermal coefficient of expansion in order to provide a control device independent of ambient temperature variations, it is also to be observed that by selecting materials of different coefficients of expan-

sion or providing different lengths of the same material in the wire and strip, the control device can be made dependent on ambient variations, if desired.

Means are provided on the support 10 for connecting the fixed end of the wire 13 and the fixed end of the strip 17 in an electric circuit so that current will pass through the wire and strip in series, the rigid connection between the free end of the wire and strip being current conducting. To effect this series connection, a pair of terminal jacks 20 and 21 is mounted on the support 10. A lead 22 is provided from the terminal 20 to the stud 12 and a lead 23 is provided from the terminal 21 to the stud 15. By means of this electrical connection current is adapted to traverse the wire 13 and strip 17, the electrical circuit being from the terminal 20 through the conductor 22, the stud 12, the wire 13, the boss 19, the strip 17, the stud 15, the lead 23, through terminal connection 21.

In the form of my invention illustrated in Figs. 1–4, the movement of the joined ends of the wire and strip in response to the differential expansion of the wire and strip is utilized to cause the opening and closing of a pair of contacts which are adapted to be connected in a controlling circuit or a circuit to be controlled. The contact structure comprises a contact 24 which is carried by a resilient arm 25 firmly attached at one end by means of a screw 26 and having its opposite end free to move in accordance with movement of an adjusting screw 27. Arranged to cooperate with the contact 24 is a contact 28 which is carried by a resilient arm 29 having one end fixed to the support 10 by means of the screw 29a. The contact 28 may be termed the movable contact of my improved control device and I have provided means for transmitting the movement of the operating unit formed by the strip 17 and the wire 13 to the resilient arm 29. Referring to Fig. 4, the transmitting means comprises a strip of suitable insulating material 30 having an opening 31. The opening 31 is provided with a slotted portion 32 which is sufficiently wide to receive the end of the arm 29 and the end extension provided on the strip 17. The opening 31 is provided with a narrower portion 33 which engages a slotted portion 34 provided adjacent the end of the arm 29 and strip 17. By means of this last described construction, the insulating strip 30 is retained in its operating position. The strip 17 and arm 29 have sufficient resilience to bias them against the edge of the opening formed in the strip 30. By means of the insulated strip 30, movement of the joined ends of the wire 13 and the strip 17 in response to the differential expansion caused by the passage of current therethrough, is transmitted to the arm 29 to cause movement of the contact 28 relative to the contact 24. It will be observed that by varying the position of the adjusting screw 27, the normal position of the contact 24 relative to the contact 28 may be altered so that the wire and strip assembly will have to move a greater or lesser distance, as the case may be, to effect the circuit opening or circuit closing positions of the contacts 24 and 28. In this manner, a range of operation of the control device is provided so that the conditions under which the control device operates may be altered.

The contacts 24 and 28 are adapted to be connected in the electric circuit to be controlled. In order to facilitate this connection a pair of terminal jacks 35 and 36 is mounted in the supporting base 10. The terminal jack 36 is electrically connected to the arm carrying the contact 28 by means of a lead 37 and the terminal jack 35 is connected to the arm 25 carrying the contact 24 by means of a lead 38.

As previously stated, the form of my invention illustrated in Figs. 1–4 is especially constructed to be used as a time delay relay and in particular a time delay relay for controlling the application of the starting voltage to a glow discharge lamp. In operation, the control device is adapted to be plugged into a suitable socket connection so that the terminal jacks 20, 21, 35, and 36 are connected to the appropriate electrical circuits. The contacts of the control device are normally closed as illustrated in Fig. 2 and a current is passed through the wire and strip assembly. After a predetermined interval of time depending upon the ratio of resistances of the wire and strip and upon the position of the contact 24 relative to the contact 28, the joined ends of the strip and wire will move downwardly, which movement will be transmitted to the arm 29 to cause the contact 28 to be moved out of engagement with the contact 24 thereby opening the electrical circuit controlled by these contacts, in the particular instance the starting voltage circuit for the lamp. It is thus observed that the contacts 24 and 28 are opened a predetermined time after the current is applied to the wire and strip arrangement. As long as the current continues to be applied to the wire and strip, the contacts 24 and 28 will be maintained opened. Since in this form of my invention the thermal coefficients of expansion of the wire and strip are substantially the same, the device will operate independently of ambient temperature variations.

