

March 18, 1941.

H. W. WILKINSON

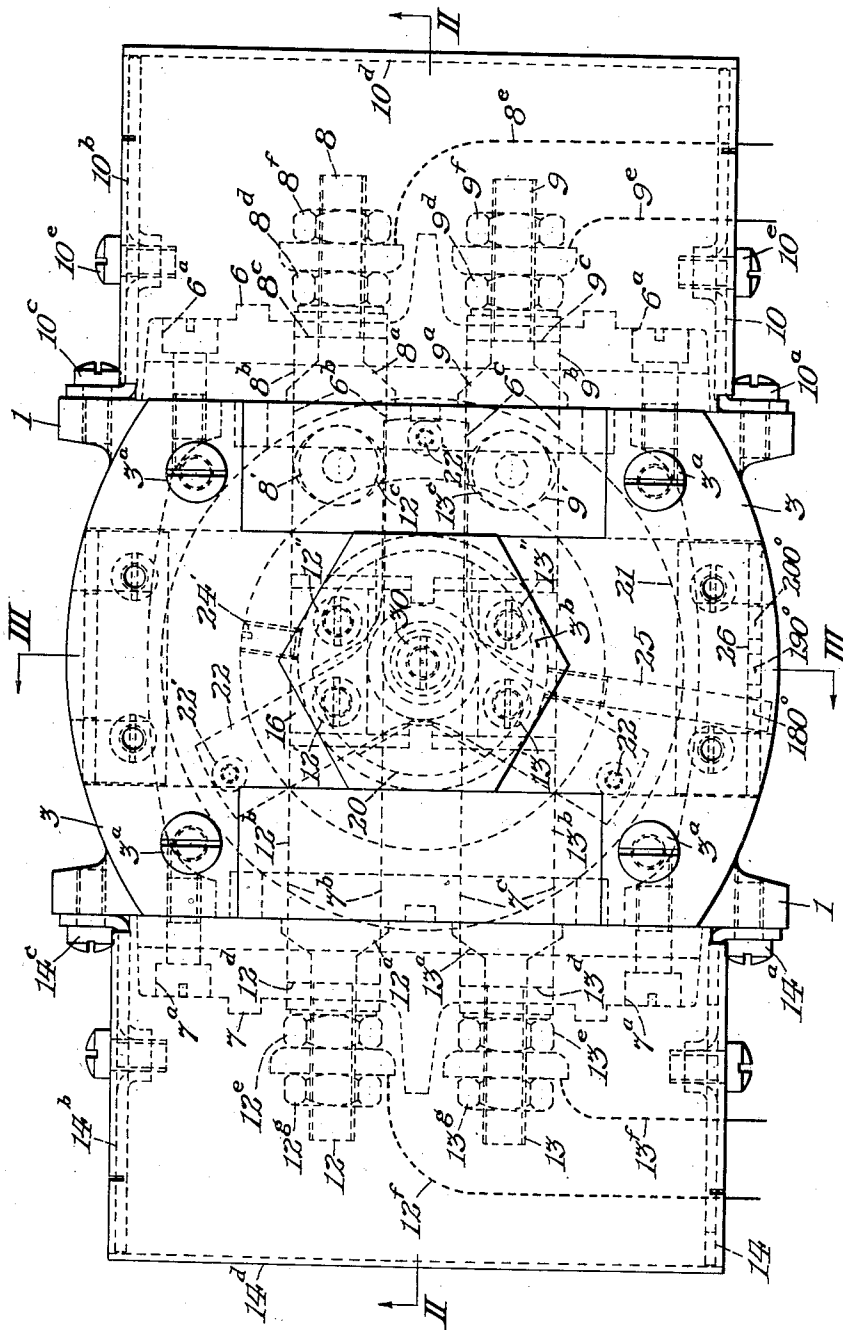
2,235,186

TEMPERATURE LIMIT SWITCH FOR ELECTRIC HEATERS

Filed Dec. 7, 1939

4 Sheets-Sheet 1

FIG. 1.



INVENTOR:
HARRY W. WILKINSON,
BY *Arthur E. Paige*
Attorney.

March 18, 1941.

