Feb. 23, 1926. 1,574,508

G. W. O'KEEFFE

THERMAL ELECTRIC CIRCUIT CONTROLLER

Filed April 28, 1922

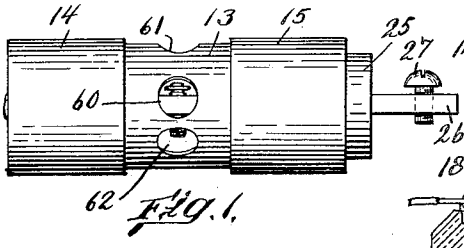


Fig. 1.

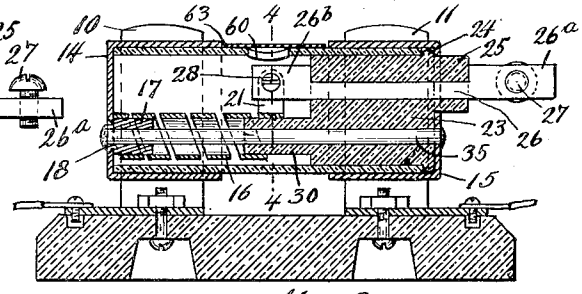


Fig. 2.

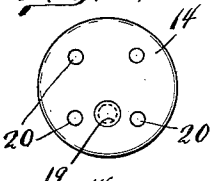


Fig. 3.

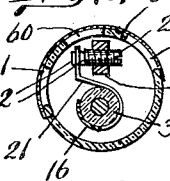


Fig. 4.

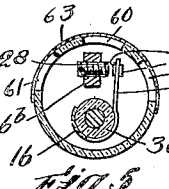


Fig. 5.

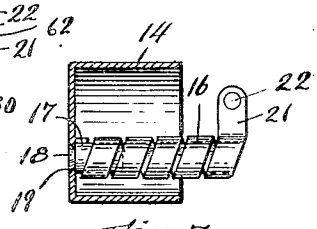


Fig. 7.

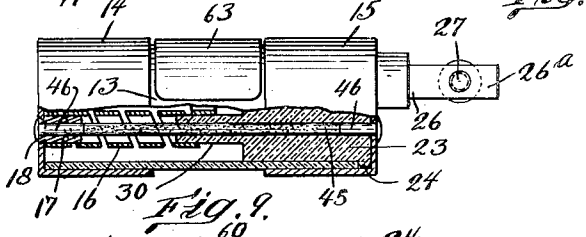


Fig. 9.

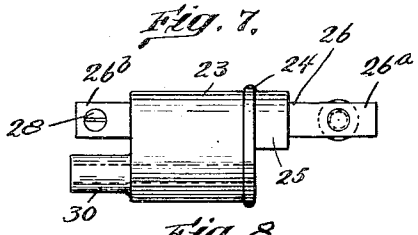


Fig. 8.

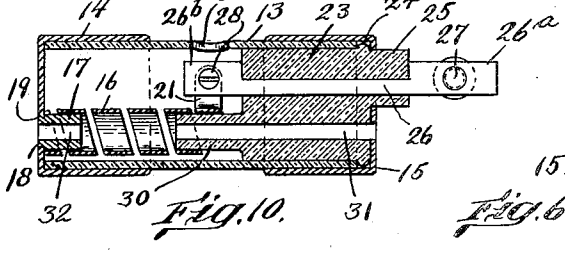


Fig. 10.

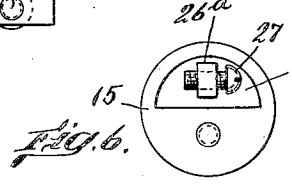


Fig. 6.

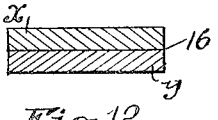


Fig. 12.

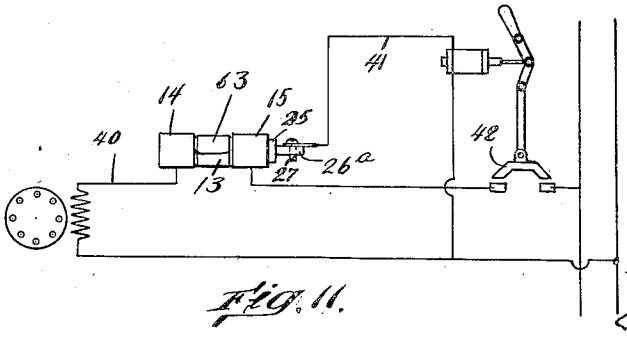


Fig. 11.