In Figs. 5–7 I have shown a modified form of control device made in accordance with my invention. As in the form illustrated in Figs. 1–4, the operating elements of the control device comprise a wire 39 and a strip 40 made of the same material or of different materials having substantially the same thermal coefficient of expansion. The wire and strip are firmly connected together at one end and the opposite ends of each of the elements are firmly attached to a suitable base member 41 by means of screws 42. The connection between the wire and strip is electrically conducting and current is adapted to be passed through the strip and wire in series. The strip 40 is adapted to project beyond the point of attachment to the wire 39 and this projection is adapted to carry a contact 43 which cooperates with a contact 44 carried by the resilient arm 45. The arm 45 is firmly attached to the supporting base 41 by means of a screw 46 and it is to be observed that the arm 45 extends in a direction opposite to that of the wire and strip assembly. By means of this construction, the contacts 43 and 44 will be opened and closed with a wiping action since the contact 43 when moved in accordance with the differential expansion of the wire 39 and the strip 40 moves in a slightly curved path. This wiping action of the contacts is desirable since it serves to keep the contacts free from dirt and other foreign substances and assures a good electrical connection between the contact elements 43 and 44.

In order to cause the contacts 43 and 44 to be actuated with a snap action and to provide means of adjusting the control device so as to control its operating conditions over a predeter-

mined range, a permanent magnet 47 is mounted in the base member 41. The magnet 47 is arranged to act upon an armature 48 mounted on the under side of the portion of the spring strip 40 which projects beyond the joined portion of the strip 40 and the wire 39 and is insulated from the strip by means of a spacer 48a of suitable insulating material.

The condition under which the control device is operated is adjusted by varying the air gap between the armature 48 and the magnet 47. From Figs. 6 and 7 it will be observed that the upper face of the magnet 47 is slotted so as to receive the end of the resilient member 49 which is provided with an up-turned portion 50. The armature carried by the strip 40 is adapted to engage the end of the up-turned end 50 of the resilient arm 49, as shown in Fig. 7. It is apparent therefore that the position of the up-turned end of the arm 49 determines the width of the air gap between the armature 48 and the magnet 47 and hence the force with which the armature is attracted by the magnet. In order to adjust the position of the segment 50, adjusting screw 51 is threadedly mounted in the supporting base 41 and is adapted to bear against the arm 49 intermediate its fixed end and the up-turned end portion.

The form of my invention illustrated in Figs. 5–7 has been particularly designed to operate as an accelerating or starting relay for the motor of a household appliance such as a refrigerator. In such an application, the relay must be arranged so that after a predetermined interval it will operate to cut out the starting winding of the motor and will remain in the cut out position as long as the motor continues to run. In Fig. 6 I have shown the relay connected to the starting and running windings of a motor and have shown the position of the elements of my improved relay upon the starting of the motor. One terminal of the starting winding S is connected to the arm 45 and the other terminal is connected to the line. The wire and strip, on the other hand, are connected in series with each other and in series with the running winding R across the line, the terminal end of the strip being connected to one terminal of the running winding and the terminal end of the wire being connected to the line, the opposite end of the running winding being connected to the opposite side of the line. When the line switch of the motor is closed, the running and starting windings are both energized and will continue to be energized as long as the contacts 43 and 44 are closed. With current applied to the wire and strip, the wire begins to heat and expand causing the contact 43 to be moved downward. In the first movement of the contact 43 downwardly, the contact 44 due to the resilience of the arm 45 tends to follow maintaining the contacts closed. After a predetermined downward movement, the armature 48 will be moved into the field of the magnet 47 and the contact 43 will be moved downwardly quickly with a snap action causing the contacts 43 and 44 to be opened, as shown in Fig. 7. With the contacts open, the starting winding S is deenergized. However, since the wire and strip are in series relation with the running winding across the line, the wire will continue to be heated and although the current passing through the wire and strip is less than the current previously traversing the two elements, the wire will be maintained in a sufficiently expanded condition to prevent the pull of the magnet 47 on the armature 48 from being overcome, thus maintaining the contacts 43 and 44 open. When the motor is deenergized, no current will pass through the wire and strip and upon a predetermined amount of contraction of the wire 39, the contact 43 will be moved upwardly against the force exerted by the magnet 47 and the contacts 43 and 44 will be closed, as shown in Fig. 6.