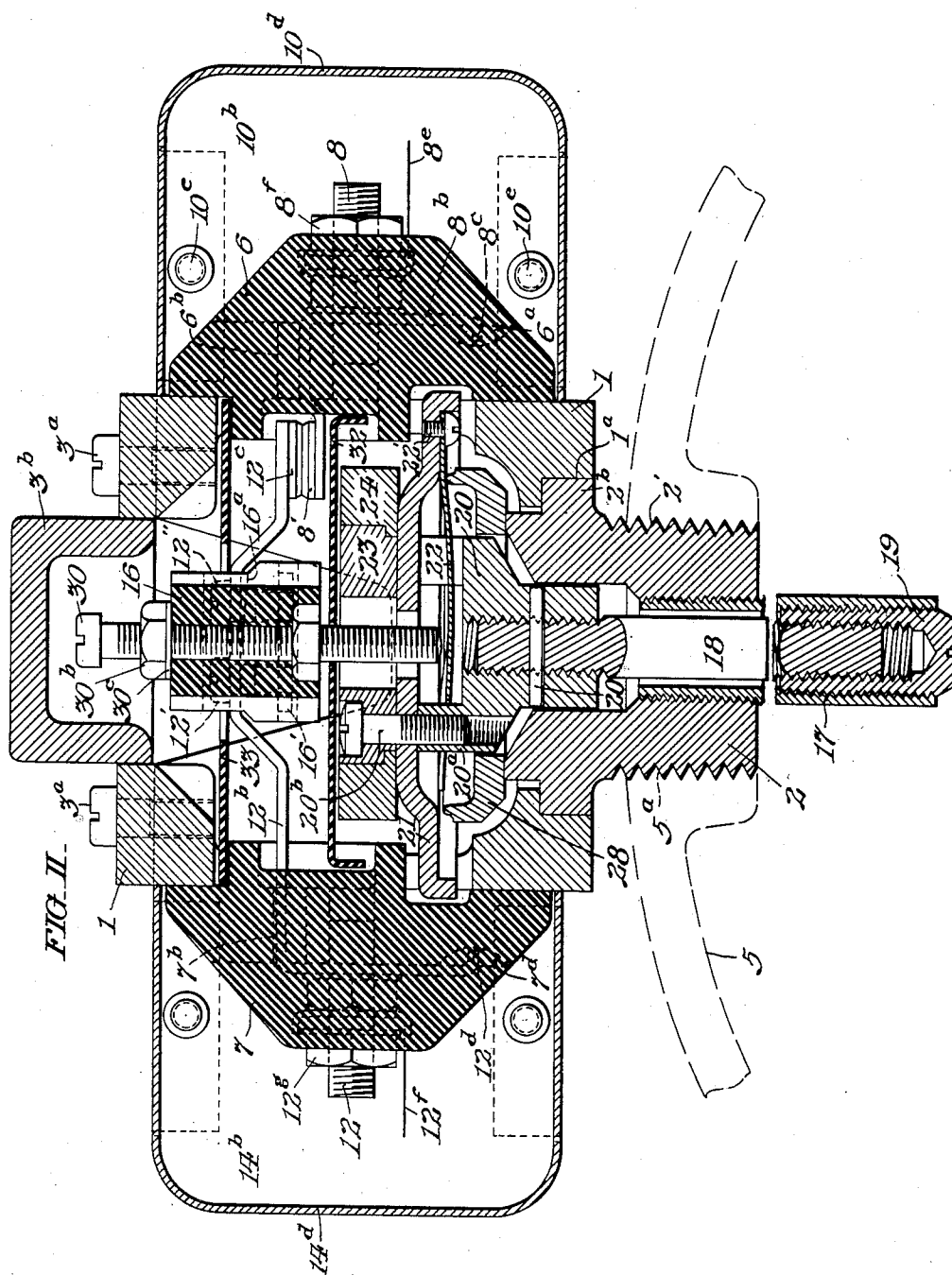
H. W. WILKINSON

2,235,186

TEMPERATURE LIMIT SWITCH FOR ELECTRIC HEATERS

Filed Dec. 7, 1939

4 Sheets-Sheet 2



INVENTOR:
HARRY W. WILKINSON,
BY *Arthur E. Paige*
Attorney.

March 18, 1941.

H. W. WILKINSON

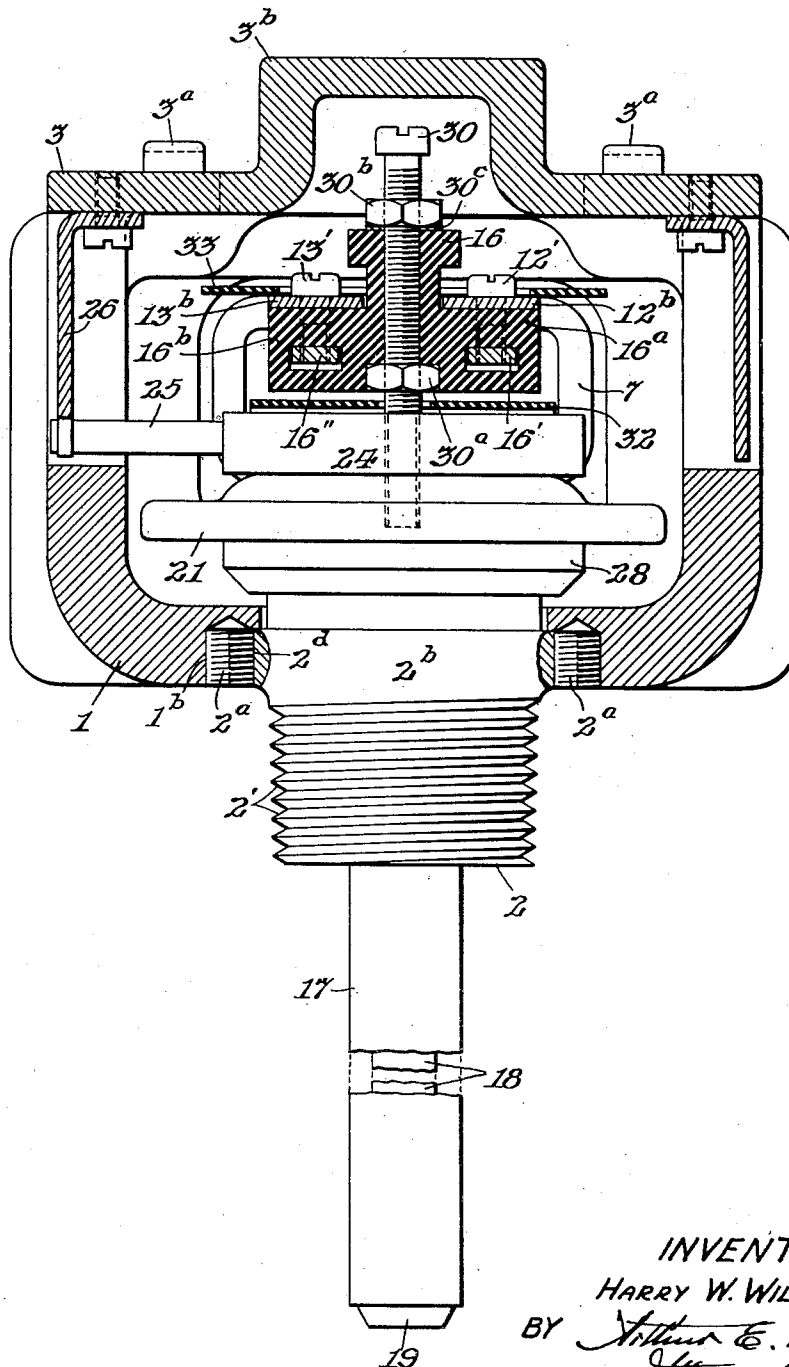
2,235,186

TEMPERATURE LIMIT SWITCH FOR ELECTRIC HEATERS

Filed Dec. 7, 1939

4 Sheets-Sheet 3

FIG. III.



INVENTOR:

HARRY W. WILKINSON,

BY *Arthur E. Baig,*
Attorney.

March 18, 1941.