Inventor:
George W. O'Keeffe
by
Atty

Patented Feb. 23, 1926. 1,574,508

# UNITED STATES PATENT OFFICE.

GEORGE W. O'KEEFFE, OF DORCHESTER, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO CONDIT ELECTRICAL MANUFACTURING CORPORATION, OF BOSTON, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

## THERMAL ELECTRIC-CIRCUIT CONTROLLER.

Application filed April 28, 1922. Serial No. 557,054.

*To all whom it may concern:*

Be it known that I, GEORGE W. O'KEEFFE, a citizen of the United States, residing at Dorchester, in the county of Suffolk and State of Massachusetts, have invented an Improvement in Thermal Electric-Circuit Controllers, of which the following is a specification.

This invention relates to thermally-controlled electric circuit controllers.

An object of this invention is the provision of a circuit controller adapted to be received in and supported by spring clips similar to a cartridge type electric fuse.

A further object is to provide a thermal circuit controller with an electrical heating element for the thermal element; and with means for applying heating elements of various capacities to the controller whereby the controller may be adjusted to operate at various different values of current passed through the heating element.

A further object is to provide a thermal circuit controller with means by which the contact members may be inspected and adjusted externally of the enclosing casing and after the component parts thereof have been assembled within the casing.

A further object is generally to improve the construction and operation of thermally controlled circuit controllers.

Certain features of this invention are disclosed in my co-pending application Serial No. 557,055, filed concurrently herewith.

Fig. 1 is a plan view of a thermal circuit controller embodying the invention.

Fig. 2 is an axial sectional elevation of the controller supported in spring clips.

Fig. 3 is a left-hand end view of the controller of Fig. 1.

Fig. 4 is a section along line 4—4 of Fig. 2.

Fig. 5 is a section similar to Fig. 4 but with the thermal element and stationary contact member arranged to control a normally open control circuit.

Fig. 6 is a right-hand end view of the controller of Fig. 1.

Fig. 7 is a section through an end cap illustrating the attached tubular thermal element.

Fig. 8 is a view of the insulating plug bearing the stationary contact member.

Fig. 9 is an elevation, partly in section of the controller having a heating element adapted for low values of current.

Fig. 10 is a section of the controller of Fig. 1 without the heating element.

Fig. 11 is a diagram of a typical control circuit including the circuit controller.

Fig. 12 is a transverse cross-section, enlarged, through a convolution of the thermal element.

As here shown, the thermal circuit controller embodying the invention is tubular in form and is adapted to be received in and supported by the spring clips 10 and 11 in a manner similar to a cartridge type enclosed electric fuse. Said controller includes the tubular enclosing casing 13 of insulating material having the metal caps 14 and 15 disposed on and sealing the ends of said casing. In assembled condition, said end caps are preferably secured permanently in place by suitable means, as crimping them over the casing. The thermal element comprises the tubular and spiral coil 16 preferably formed of thermostatic metal and adapted to expand and rotate about its axis when heated. The thermostatic metal forming the thermal element 16 may comprise two metals having dissimilar coefficients of expansion united mechanically in any suitable manner to form, in effect, a single sheet or strip of material having marked susceptibility to temperature variations. Fig. 12 illustrates in cross-section such a strip of thermostatic metal wherein the dissimilar metals composing said strip are represented by $x$ and $y$. One end of said coil may be secured permanently to one of the end caps, as the end cap 14 by suitable means, and the specific securing means here shown comprises a tube 17 which is inserted in the end of and is secured to the spiral coil by solder. Said tube has a reduced portion 18 which is extended through an aperture 19 in the end cap 14 and the extended end of the reduced portion 18 may be expanded over the end face of the end cap to secure the tube and spiral coil securely in place. The aperture 19 in said end cap is disposed below the center of the cap whereby the spiral coil is located below the axis of the enclosing casing. Said end cap 14 may also be formed with other apertures 20 in its end wall adapted to serve as vents for the controller.

The free end portion 21 of the thermal element 16 is reflexed upwardly and has contact points 22 disposed preferably on opposite sides of said end portion either of which is adapted to engage a fixed contact member hereinafter to be described.

A cylindrical plug 23 of insulating material is received in the opposite end of the enclosing casing 13 and may have the peripheral outstanding flange 24 which is received between the end of the casing and the end wall of the end cap 15 whereby to retain said plug in position. Before the end cap 15 is secured finally to the casing, said plug may be moved angularly in the casing whereby to align the elements carried by it with the components of the controller but will be held in adjusted position by said end cap when it is fixed permanently to the casing.