By varying the position of the adjusting screw 51, the air gap between the armature 48 and the magnet 47 may be varied and the current necessary to operate the contacts may be varied. Thus, if the relay is designed so that the contacts will open when the current through the wire and strip is, say, 5 amperes and will remain open so long as the current is in excess of 1 ampere, then moving the adjusting screw 51 so as to cause the armature 48 to lie farther away from the magnet 47 will cause the low current limit to be increased so that the contacts will be maintained open only if the current is in excess of, say, 3 amperes.

As in the arrangement described in Figs. 1–4, since the wire and strip are of the same material or of materials having substantially the same coefficient of expansion, they will be equally affected by ambient temperature changes and no auxiliary compensation means for ambient temperature variation is required.

While the arrangement shown in Figs. 5–7 is illustrated as applied to a motor starting circuit, it is to be understood that it is of general application. For example, if the device were connected in an electrical circuit so that the contacts 43 and 44 are arranged in series with the wire 39, the device will operate intermittently and may be used as a flasher.

From the foregoing it will be observed that I have provided simple, sensitive and effective control devices which may be manufactured at low cost.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. In a control device, a wire and a strip connected together at one end and lying in superposed relation, said wire and strip having substantially the same thermal coefficient of expansion so as to be affected in a similar manner by ambient temperature variations, means for passing an electric current through said wire and strip, and contact means associated with the joined ends of said wire and strip and adapted to be actuated by the movement of said end in response to the differential expansion of said wire and strip caused by the heating effect of said current passing therethrough.

2. In a control device, a wire, a strip having substantially the same thermal coefficient of expansion as said wire and a different cross-sectional area from said wire, means for securing one end of said strip to one end of said wire so that said wire and strip lie in superposed relation, means for connecting the opposite ends of said wire and strip in an electric circuit so that current will pass through said wire and strip in series and said wire and strip will be heated, control means associated with said wire and strip so

as to be actuated by the movement thereof in response to the differential expansion of said wire and strip when heated, and means for controlling the operation of said control means so as to provide a range of operation for said control device.

3. In a control device, an element, a second element having substantially the same thermal coefficient of expansion but different electrical resistance, means for connecting said elements together at one end so that the elements lie one above the other at an angle to each other, a base to which the opposite ends of said elements are attached, means for passing a current through said elements, said current causing a movement of the connected ends of said elements due to the differential expansion of said elements caused by said difference in electrical resistances, control means associated with said elements and adapted to be actuated by said movement, and adjusting means for controlling the conditions under which said control means is operated by movement of said elements.

4. In a control device, an element, a second element having substantially the same thermal coefficient of expansion as said first element but having a different electrical resistance than said first element obtained by a difference in cross-sectional area, means for connecting said elements together at one end so that they lie in substantially superposed relation, a base member, means for attaching the opposite ends of said elements to said base member, means for passing a controlling current through said elements in series, said controlling current causing said elements to be heated and producing a differential expansion thereof due to said difference in electrical resistances, control means mounted on said base member and associated with said elements so as to be actuated by the movement caused by said differential expansion, and adjustable means associated with said control means for adjusting said control means to predetermine the magnitude of the controlling current required to actuate said control means.