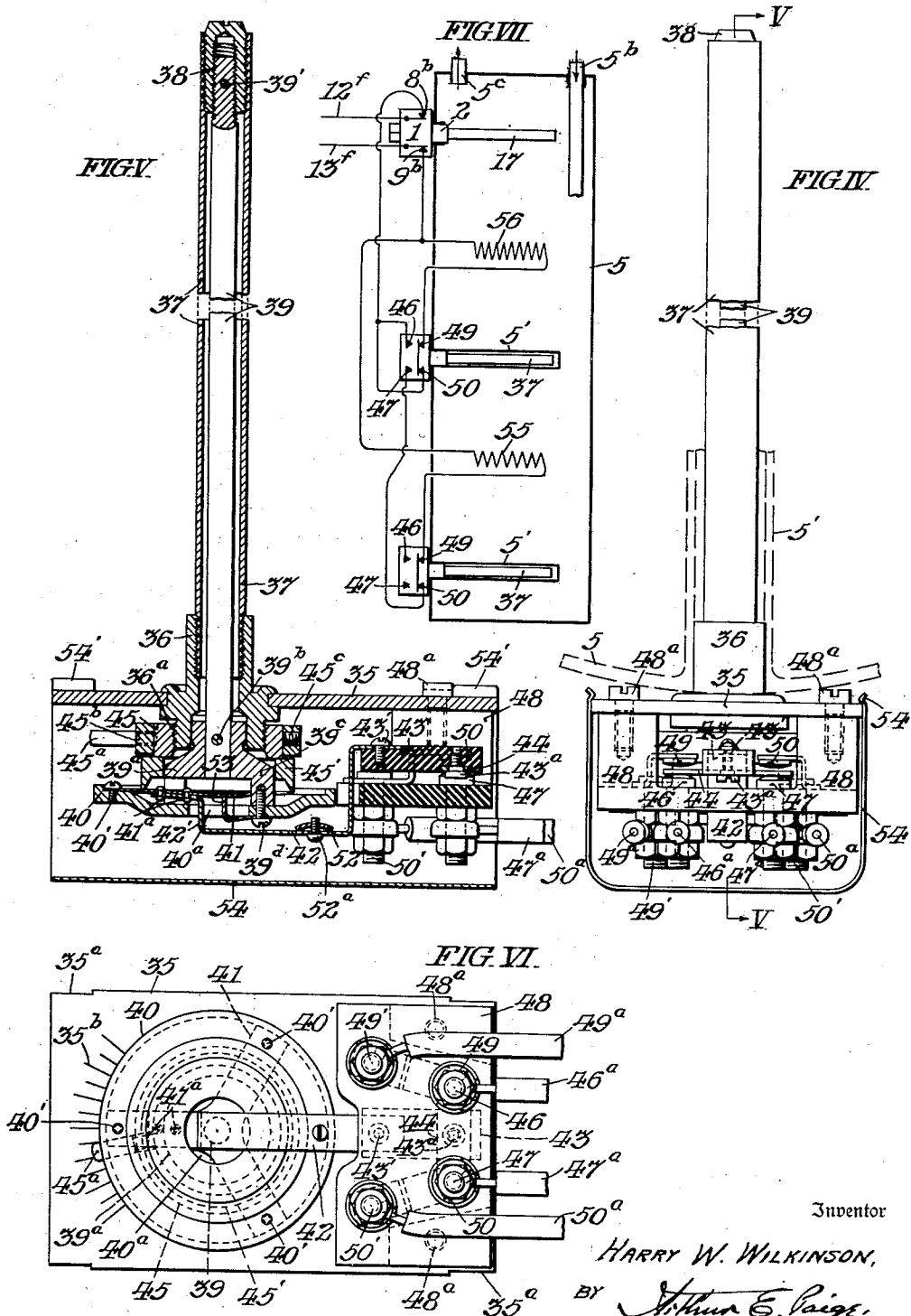
H. W. WILKINSON

2,235,186

TEMPERATURE LIMIT SWITCH FOR ELECTRIC HEATERS

Filed Dec. 7, 1939

4 Sheets-Sheet 4



Inventor

HARRY W. WILKINSON,

BY *Arthur E. Paige*
Attorney

UNITED STATES PATENT OFFICE

2,235,186

TEMPERATURE LIMIT SWITCH FOR
ELECTRIC HEATERSHarry W. Wilkinson, Mount Airy, Pa., assignor to
John Wood Manufacturing Company, Inc.,
Conshohocken, Pa., a corporation of Delaware

Application December 7, 1939, Serial No. 303,676

17 Claims. (Cl. 200—137)

My invention relates to means for installation in electric heaters, to prevent the dangers of overheating them, arising if their ordinary controlling means fail to function. Ordinary devices for that purpose include a fusible chemical compound designed to melt or explode when subjected to a predetermined temperature, and thereby release a spring which breaks a circuit. Such devices are objectionable. First, because there can be no method of predetermining if any such fuse is dependable, as any test thereof would destroy it. Such fuses are only judged by tests of samples picked at random from quantity lots. Second, the temperature of fusion cannot be changed to suit varying conditions of installation. Third, to service heaters with such fuse devices the operator must carry a supply of fuses. Fourth, the cost of heater service is increased by the cost of the operator's time expended in removing the old fuse and substituting the new one, and the cost of the latter.

Therefore, the object and effect of my invention is to provide an electric switch which may be installed as a permanent accessory in such a heater, to automatically break the energizing circuit thereof, at a critical temperature which may be readily changed and predetermined by adjustment.

In each form of my invention hereinafter described, there is a thermostatic couple including two members differentially affected by temperature, whereby movement is imparted to a spring switch lever to shift it to and from electrical contact with terminals of an electrical circuit to close and open said circuit. A snap spring device is interposed between the thermostatic couple and said switch lever to effect snap action of the latter; the snap spring element being formed of a primarily plane sheet of spring metal, which is stressed on a circular line of force in its plane, to cause it to take an arcuate form with its convex surface toward the thermostat.

This invention is an improvement upon that disclosed in my application Serial No. 232,136 filed September 28, 1938, and co-pending herewith, which discloses a switch arranged to be operated by a thermostatic couple and a snap spring. The present invention differs from the disclosures of said application in that: First, whereas in said application the snap spring is supported in a stationary frame, independently of both members of the thermostatic couple; in the present invention the whole snap spring device, including the spring lever, is carried by and bodily moved with, one member of said couple. Second, on the con-

trary, in my prior device a thrust disk is rigidly connected with a screw threaded member of the thermostatic couple and continually thrusts the snap spring, tending to displace it from said stationary frame. Third, in my prior device pressure on the snap spring increases with fall in temperature; consequently, if such a control is subjected to sub-zero temperature, during storage or transportation, its initial calibration may be destroyed by the abnormal stress on the snap spring by the thermostatic couple imparting a permanent set to that spring and thus rendering such control useless; whereas, in the present invention, such abnormal stresses are prevented, and the control retains its initial calibration despite subjection to sub-zero temperature. Fourth, whereas my prior device does not include any means for calibrating the switch lever per se to determine its position relative to the contacts with which it is to cooperate; my present invention includes such calibrating means entirely independent of any means for adjusting the snap spring per se. Fifth, in my prior device aforesaid, changes in the temperature for which the control is set are only manually effected by change in the relative axial position of the two members of the thermostatic couple, by rotation of one of them which is screw-threaded at one end in engagement with the other member of the couple; whereas, in the present invention, such changes are effected by means manually movable independently of both members of the thermostatic couple. Sixth, in my prior device aforesaid the range of adjustment of the temperature setting which may be manually effected after installation of the control of a water heater is limited to less than one-half revolution of the screw-threaded member of the thermostatic couple; whereas, in the present invention the range of adjustment is several times greater, and may be effected by several revolutions of a screw nut engaging a stationary screw, independently of both members of the thermostatic couple. Seventh, in my prior device aforesaid, the angle of the screw thread on one member of the couple which must be free to be manually turned, in connection with the other, is necessarily so great that there is a continual tendency for it to automatically turn and "back off," under the stresses to which it is subjected by changes of temperature; whereas, in the present invention, the screw thread by which the temperature setting is changed is independent of the couple and more nearly normal to its axis, thus avoiding any tendency to "back off" during operation. Eighth, in said prior device an

insulating block for supporting the electrical contacts is variably mounted on two screw posts and must be carefully adjusted by a skilled operator to calibrate each control; whereas, in the present invention the insulating block is rigidly fixed in invariable relation with the frame; whereby the cost of construction of my present invention, both for machined parts and the labor of assembling and calibrating them is materially reduced in comparison with my prior device.

In one embodiment of my invention chosen for illustration, when the electric circuit is thus automatically broken at a predetermined critical temperature, it is not closed again automatically when the temperature to which the switch is subjected lowers below said critical temperature, but it is necessary for the operator to manually move means for causing said snap spring to reverse its curvature to its original convexity.

The latter construction and arrangement are advantageous in that they compel the attention of the operator to the fact that the heater is in an abnormal condition.

My invention includes the various novel features of construction and arrangement herein-after more definitely specified.