Said plug 23 is formed with the eccentrically disposed projecting member 25, here shown of segmental shape, which protrudes through a correspondingly shaped aperture in the end wall of the end cap 15 and extends beyond the end cap to form an insulating member for the terminal or fixed contact member of the controller to which a lead of the control circuit is adapted to be connected.

Said contact member comprises the bar 26 which is enclosed within said insulating plug 23. The outer end $26^a$ of said bar extends outwardly beyond the projecting member 25 of the plug and may be provided with attaching means, as the screw 27, for a lead of the control circuit. The inner end $26^b$ of said bar is extended beyond the inner end of said plug within the enclosing casing 13 and bears the contact which may comprise the screw 28 adjustably threaded in said inner end $26^b$ and adapted to be engaged by one or the other of the contact points 22 carried by the thermal element 16. In Fig. 4, the thermal element and fixed contact member are arranged to control a normally closed control circuit and, when said thermal element is heated, it expands and rotates about its axis toward the left to interrupt the control circuit.

In Fig. 5, the fixed contact member and thermal element are arranged to control a normally open control circuit and, when heated, the thermal element rotates toward the left to engage the fixed contact member and close the control circuit.

The free end of the thermal element 16 is rotatably supported on the insulating cylindrical projection 30 which is formed integrally with the plug 23 and extended axially within the thermal element.

The heating element for the thermal element 16 is adapted to extend within said tubular element. For this purpose, the plug 23 is formed with the aperture or passage 31 which is extended through it and the cylindrical projection 30 thereof and aligned with the passage 32 in the tube 17 by which the thermal element is secured to and electrically connected with the end cap 14, and an aperture in the end cap 15.

The heating element may comprise an electrically conducting rod 35 which is extended through the tubular thermal element and the aligned passages. After the other elements of the controller have been assembled, said rod may be fixed permanently in position and in electrical connection with the end caps by suitable means as solder applied over the ends of said rod in the end caps.

When current above a predetermined value passes through the power circuit 40, Fig. 11, in which the controller with its heating element 35 is included, the heating element becomes heated and gives up its heat to the thermal element 16 and causes said element to expand and make or break contact with the fixed contact member 26, as the case may be, and control the control circuit 41 to operate the switch 42 or other protective device.

The current value at which the controller is set to operate is designed to be varied by varying the character of the heating element. When the controller is adapted to operate at relatively large values of current, the heating element may be a rod having relatively low electrical resistance, as, for instance, a copper rod. For lesser values of current the rod may be of material having higher resistance as, for instance, Monel metal. For relatively low values of current, the heating element may be a carbon rod.

Fig. 9 illustrates the controller having a carbon rod 45 as the heating element. Said rod may have the metal plated end portions 46 by which it may be soldered to the end caps and electrically connected therewith.

The controller is adapted to be manufactured as a unit without the heating element, as illustrated in Fig. 10, and heating elements having various heating capacities are adapted to be inserted and permanently secured in the controller to provide a controller adapted to operate at various predetermined values of current.

In assembling the component parts of the controller, it is desirable to inspect the relative position of the movable and fixed contact points and, if necessary, to adjust them into proper relative positions, before the end caps are fixed permanently to the enclosing casing. For this purpose, the enclosing casing 13 is formed with the peep hole 60 disposed above the contact points, and the adjusting holes 61 and 62 on opposite sides of the peep hole. The contact points are visible through the peep hole and the fixed contact point 28 may be adjusted by the inser-

tion of a suitable tool through one or the other of the holes 61 and 62. After the adjustments are made, and the component parts of the controller are fixed permanently in position, the holes may be sealed by the application of a seal, as a label 63, to the casing over the holes.

The heating element is adapted to be so constructed as to operate the controller at various different values of current as, for instance, five amperes, ten amperes, etc., with a normal heating effect on the thermal element as governed by the heat radiation from the controller, as through the vent holes 20, from the exposed surface of the controller components, as the end cap 14, etc. The operation of the controller for some moderate value of current different than that provided by a particular heating element may be obtained by varying the position of the adustable contact point 28 with respect to the thermal element whereby to require a greater or less deflection of the thermal element before making or breaking contact, as the case may be, with the adjustable contact point. The temperature of the thermal element at which it will operate to control the control circuit will thereby be varied somewhat from its normal operating temperature, but this, ordinarily, is of no particular importance.