5. In a control device, a wire and a strip connected together at one end and having their opposite ends fixed in spaced superposed relation to each other so that one lies above the other, said wire and strip having substantially the same thermal coefficient of expansion, contact means associated with the joined ends of said wire and strip, and means for passing an electric current through said wire to cause expansion thereof relative to said strip so that said joined end moves to produce actuation of said contact means.

6. In a control device, a base member, a strip fixed at one end on said base member, a wire mounted above said strip and having an end fixed to said base member, means for mechanically and electrically connecting the opposite ends of said strip and said wire, means for passing a current through said wire and strip in series to cause heating and expansion thereof, said wire due to its higher electrical resistance expanding more than said strip and producing movement of the connected end of said wire and strip, a contact associated with said connected end and adapted to move therewith, a second contact mounted on said base member and adapted to be engaged by said first mentioned contact, and means for adjusting said second mentioned contact relative to said first mentioned contact so as to control the amount of movement of said first mentioned contact required to operate said contacts from one controlling position to another controlling position.

7. In a control device, a base member, a strip mounted on said base member and having one end fixed and its opposite end free to move, a wire mounted on said base member above said strip and having a fixed and a movable end, said wire and strip being made from materials having substantially the same thermal coefficient of expansion and said wire having a higher electrical resistance than said strip, means for mechanically and electrically connecting the movable ends of said wire and strip together so that they lie at an angle to each other, means for passing a current through said wire and strip in series so as to cause heating and expansion thereof, said wire due to its higher electrical resistance expanding more than said strip and producing movement of said mechanically connected movable ends, a resilient arm having a fixed and a movable end mounted on said base member and extending in the same direction as said wire and strip, a contact member carried by said resilient arm, means for mechanically connecting the movable ends of said arm and strip to transmit movement of said wire and strip unit to said arm, a second arm mounted on said base member and carrying a contact member adapted to be engaged by said contact member carried by said first mentioned arm, and means for adjusting one end of said second mentioned arm so as to vary the position of said second contact member relative to said first contact member and thereby control the amount of movement of said first contact member required to move said contact members from one controlling position to a different controlling position.

8. In a control device, a base member, a strip mounted on said base member so as to have one end fixed, a wire having a smaller cross-sectional area than said strip and hence a higher electrical resistance mounted on said base member above said strip and having one end fixed, means for electrically and mechanically connecting the free ends of said wire and strip together, means for heating said wire and strip by the passage of electric current therethrough, contact means associated with said connected ends of said wire and strip and adapted to be actuated by the movement of said connected end in response to differential expansion of said wire and strip caused by said heating a resilient arm secured to said base member and extending in a longitudinal direction opposite to that in which said strip extends, second contact means carried by the free end of said resilient arm and adapted to be engaged by said first mentioned contact means, magnetic means for effecting snap action movement of said contact means, and means for effecting the operation of said magnetic means to vary the electrical condition under which said control device operates.

9. In a control device, a base member, a strip mounted on said base member so as to have one end fixed and its opposite end free to move, a wire having a smaller cross-sectional area than said strip and hence a higher electrical resistance mounted on said base member above said strip and having a fixed and movable end, means for electrically and mechanically connecting said movable ends of said wire and strip together, means for heating said wire and strip by the passage of electric current therethrough to produce a differential expansion of said wire and

strip due to said difference in resistance, a contact member associated with said connected end of said wire and strip and adapted to be actuated by the movement of said connected end in response to said differential expansion, a resilient arm secured to said base member and extending in a longitudinal direction opposite to that in which said strip extends, a second contact member carried by the free end of said resilient arm and adapted to be engaged by said first contact member, means for producing movement of said first contact member with a snap action comprising a magnet mounted on said base member and an armature mounted on the under side of said strip adjacent the free end thereof, and means for varying the air gap between said armature and said magnet to control the electrical condition under which said contact members are actuated with said snap action.