In said drawings; Fig. I is an outside end elevation of switch mechanism embodying my invention of the type requiring the operator to manually reverse the snap spring after the circuit is broken, as above contemplated. That form includes a screw adapter in coaxial relation with the thermostatic couple by which the entire structure may be secured in a threaded opening in the wall of the water container of the heater.

Fig. II is a fragmentary horizontal sectional view of the structure shown in Fig. I, taken on the line II, II in the direction of the arrows on said line. Fig. III is a fragmentary vertical sectional view of the structure shown in Fig. I, taken on the line III, III. Fig. IV is a plan view of a simplified embodiment of my invention showing a fragmentary section of a water container having a cylindrical pocket in which the thermostatic couple may be slip-fitted. That embodiment of my invention is adapted to break the energizing circuit of the heater at the limit temperature to which it is adjusted and to automatically close the circuit to resume operation of the heater at a predetermined temperature. Fig. V is a vertical sectional view of the structure shown in Fig. IV, taken on the line V, V in the direction of the arrows on said line, but omitting the water container. Fig. VI is an outside elevation of the outer end of the structure shown in Figs. IV and V. Fig. VII is a diagram of a typical wiring system for an electrical water heater embodying both of said forms of my invention. Figs. I—III are double size. Figs. IV—VI are full size.

Referring to the form of my invention shown in Figs. I, II, and III; the switch housing 1 is conveniently formed of cast iron having the bar brass screw adapter 2 detachably rigidly connected therewith by the screws 2a at its circumference, as shown in Fig. III. The cast iron housing cap 3 is detachably rigidly connected with said housing 1, conveniently by the four screws 3a, shown in Fig. I. As shown in Fig. I, said cap 3 has the hexagonal projection 3b adapted to be readily engaged by a wrench; whereby the entire structure may be turned to screw the adapter 2 into a screw threaded opening 5a in the heater water container 5.

As shown in Fig. I, said housing 1 has at its

opposite sides terminal mounting blocks 6 and 7, of Bakelite or the like, respectively rigidly connected therewith, by screws 6a and 7a. Said block 6 supports the terminal screw binding posts 8 and 9 having cross-heads 8a and 9a fitted in sockets in said block 6, so shaped as to prevent turning movement thereof. Said posts 8 and 9 respectively rigidly connect with the mounting block 6 circuit terminals including contacts 8' and 9' riveted on spring brass strips 8b and 9b. Said strips are bent as shown in Fig. II, so that they may be fitted through openings 6b and 6c in said block 6, and their outer ends 8c and 9c are turned inwardly to engage recesses 6d in said block 6, as indicated in Fig. II, to prevent turning movement of the strips when they are rigidly connected with said block 6 by the nuts 8d and 9d. The flexible conductors 8e and 9e are detachably secured to said binding posts 8 and 9 by nuts 8f and 9f. As shown in Fig. I, said conductors extend through an opening in the terminal box lower end piece 10, of sheet steel, which is rigidly connected with the housing 1, by screws 10a, as shown in Fig. I. The terminal box upper end piece 10b, of steel, is rigidly connected with said housing 1, by screws 10c. The terminal box cover 10d, also formed of sheet steel, is fitted to said box end pieces 10 and 10b and held by screws 10e, as shown in Figs. I and II, but is removable to afford access to the binding posts 8 and 9.

Said mounting block 7 supports the terminal screw binding posts 12 and 13 having cross-heads 12a and 13a fitted in sockets in said block 7, so shaped as to prevent turning movement thereof. Said posts 12 and 13 respectively rigidly connect with the mounting block 7 the left hand ends of spring brass switch levers 12b and 13b, as shown in Fig. I. Said levers have at their right hand ends contact rivets 12c and 13c in registry with the contacts 8' and 9' of terminals 8b and 9b. As shown in Fig. II, the left hand ends of said levers 12b and 13b are bent at right angles so that they may be fitted through openings 7b and 7c in said block 7; the outer ends 12d and 13d of said springs being turned inwardly to engage recesses 7d in said mounting block 7, as indicated in Fig. II, to insure proper placement of said springs and prevent turning movement thereof when they are rigidly connected with said mounting block 7 by the nuts 12e and 13e. The flexible conductors 12f and 13f are detachably secured to said binding posts 12 and 13, by nuts 12g and 13g. As shown in Fig. I, said conductors 12f and 13f extend through an opening in the terminal box lower end piece 14 which is rigidly connected with the housing 1, conveniently by screws 14a, as indicated in Fig. I. The terminal box upper end piece 14b is likewise rigidly connected with said housing by screws 14c. The terminal box cover 14d is conveniently formed of pressed sheet metal fitted to said box end pieces 14 and 14b, as shown in Figs. I and II, but is removable to afford access to said binding posts 12 and 13.

As above indicated, I provide means for calibrating the spring switch levers 12b and 13b to determine their position relative to the contacts of the terminals 8b and 9b with which they are to cooperate and insure that they shall maintain the circuit closed until the temperature to which the thermostatic couple is subjected rises to the degree at which the snap spring will be instantly reversed to instantaneously break the circuit. Such means includes the bridging block 16 having respective arched members 16a and 16b respec-

tively rigidly adjustably connected with the respective spring levers 12^b and 13^b.

As indicated in Fig. II; the arch member 16^a is permanently rigidly connected with the spring lever 12^b by the single screw 12', which extends through said spring and arch member and rigidly engages the nut plate 16' bearing upon the face of said arch member opposite to said spring 12^b, as shown in Fig. III. The screw 12'' in spaced relation with the screw 12', as indicated in Figs. I and II, extends through said spring 12^b and arch member 16^a and also engages said nut plate 16'. As shown in Fig. II, the spring lever 12^b is so shaped as to afford a space between it and the adjacent face of the arch member 16^a; so that by axial movement of said screw 12'' toward said arch member 16^a, the pressure of the spring lever 12^b upon the circuit terminal 8^b is increased, and by axial movement of the screw 12'' in the opposite direction, such pressure is decreased. Consequently, the operator may precisely determine by axial adjustment of said screw 12'' the pressure of contact of said spring lever 12^b upon said terminal 8^b.

Similarly, the arch member 16^b is permanently rigidly connected with the spring lever 13^b by the single screw 13' which extends through said spring and arch member and rigidly engages the nut plate 16'' bearing upon the face of said arch member opposite to the spring 13^b, as shown in Fig. III. The screw 13'' in spaced relation with the screw 13', as indicated in Fig. I, extends through the spring 13^b and arch member 16^b and also engages said nut plate 16'', and is axially adjustable to determine the pressure of contact of said spring lever 13^b upon the terminal 9^b.

Said adapter 2 carries the copper tube 17 which is rigidly connected therewith by the screw thread shown in Fig. II, and is expansible and contractable in accordance with the temperature to which it is subjected in the container 5, as a member of a thermostatic couple, the other member of which is the rod 18 in coaxial but radially spaced relation with said tube 17. Said rod is formed of material which is substantially invariable by the temperatures to which the couple is subjected; for instance, the ferric alloy known commercially as "Invar." Said couple members are rigidly connected with each other, at their ends remote from said adapter 2, conveniently by the screw threaded bushing 19, shown in Fig. II, which is employed to effect primary adjustment of the members of the couple at the factory, and when assembled is thus rigidly connected with the couple member 17.