It is to be noted that the lower vent holes 20 in the end cap 14, see Fig. 3, are disposed adjacent the thermal element whereby to direct cool air over the thermal element and cool it whereby to provide for the operation of said element at increased values of current passed through the heating element; and also to provide for the more rapid resetting of the thermal element. For operation on currents of relatively low values, the vent holes may be reduced in size, or eliminated entirely.

It is also to be noted that the heating element is covered and heat-insulated for a portion of the length by the insulating plug 23 and the projection 30 thereof. With this arrangement, the heat-insulated portion of the heating element becomes heated to a higher degree than the unshielded portion thereof and transmits its heat by conduction to the unshielded portion whereby to raise the temperature of the unshielded portion higher than the increase resulting directly from the current passing therethrough; and consequently considerable latitude in construction of the heating element may be permitted by properly adjusting the length of the shielded and unshielded portions of the heating element.

It is to be noted that the electrical heating unit is in electrical and therefore in thermal connection with the end caps 14 and 15 and, consequently, under certain conditions, said end caps act as heat radiators for the heating unit. With heating units of relatively high electrical resistance, and therefore adapted to condition the controller for operation at low values of current, the thermal conductivity is low and consequently little heat will be conducted into and radiated from the end caps. With heating units of low resistance, and high current carrying capacity, the thermal resistance is low and consequently the amount of heat conducted along the heating unit and into and dissipated by the end caps may be of some substantial amount. With this arrangement, the upper operating range of the controller may be substantially extended without increasing the diameter, or other dimensions, of the heating unit.

The invention may be otherwise modified without departing from the spirit thereof.

I claim:

1. A thermal electric circuit controller including a tubular insulating enclosing casing, metal caps on the ends thereof, a fixed contact member disposed within the casing, a thermally expansible element connected electrically with one of said end caps and arranged within said casing in operative relation with said fixed contact member, and a cylindrically-formed electric heating element disposed within said casing to lie along the length of and close to said thermally expansible element and having its ends electrically connected with said metal caps.

2. A thermal electric circuit controller including an enclosing casing, metal end caps carried thereby, an insulated stationary contact member carried by said casing and having attaching means for a circuit lead at the outer end thereof, and extended through one of said end caps, and insulated from said end cap, a thermally expansible element disposed within said casing, and heating means for said expansible element disposed within said casing, and electrically connected with said end caps.

3. A thermal electric circuit controller including an enclosing casing, end caps carried thereby, a fixed contact member carried by said casing, a thermal element disposed within said casing in operative relation with said contact member, and an electrical heating element comprising a resistance rod extended within said casing in heat-imparting relation with said thermal element and electrically connecting said end caps.

4. A thermal electric circuit controller including an enclosing casing, end caps carried thereby, an insulated fixed contact member carried by and extended through said casing, a thermal element having tubular formation disposed within said casing in operative relation with said fixed contact member and an electrical heating element disposed within said tubular thermal element.

5. A thermal electric circuit controller including a fixed contact member, a spiral thermal element having its convolutions arranged in tubular formation and cooperating with said contact member, and an electrical heating element disposed within and in heat-imparting relation with said thermal element.

6. A thermal electric circuit controller including a fixed contact member, a spiral thermal element having tubular formation with its convolutions arranged side by side, said element fixed at one end and having its free end disposed in cooperative relation with said contact member, and an electrical heating element disposed within said thermal element and in heat-imparting relation therewith.

7. A thermal electric circuit controller including a fixed contact member, a spiral thermal element having tubular formation with its convolutions arranged side by side, said element fixedly supported at one end and having its free end disposed to engage and disengage said fixed contact member, and an electrical heating element comprising a resistance rod disposed within said spiral thermal element and in heat-imparting relation therewith.

8. A thermal electric circuit controller including an enclosing casing, end caps carried thereby, an insulated contact member carried by and extended beyond said casing, a spiral thermal element carried by one of said end caps, and an electrical heating element disposed within said thermal element and electrically connected with said end caps.

9. A thermal electric circuit controller including an enclosing casing, end caps carried thereby, an insulated fixed contact member carried by and extended within one end of said casing on one side of the axis thereof, a thermal element extended within the other end of said casing on the opposite side of the axis thereof and having an end portion extended into cooperative relation with said fixed contact member, and an electrical heating element disposed within said casing in heat-imparting relation with said thermal element.