10. In a control device, a wire, a strip having substantially the same thermal coefficient of expansion as said wire so as to be similarly affected by changes in ambient temperature, means for connecting said wire and strip together at one end so that they lie in substantially superposed relation, a base member, means for attaching the opposite ends of said wire and strip to said base member, means for passing a controlling current through said wire to heat said wire and cause expansion thereof relative to said strip so that the connected ends of said wire and strip move, control means mounted on said base member and associated with said connected ends of said wire and strip so as to be actuated by the movement caused by said controlling current, and adjustable means associated with said control means for adjusting the magnitude of the controlling current required to actuate said control means.

11. In a control device, a wire, a strip having substantially the same thermal coefficient of expansion as said wire so as to be similarly affected by changes in ambient temperature, means for connecting one end of said wire to said strip so that said wire and strip lie in substantially superposed relation and so that a portion of said strip extends beyond the connection between said wire and strip, a base member, means for securing the opposite ends of said wire and strip to said base member, means for heating said wire by passing a controlling current therethrough, said heating causing expansion of said wire and movement of the connected ends of said wire and strip, a contact mounted on said extended portion of said strip, a fixed contact mounted on said base so as to be engaged by said first mentioned contact to form switch means for performing a circuit controlling function, and adjustable means for regulating the magnitude of the controlling current required to actuate said switch means to perform said circuit controlling function.

12. In a control device, a base member, a strip having one end fixed to said base member and its opposite end free to move, a wire having one end secured to said base member and its opposite end free to move, said wire and strip having substantially the same thermal coefficient of expansion so as to be similarly affected by ambient temperature changes, means for electrically and mechanically connecting the free end of said wire to said strip near the free end of said strip, means for heating said wire by the passage of a controlling current therethrough to produce expansion of said wire and movement of the connected ends of said wire and said strip, a contact member mounted adjacent the free end of said strip and adapted to be actuated by movement of said connected ends of said wire and strip in response to expansion of said wire, a resilient arm secured to said base member so as to have a free end adjacent the connected ends of said wire and strip, and a second contact member mounted at the free end of said resilient arm and adapted to be engaged by said first contact member to perform a circuit controlling function.

13. In a control device, a base member, a strip having one end fixed to said base member and its opposite end free to move, a wire having one end secured to said base member and its opposite end free to move, said wire being made from the same material as said strip but having a smaller cross-sectional area than said strip and hence a higher electrical resistance, means for electrically and mechanically connecting the free end of said wire to said strip near the free end of said strip, means for heating said wire by the passage of a controlling current therethrough to produce expansion of said wire and movement of the connected ends of said wire and said strip, a contact member mounted adjacent the free end of said strip and adapted to be actuated by movement of said connected ends of said wire and strip in response to expansion of said wire, a resilient arm secured to said base member so as to have a free end adjacent the connected ends of said wire and strip, a second contact member mounted at the free end of said resilient arm so as to engage said first contact member to perform a circuit controlling function, and means for producing movement of said first contact member with a snap action comprising a magnet mounted on said base member and an armature mounted on the under side of said strip near the free end thereof.

14. In a control device, a base member, a strip having one end fixed to said base member and its opposite end free to move, a wire having one end secured to said base member and its opposite end free to move, means for electrically and mechanically connecting the free end of said wire to said strip near the free end of said strip, means for heating said wire by the passage of a controlling current therethrough to produce expansion of said wire and movement of the connected ends of said wire and said strip, a contact member mounted on the free end of said strip and adapted to be actuated by movement of said connected ends of said wire and strip in response to expansion of said wire, a resilient arm secured to said base member so as to have a free end adjacent the connected ends of said wire and strip, a second contact member mounted at the free end of said resilient arm and adapted to be engaged by said first contact member to perform a circuit controlling function, means for producing movement of said first contact member with a snap action comprising a magnet mounted on said base member and an armature mounted on the under side of said strip near the free end thereof, and means for varying the air gap between said armature and said magnet to control the electrical condition under which said contact members are actuated with a snap action.

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