The outer end of said couple member 18 has the yoke 20 rigidly connected therewith, conveniently by the cross pin 20', shown in Fig. II. Said yoke 20 is of circular configuration, as indicated by the dotted line in Fig. I and has three sectoral lugs 20^a at its perimeter which are rigidly connected by respective screws 20^b with the rigid snap spring frame 21 which is also circular, as indicated by the dotted line in Fig. I. Said snap spring frame 21 carries the snap spring 22 which has a circular series of three radial arms, the outer ends of which are rigidly respectively connected with said frame 21 by screws 22', as indicated in Figs. I and II. As shown in Fig. II; the screws 20^b extend through the adjusting hub 23 and rigidly connect it with said snap spring frame 21. Said hub 23 holds the adjusting ring 24 between an annular flange on the hub and the outer surface of said spring frame 21, as shown in Fig. II. As shown in Fig. I, said ring carries

the set screw 24' by which it may be rigidly clamped upon said hub 23 to precisely determine with reference to the couple rod 18 which carries said hub, the relative circumferential position of the lever 25 which is rigidly connected with said ring 24 and projects radially therefrom. Said lever 25 may be turned by the operator to vary the temperature at which the heat producing circuit may be broken, by the selective placement of said lever with its outer end detained in any one of three notches in the indicator plate 26, shown in Fig. I, and which are respectively marked 180°, 190°, and 200° to indicate the limit degrees Fahrenheit of the water in the container 5 at which the heating circuit shall be broken.

As shown in Fig. II, said adapter 2 supports, in loosely spaced coaxial relation with said yoke 20, the compression ring 28 which has an annular flange extending outwardly against the inner face of the snap spring 22 so that expansion of said thermostatic tubular member 17 under increment of temperature of the water in the container 5 causes the entire snap spring structure above described to be drawn inwardly by the invariable rod member 18 of said couple until, at the critical temperature for which the device has been set, say 180° F., as indicated in Fig. I, said snap spring which is primarily convexly curved inwardly toward said container 5, as shown in Fig. II, is instantaneously reversed in curvature to break the circuit by pushing the spring levers 12^b and 13^b outwardly to separate the spring contacts 12^c and 13^c from the stationary terminal contacts 8' and 9'.

In order to precisely predetermine the effect of the snap spring 22 upon the switch spring levers 12^b and 13^b, I provide the bridging block 16 with manually adjustable power transmitting means including the adjusting screw 30 which extends through said block 16 in coaxial relation with the thermostatic rod 18, as indicated in Figs. I and II. As shown in Fig. III; said adjusting screw 30 is provided with the hexagonal nut 30^a set in a correspondingly shaped recess in said block 16 at the inner face thereof and is provided with the jam nut 30^b bearing upon the spring washer 30^c at the outer face of said block 16. Fig. II illustrates the position of the parts of the switch mechanism when the thermostatic couple 17, 18 is cold. In that position the inner end of the adjusting screw 30 is in spaced relation with the outer surface of the snap spring 22, so that there may be a considerable increment in temperature of the water in the container 5 and consequently of the thermostatic couple before the inward movement of the snap spring structure carried by the outer end of the rod member 18 of said couple causes the snap spring 22 to be thrust outwardly, by its inward movement with respect to the compression ring 28, into contact with the inner end of said adjusting screw 30. Moreover, in accordance with the degree of flexure to which the free ends of spring levers 12^b and 13^b have been set by the axially adjustable screws 12'' and 13'' with respect to the arch members with which they are connected, the pressure of the spring levers upon the stationary terminals may be equalized. The levers are under such pressure on said contacts that there is considerable rise in temperature of the water permitted with consequent outer movement of the snap spring 22, without breaking the circuit, because the resilience of the spring levers 12^b and 13^b continues to maintain

the contacts 12^c and 13^c thereof in electrical connection with the contacts 8' and 9' of the stationary terminals. That construction and arrangement are such that by placement of the inner end of screw 30 in spaced relation to the snap spring the electrical circuits between the terminals 8 and 9 and the switch levers 12^b and 13^b shall be instantaneously broken when the snap spring reverses and only at a precisely predetermined degree of temperature which, in the apparatus illustrated in Fig. I, may be at 180 or 190 or 200° F. in accordance with the position to which the lever 25 has been adjusted, such adjustment precisely determining the relative axial position of the thermostatic rod 18 in its connection with the thermostatic tube 17, because of the screw threaded connection between them at the inner end thereof, which is axially varied by the turning movement of said lever 25.

In order to prevent sparking from the electrically energized parts to other adjacent parts, I find it convenient to insert in the housing 1 the two dielectric barriers 32 and 33, respectively at the inner and outer sides of the electrical contacts, as shown in Fig. II. Said barriers may be conveniently made of hard vulcanized fiber.

It is to be understood that the limit switch mechanism above described is intended to break the electrical heating circuit only when the normal temperature of the water stored in the container 5 is exceeded because of some failure of the controls by which the normal temperature is supposed to be governed. For instance, it is common practice to so construct and arrange an electrical water heating system as to maintain a supply of water in the container at a temperature of 160° F. Therefore, with the lever 25 set as shown in Fig. I, there may be an increment of temperature above the norm of 160° ample to compensate for considerable lessening of the use of the water from said container before the set temperature of 180° F. is reached and consequently without any disruption of the service, which is caused when the limit switch mechanism operates as above described.

In the above described form of my invention, shown in Figs. I to III inclusive, there is no means for re-closing the electric circuits aforesaid automatically after they have been broken automatically as above described. Therefore, it is necessary to remove the housing cap screws 3^a, remove the housing cap, and manually push the adjusting screw 30 inwardly against the stress of the then outwardly convexed snap spring 22 in order to restore the latter to its normal inwardly convexed position shown in Fig. II, after the water in the container 5 and consequently the thermostatic couple 17 and 18 have cooled to a degree permitting such closure. If the temperature has not lowered to that degree it is impossible to manually effect the inward movement of said snap spring to the position shown in Fig. II, because it continues to be thrust outwardly by its contact with the compression ring 28. Therefore, closure of the electrical heating circuit while the water is above the temperature for which the limit switch mechanism described has been set is impossible and necessity for attention to the apparatus is thus imposed upon the operator to restore it to normal operative condition.

In the form of my invention shown in Figs. IV to VI inclusive, means are provided to not only automatically break the electrical circuits when

the thermostatic couple is subjected to a predetermined limit of temperature for which the device is adjusted, but also to automatically re-close the electric circuits when the temperature to which the thermostatic couple is subjected falls below that for which it is set to open the circuit. Incidentally, the structure shown in said figures is less costly to construct and assemble than that shown in Figs. I to III inclusive.