10. A thermal electric circuit controller including an enclosing casing, end caps carried thereby, an insulated fixed contact member carried by said casing on one side of the axis thereof, a thermal element fixed to one of said end caps and disposed within said casing on the opposite side of the axis thereof having an end portion extended into cooperative relation with said fixed contact member, and an electrical heating element disposed within said casing in heat-imparting relation with said thermal element and electrically connected with and supported by said end caps.

11. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, an insulated fixed contact member carried by said casing, a thermal element disposed within said casing in cooperative relation with said fixed contact member, said end caps having aligned apertures therein adapted to receive and support an electrical heating element for said thermal element.

12. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, an insulated fixed contact member carried by said casing, a thermal element disposed within said casing in cooperative relation with said fixed contact member, said end caps having aligned apertures therein adapted to receive and support an electrical heating element for said thermal element and a rigid electrical heating element extended within said casing and received in and supported by the aligned apertures in said end caps.

13. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, an insulating plug received in one end of said casing, a fixed contact member carried by said plug and extended within said casing, a thermal element disposed within said casing in cooperative relation with said fixed contact member, and an electrical heating element for said thermal element disposed within said casing and electrically connecting said end caps.

14. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, an insulating plug received within one end of said casing, a contact member carried by said plug and extended within said casing, a thermal element having tubular formation carried by one of said end caps having its free end disposed in cooperative relation with said contact member, and an electrical heating unit extended through said tubular thermal element and between and electrically connected with said end caps.

15. A thermal electric circuit controller including a spiral thermal element fixed at one end and having its other end extended laterally outward beyond the bounds of the spiral and free for angular movement, a fixed contact member cooperating with the free end of said thermal element, and fixed supporting means on which the free end of said thermal element is angularly movable.

16. A thermal electric circuit controller including a spiral thermal element fixed at one end and having its other end free for angular movement, a fixed contact member cooperating with the free end of said thermal element, supporting means on which the free end of said thermal element is angularly movable, and an electrical heating unit comprising a rod extending through said

tubular thermal element and said supporting means.

17. A thermal electric circuit controller including a tubular enclosing casing of insulating material, end caps carried thereby, a spiral thermal element having one end fixed to and connected electrically with one of said end caps and extended within one end of said casing and having its inner end free to move angularly, an insulating plug received within the other end of said casing, a fixed contact member carried by said plug and disposed in cooperative relation with the movable end of said thermal element, said insulating plug having a supporting projection for said tubular thermal element received loosely within the inner end of said thermal element.

18. A thermal electric circuit controller including a tubular enclosing casing of insulating material, end caps carried thereby, a spiral thermal element having one end fixed to and connected electrically with one of said end caps and extended within one end of said casing and having its inner end free to move angularly, an insulating plug received within the other end of said casing, a fixed contact member carried by said plug and disposed in cooperative relation with the movable end of said thermal element, said insulating plug having a supporting projection for said thermal element received loosely within the inner end of said thermal element said end caps and insulating plug having aligned apertures arranged to receive an electrical heating unit.

19. A thermal electric circuit controller including a tubular enclosing casing of insulating material, end caps carried thereby, a spiral thermal element having one end fixed to and connected electrically with one of said end caps and extended within one end of said casing and having its inner end free to move angularly, an insulating plug received within the other end of said casing, a fixed contact member carried by said plug and disposed in cooperative relation with the movable end of said thermal element, said insulating plug having a supporting projection for said thermal element received loosely within the inner end of said thermal element said end caps and insulating plug having aligned apertures arranged to receive an electrical heating unit and an electrical heating unit comprising a resistance rod received in said aligned apertures and connected electrically with said end caps.

20. A thermal electric circuit controller including a tubular enclosing casing, end caps carried by the ends of said casing, an insulated contact member comprising a bar disposed within said casing having a terminal extended outwardly beyond the end of the casing, and a thermally expansible element disposed within said casing in operative relation with the inner end of said bar.

21. A thermal electric circuit controller including a tubular enclosing casing, end caps carried by the ends of said casing, an insulating member received in one end of said casing and extended outwardly beyond the end thereof, and the end cap on the casing, a contact member carried by said insulating member having its inner end disposed within the casing and its outer end extended outwardly through the end of said insulating member, and a thermally expansible member disposed within said casing in operative relation with said contact member.

22. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, stationary and movable contact members disposed within said casing, a thermal element controlling one of said contact members, said casing having a peep hole through its side wall disposed above said contact members.

23. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, stationary and movable contact members disposed within said casing, a thermal element controlling one of said contact members, said casing having a peep hole through its side wall disposed above said contact member and an adjusting hole through its side wall for said stationary contact member.

24. A thermal electric circuit controller including a tubular enclosing casing, end caps carried thereby, a thermally expansible element disposed within said casing, a fixed contact member disposed within said casing in cooperative relation with said thermal element, said casing having a peep hole through its side wall disposed above said fixed contact member and thermal element.

25. A thermal electric circuit controller including a tubular enclosing casing, stationary and movable contact members disposed within said casing, a thermal element controlling one of said contact members, said casing having a peep hole through its side wall above said contact members, and sealing means for said peep hole.

26. A thermal electric circuit controller including a tubular enclosing casing, conducting end caps on the ends thereof, an insulating plug received within one end of said casing and having a projection extended through one of said end caps, a fixed contact member carried by said plug and having a terminal-portion thereof extended outwardly and through said plug-projection, a thermally expansible element disposed within said casing in operative relation with said fixed contact member, and means to heat said thermally expansible element.

27. A thermal electric circuit controller

having a thermally expansible element, a fixed contact member cooperating therewith, an electrical heating element for said expansible element having a portion thereof exposed for transfer of heat to said expansible element and having another portion thereof shielded from heat-radiation.

28. A thermal electric circuit controller comprising a thermally expansible element, a cooperating contact member, an electric heating element for said thermally expansible element, circuit terminals connected electrically to the ends thereof, and heat-insulating means disposed to cover a portion of said heating element between the ends thereof and expose a portion thereof to heat-imparting relation with said thermally expansible element.

29. A thermal electric circuit controller having a thermally expansible element, an electrical heating element for the thermally expansible element, and a heat radiator arranged in thermal connection with at least one end of said heating element.

30. A thermal electric circuit controller including the combination of an enclosing casing, a thermally expansible element disposed therein, an electrical heating element for the thermally expansible element disposed within said casing, and heat radiators arranged in thermal connection with said heating element and disposed without said casing.

31. The combination of a tubular enclosing casing, an electrical heating element disposed within said casing having exposed end-terminals, and a spiral thermal element disposed within said casing and enclosing said heating element.

32. The combination of a tubular enclosing casing, an electrical heating element disposed within said casing having exposed end-terminals, a spiral thermal element disposed within said casing and enclosing said heating element having one end fixed and the other end free to move under influence of heat.

33. The combination of a tubular enclosing casing, end caps thereon, an electrical heating element extended within said casing and connected electrically with said end caps, and also thermally therewith, whereby there is a material transfer of heat between said heating element and end caps when said heating element is hot, and a thermal element disposed within said casing in heat-exchanging relation with said heating element and having a good thermal connection with at least one of said end caps.

34. The combination of a tubular enclosing casing, end terminals thereon, an electrical heating element extended within said casing and connected with said end terminals, and a spiral thermal element enclosing said heating element.

35. The combination of a tubular enclosing casing, end terminals thereon, an electrical heating element extended within said casing and connected with said end terminals, and a spiral thermal element enclosing said heating element having one end fixed and the other end free to move, said casing having an aperture adjacent the free end of said thermal element.

36. The combination of a tubular enclosing casing, an electrical heating element disposed within said casing having exposed end-terminals, and a thermal element disposed within said casing in heat receiving relation with said heating element, said thermal element having one end fixed and the other end free to move, and said casing having an aperture adjacent the free end of said thermal element and across which aperture the free end of said thermal element is adapted to move.

37. The combination of a tubular enclosing casing, a metal end cap forming a closure for one end of said casing, an electric heating element disposed within said casing and having an electrical and also a thermal connection with said end cap, whereby there is provision for a material transfer of heat between said heating element and end cap, and a thermally-expansible element disposed within said casing in proximity to said heating element and also having an electrical and thermal connection with said end cap.

38. The combination of a tubular enclosing casing, an end cap forming a closure for one end of said casing, a conducting support carried by said end cap within said casing, an electric heating element disposed within said casing and connected electrically with said support and also thermally therewith for material heat flow therebetween, and a thermally expansible member disposed within said casing in proximity with said heating element and connected electrically with said support and also thermally therewith for material heat flow therebetween.

In testimony whereof I have signed my name to this specification.

GEORGE W. O'KEEFFE.