Referring to Figs. IV to VI inclusive; the housing frame plate 35 has the tubular pipe fitting spud 36 rigidly connected therewith, conveniently by clinching the outer end of said fitting in said plate, as shown in Fig. V. The thermostatic couple includes the outer tube 37 of copper having its outer end screwed into said fitting 36. The inner end of said couple member 37 is internally screw threaded to receive the bushing 38 which is internally screw threaded to receive the inner end of the other member 39 of the thermostatic couple, which is conveniently formed of said ferric alloy "Invar." Said bushing 38 is employed as above indicated to effect primary adjustment of the members of the couple at the factory, and when assembled is rigidly connected with the couple member 39, conveniently by the cross pin 39' shown in Fig. V.

The outer end of said couple member 39 has the yoke 39^a rigidly connected therewith, conveniently by the cross pin 39^b shown in Fig. V. Said yoke 39^a is of circular configuration, as indicated by the dotted line in Fig. VI, and has three sectoral lugs 39^c at its perimeter which are rigidly connected, by respective screws 39^d, with the rigid snap spring frame 40 which is also circular, as shown in full lines in Fig. VI.

Said snap spring frame 40; which is thus rigidly connected with the outer end of the thermostatic couple member 39, carries the snap spring 41 which has a circular series of three radial arms, the outer ends of which are rigidly respectively connected with said frame 40 by screws 40', as indicated in Fig. VI. As indicated in Figs. V and VI, said snap spring 41 is rigidly connected, conveniently by two rivets 41^a, with one end of the switch spring lever 42. As best shown in Fig. V, said lever 42 is offset at 42' and extends through the axial hole 40^a in the circular frame 40 and radially outward with respect to said frame and the snap spring 41, and carries at its outer free end the block of dielectric material 43, conveniently formed of Bakelite or similar material which is rigidly connected therewith by the screw 43'.

As best shown in Fig. V; said insulating block 43 has, rigidly connected therewith by the screw 43^a, the contact plate 44 which is set in a recess in said block, as shown in Fig. V, and has its opposite ends projecting laterally from said block, as shown in Fig. IV, respectively overhanging the circuit terminals 46 and 47 and in contact therewith in the position of the device as shown in Figs. IV and V, wherein the thermostatic couple member 37 is expanded axially with respect to the thermostatic couple member 39. Said contact terminals are heads of screws forming binding posts for conductors 46^a and 47^a and are rigidly connected in stationary relation in the terminal mounting block 48 which is formed of dielectric material rigidly connected with said frame plate 35, conveniently by two screws 48^a.

The snap spring device last above described, including the spring lever 42 carried by the thermostatic couple member 39 is cooperatively

related to the other couple member 37 by providing said spud 36 with the screw thread 36^a at its outer end in coaxial relation with the inwardly extending hub portion of said yoke 39^a which is loosely telescopically fitted in the outer end of said spud 36. Said stationary screw thread 36^a is engaged by the screw nut 45 which may be manually turned thereon by means of the lever 45^a to adjust said nut axially with respect to said thermostatic member 37 which, as above described, is in rigid relation with the spud 36 upon which said stationary thread is formed. The outer rim of said nut 45 bears upon the separate compression ring 45' which is interposed between said nut and the snap spring 41, and has an annular flange bearing upon the three radial arms of said snap spring, as best shown in Fig. V. Said compression ring is loosely telescopically fitted upon said yoke 39^c so as to be maintained in coaxial relation with the thermostatic couple members 37 and 39.

As shown in Fig. V, said nut 45 is axially adjusted outward with respect to the snap spring frame 40 so as to convex the snap spring outwardly and press the contact plate 44 upon the terminals 46 and 47 and close the circuit between those terminals when said couple member 37 is expanded as shown.

Said mounting block 43 also supports the two terminals 49 and 50 which overhang said contact plate 44, as shown in Fig. IV. Said terminals 49 and 50 are rigidly connected with said mounting block 43 by respective screw members 49' and 50' of binding posts for conductors 49^a and 50^a.

In order to calibrate the spring lever 42 to obtain equal pressures of the contact plate 44 upon the lower terminals 46 and 47 and upon the upper terminals 49 and 50 in the extreme positions to which said contact plate 44 is alternately snapped by the snap spring 41; I provide the spring lever 42 with the arch plate 52, which is a channel having its opposite edges in contact with said spring 42 and its intermediate portion in spaced relation therewith, as shown in Fig. V. Said plate 52 is threaded as a nut and is engaged by the screw 52^a so that such calibration may be effected by turning said screw to more or less bend said spring lever 42 toward said arch plate 52. Such calibration does not in any wise affect the calibration of the snap spring, which is flexed by the compression ring 45' under pressure of the nut 45, as above described.

The water container 5 has an upper cylindrical pocket 5' in which said spud 36 is slip-fitted, as shown in Figs. IV and VII to support the thermostatic couple 37, 39 in temperature interchanging relation with the water in said container.

The construction and arrangement above described are such that when the thermostatic couple member 37 is below the set temperature it is contracted axially so that the snap spring 41 is convexed inwardly, and the circuit between terminals 49 and 50 is closed, as indicated in Fig. VII, until the temperature local to said pocket 5', rises to the degree for which the thermostatic nut 45 has been set by the lever handle 45^a, for instance, 160° F. During that rise in temperature the couple member 37 has expanded axially, increasing the pressure of the snap spring 41 upon the compression ring 45' and relaxing the pressure of the contact plate 44 upon the terminals 49 and 50; but it is not until the thrust of said spring upon the ring 45' is increased to the point where the snap spring 41 will snap

outwardly away from the couple member 39, that the contact plate 44 is instantly snapped away from the terminals 49 and 50 and into contact with the terminals 46 and 47, as shown in Figs. IV and V, thus breaking the one heating circuit 5 through the conductors 49^a and 50^a and closing the other heating circuit through the conductors 46^a and 47^a. When the temperature of the water, local to the upper pocket 5', again falls below that for which the thermostatic couple 37, 39 therein is set; the snap spring 41 instantly snaps the contact plate 44 away from the terminals 46 and 47 and into contact with the terminals 49 and 50, as indicated in Fig. VII, until the water, local to that pocket, is again heated to the limit temperature 15 of 160° F.

I find it convenient to provide the structure of Figs. IV to VI with a resilient sheet metal cover 54 which has four spring tabs 54' so that it may be snapped into detachable engagement with said frame plate 35, but is readily removable to afford access to the binding posts. As shown in Fig. VI, said frame plate 35 is conveniently provided with four recesses 35^a at the respective corners thereof to receive said tabs 54'.

Although the handle lever 45^a may be directly screwed into the nut 45; I prefer to mount it in a wrench collar 45^b which surrounds said nut and is adjustably rigidly connected therewith by said lever and by the set screw 45^c shown in Fig. V; for the latter arrangement permits of convenient location of said lever 45^a after the nut 45 has been primarily assembled in the desired axial position. The outer surface of said frame plate 35 may be provided with graduations 35^b to indicate the temperature to which said thermostatic couple 37, 39 has been set.

Moreover, the reversal of the snap spring 41 from its outwardly convexed position shown in Fig. V to its inwardly convexed position above contemplated, may be facilitated by the auxiliary spring 53, shown in Fig. V, which has one end fixed beneath the head of the screw 39^d, shown in Fig. V, and the other end bearing upon the outer surface of said spring 41, adjoining the axis of the latter.

Fig. VII is a diagram of a typical wiring system for an electrical water heater embodying both forms of my invention above described, in connection with the water container 5. Said container has the cold water inlet 5^b and the hot water outlet 5^c through which water is dispensed. Said container is provided with the lower, main, heating coil 55 of such proportions as to maintain the water in said container 5 heated to the desired degree, under normal conditions of withdrawal through the dispensing outlet 5^c. However, to maintain the desired temperature of the water under abnormal conditions of withdrawal, I provide said container 5 with the upper, auxiliary, heating coil 53. As indicated in Fig. VII; a temperature limit switch embodying my invention as above described with reference to Figs. I to III inclusive, is installed near the top of said container 5 and the electrical energy for selectively heating the coils 55 and 53 is supplied through the conductors 12^f and 13^f. A temperature limit switch embodying my invention as above described with reference to Figs. IV, V, and VI is installed in said container between said heating coils 55 and 56. Another such limit switch as described with reference to Figs. IV, V, and VI is installed near the bottom of said container 5. As above noted and indicated in Fig. I, the uppermost switch in Fig. VII

is set to break the circuit at the limit of 180° F. With such a setting of that switch; the switch between the coils 55 and 56 is set to break the circuit, through coil 56, and close its circuit to coil 55 at 160° F., and the lowest switch in Fig. VII is set to break its circuit to coil 55 at 160° F.

Referring to Fig. VII; it is to be understood that the temperature of the water local to the uppermost switch thermostatic member 17 is below the limit temperature of 180° F., and consequently that switch remains closed. The temperature of the water local to the switch between the coils 55 and 56 is at a temperature below its set limit of 160° F. and, consequently, the circuit through coil 56 remains closed at that switch, and the coil 56 is energized. The temperature of the water local to the lowermost switch also is below its limit of 160° F., and the circuit to the coil 55 is closed at said switch. However, as the auxiliary coil 56 is being energized because its switch is also closed, the main coil 55 must remain deenergized until the switch controlling the coil 56 moves to open position (due to rise of temperature of the water local thereto), thereby closing the gap in the circuit to the lowermost coil 55. Thereupon, if the circuit to the coil 55 is still closed at its switch, the main coil 55 becomes energized. Under such conditions, if the withdrawal of water from the container 5 through the dispensing outlet 5^a is at such a rate that the temperature of the water in the bottom of the container local to the lowermost switch rises above 160°, that switch will open the circuit to the main heating coil 55 until the water reaches a temperature below 160° local to that switch. However, the coil 55 cannot be energized unless and until the switch between the coils 56 and 55, which controls the coil 56, be in open position. If, for any reason, the temperature of the water local to the upper switch rises to its set limit of 180° F. the circuit will then be broken at that switch, and can only be closed after the temperature of the water local to that switch falls below 180°, and then only by the operator removing the housing cap 3^b and pushing the resetting screw 30 to restore the snap spring 22, shown in Fig. II, to the position shown in that figure, in which the heating circuit is closed.

It may be observed that when used in the bottom of the container 5, as indicated in Fig. VII, only one pair of the electrical terminals in the switch mechanism described with reference to Figs. IV to VI inclusive is used, being the terminals 49 and 50.

Commercial water containers such as indicated at 5 are of many different sizes and with different sizes of screw threaded openings in their walls for insertion of pipes or thermostatic controlling devices. Therefore, I find it convenient to provide a plurality of adapters 2, with respective external screw threads 2' of different standard pipe sizes, but each having a cylindrical circumferential flange 2^b fitting the cylindrical recess 1^a in the back wall of the housing 1; so that any such adapter may be selectively, interchangeably, rigidly connected with such a housing, by two screws 2^a each having half its circumference extending in its notch 2^d in the adapter flange 2^b, and the other half in its notch 1^b in the housing 1.

However, I do not desire to limit myself to the precise construction, arrangement, embodiment, or method of operation of the forms of my invention above described, as it is obvious that various modifications may be made therein without de-

parting from the essential features of my invention as defined in the appended claims.

I claim:

1. In a temperature limit electric switch; a thermostatic couple, of which one member is a metal tube subject to axial expansion and contraction by the temperatures to which the couple is subjected, and the other member is a rod substantially unaffected by the temperatures to which the couple is subjected, and extends in said tube; means connecting the members of said couple with each other at one end in relatively rotary and axially movable relation; a yoke rigidly connected with the free end of said rod; a snap spring frame, rigidly connected with said yoke and carried by said rod; a concavo-convex snap spring, formed of sheet metal, arranged to snap alternately in opposite directions, transversely to its plane, under pressure upon one face thereof, and having its perimeter mounted in said frame; a stationary compression ring, surrounding said rod and yoke and bearing upon the inner face of said snap spring; a spring switch lever arranged to be operated by said snap spring upon relative movement of the members of said couple; fulcrumed at one end and carrying a contact at its free end; an electric circuit terminal having a contact with which said spring lever contact is adapted to register; said switch lever and terminal being included in an electric circuit which is to be broken at a temperature limit to which said couple is subjected; and means for predetermining and varying the limit temperature of operation of said switch lever, by adjustably varying the pressure of the inner face of the snap spring on the compression ring.

2. A structure as in claim 1; comprising means for adjustably varying the shape of said lever by bending it, including an arch member extending transversely to said spring lever, and a screw extending through said lever in engagement with said arch member, whereby said lever may be more or less flexed at the region of said arch member in accordance with the adjustment of said screw, to variably determine its contact pressure on the terminal in registry therewith.

3. A structure as in claim 1; including a pair of spring switch levers with contacts; a pair of electric circuit terminal contacts with which the lever contacts are adapted to respectively register; a bridging block connecting said pair of levers and having a pair of arch members respectively extending transversely to said levers; and a pair of screws, respectively extending through said levers in engagement with said arch members; whereby each lever may be independently flexed more or less at the region of its arch member in accordance with the adjustment of its screw, to variably determine its contact pressure on the terminal in registry therewith.

4. A structure as in claim 1; wherein the snap spring is concavo-convex, in coaxial relation with the thermostatic couple, and an element, in co-operative relation therewith is movable, against one face of the snap spring for reversing the convexity of that spring.

5. A structure as in claim 1; including a stationary tubular housing member, in which is fixed the end of said tubular thermostatic member remote from its junction with the rod member; which housing member supports the compression ring.

6. A structure as in claim 1; including a stationary tubular housing member, in which is fixed the end of said tubular thermostatic member

remote from its junction with the rod member; which housing member supports the compression ring; and means interposed between said housing member and the compression ring, whereby the latter may be adjusted toward and away from the snap spring, including a nut engaging an external screw thread on said tubular housing member, and means carried by said nut, whereby it may be manually turned, to variably predetermine the limit temperature at which the electric circuit shall be broken by movement of the spring lever.

7. A structure as in claim 1; wherein the snap spring is concavo-convex, in coaxial relation with the thermostatic couple, and an element, in cooperative relation therewith, is movable, against one face of the snap spring for reversing the convexity of that spring and is an adjusting screw carried by the spring lever and adjustable toward and away from the snap spring to variably predetermine the limit temperature at which the electric circuit is broken; and a housing with a removable cap inclosing said adjusting screw; whereby, when the electric circuit is broken by reversal of the convexity of the snap spring by the action of the thermostatic couple, the reversed snap spring holds the spring lever away from the circuit terminal until the cap is removed and the snap spring restored to its initial convex position by manually pushing said adjusting screw and spring lever toward the thermostatic couple.

8. A structure as in claim 1; wherein the snap spring frame is annular and the yoke is rigidly connected with the snap spring frame by a circular series of lugs, and the snap spring has a circular series of radial arms respectively extending, between adjoining lugs of said series, to the perimeter of the snap spring mounted in the snap spring frame.

9. A structure as in claim 1; wherein the snap spring frame is annular and the yoke is rigidly connected with the snap spring frame by a circular series of lugs, and the snap spring has a circular series of radial arms respectively extending, between adjoining lugs of said series, to the perimeter of the snap spring mounted in the snap spring frame; and the spring lever is rigidly connected at one end to one of the arms of said snap spring, in eccentric relation to the axis of said snap spring, and is offset through an axial opening in said snap spring frame radially therefrom toward the circuit terminal.

10. A structure as in claim 1; including a pair of spring switch levers with contacts; a pair of electric circuit terminal contacts with which the lever contacts are adapted to respectively register; a bridging block connecting said pair of levers; an adjusting screw carried by said bridging block between said levers, and adjustable toward and away from the snap spring to variably predetermine the limit temperature at which the electric circuit is broken, and manually movable against the outer face of said snap spring to reclose the electric circuit after it has been broken by the action of the thermostatic couple.

11. In a temperature limit switch for electric heaters; a thermostatic couple, of which one member is a metal tube subject to axial expansion and contraction by the temperatures to which the couple is subjected, and the other member is a rod substantially unaffected by the temperatures to which the couple is subjected, and extends in said tube in coaxial, radially spaced, relation therewith; means connecting the members

of said couple with each other at one end by screw threads, in relatively rotary relation; a yoke rigidly connected with the free end of said rod; a rigid snap spring frame, rigidly connected with said yoke and carried by said rod; a snap spring, formed of sheet metal, arranged to snap alternately in opposite directions, transversely to its plane, under pressure upon one face thereof, and having its perimeter mounted in said frame; a compression ring, surrounding said rod and yoke, in fixed relation with said tube and having an annular rim bearing upon said snap spring in substantially symmetrical relation therewith; a spring switch lever arranged to be operated by said snap spring upon relative movement of the members of said couple, fulcrumed at one end and carrying a contact at its free end; an electric circuit terminal having a stationary contact with which said spring lever contact is adapted to register; said switch lever and terminal being included in an electric circuit which is to be broken at a temperature limit to which said couple is subjected; means for adjustably predetermining and varying the limit temperature of operation of said switch lever, by rotary adjustment of said rod in its threaded connection with said tube.

12. In a temperature limit electric switch; a thermostatic couple, of which one member is a metal tube subject to axial expansion and contraction by the temperatures to which the couple is subjected, and the other member is a rod substantially unaffected by the temperatures to which the couple is subjected, and extends in said tube; means connecting the members of said couple with each other at one end in relatively rotary and axially movable relation; a yoke rigidly connected with the free end of said rod; a snap spring frame, rigidly connected with said yoke and carried by said rod; a concavo-convex snap spring carried by said frame and arranged to snap alternately in opposite directions, transversely to its plane, under pressure upon one face thereof; a compression ring, surrounding said rod and yoke and bearing upon the inner face of said snap spring; a spring switch lever, arranged to be operated by said snap spring upon relative movement of the members of said couple, fulcrumed at one end and carrying a contact at its free end; an electric circuit terminal having a contact with which said spring lever contact is adapted to register; said switch lever and terminal being included in an electric circuit which is to be broken at a temperature limit to which said couple is subjected; and means for predetermining and varying the limit temperature of operation of said switch lever, by adjustably varying the pressure of the inner face of the snap spring on the compression ring.

13. A structure as in claim 12; including means, manually movable into cooperative relation against one face of said snap spring, for reversing the convexity of said spring; whereby, when the electric circuit is broken by reversal of the convexity of the snap spring by the action of the thermostatic couple, the reversed snap spring holds the spring lever away from the circuit terminal until said snap spring is restored to its initial position by manually pushing said means and spring lever toward the thermostatic couple.

14. A structure as in claim 12; including adjustable means, manually movable into cooperative relation against one face of said snap spring, for reversing the convexity of said spring; whereby, when the electric circuit is broken by reversal

of the convexity of the snap spring by the action of the thermostatic couple, the reversed snap spring holds the spring lever away from the circuit terminal until said snap spring is restored to its initial position by manually pushing said means and spring lever toward the thermostatic couple.

15. In a temperature limit electric switch; the combination with a pair of terminals for an electric heating circuit; of supporting means holding said terminals in relatively spaced, insulated, stationary position; a spring switch lever, formed of flexible sheet metal, having one end fulcrumed in fixed relation with one of said terminals with its other end movable to and from contact with the other terminal but biased to normally close the circuit between said terminals; a thermostatic couple, comprising a rod and a tube in coaxial relation and respectively substantially invariable and variable in axial length by the temperatures to which said couple is subjected; one end of said tube being rigidly connected to said supporting means and the other end to one end of said rod; a reversibly concavo-convex snap spring formed of sheet metal; means rigidly connecting the perimeter of said snap spring in substantially coaxial relation with, and normally convexed toward, the free end of said rod; a compression ring, held stationary by said supporting means, encircling said couple between the stationary end of said tube and said snap spring and in contact with one face of that spring; and means for transmitting movement from the center of said snap spring to push said switch lever open; whereby, increment of heat toward the temperature limit, increases the axial length of said tube and the pressure of the snap spring on said ring, without breaking the circuit until the temperature limit is reached and the snap spring then instantly reversed.

16. A structure as in claim 15; including means adjustable to vary the normal flexure of said lever and pressure of contact of its free end on the local terminal, including an arch member carried by said lever, and a screw extending through the lever and engaging said arch member.

17. In a temperature limit switch for electric heaters; the combination with a hollow, cast metal, housing having opposite walls with openings through them, with an annular cylindrical recess surrounding one of said openings; of a tubular metal adapter, having both an external standard pipe screw thread and an internal screw thread at one end, and an outwardly projecting circumferential flange at its other end fitting said recess; means detachably securing said adapter in said recess in rigid relation with said housing; a housing cap covering the opening in the other wall of said housing and having a wrench hold on its outer face, whereby said adapter may be screwed; means detachably securing said cap in rigid relation with said housing; a thermostatic couple carried by said adapter, including a metal tube, fixed at one end in the internal screw thread of said adapter and expansible and contractable by the temperatures to which the couple is subjected, and a rod in said tube in screwed connection therewith at its end remote from said housing and substantially unaffected by the temperatures to which the couple is subjected; a normally closed electric switch in said housing; a reversible concavo-convex snap spring carried by the end of said rod in said housing, and connecting means in said housing, between said snap spring and switch, whereby the switch is snapped open when the couple is subjected to the limit temperature.

HARRY W. WILKINSON.