Aug. 11, 1942. J. A. SPENCER 2,292,976

THERMAL RELAY

Filed Oct. 13, 1939

FIG. 1.

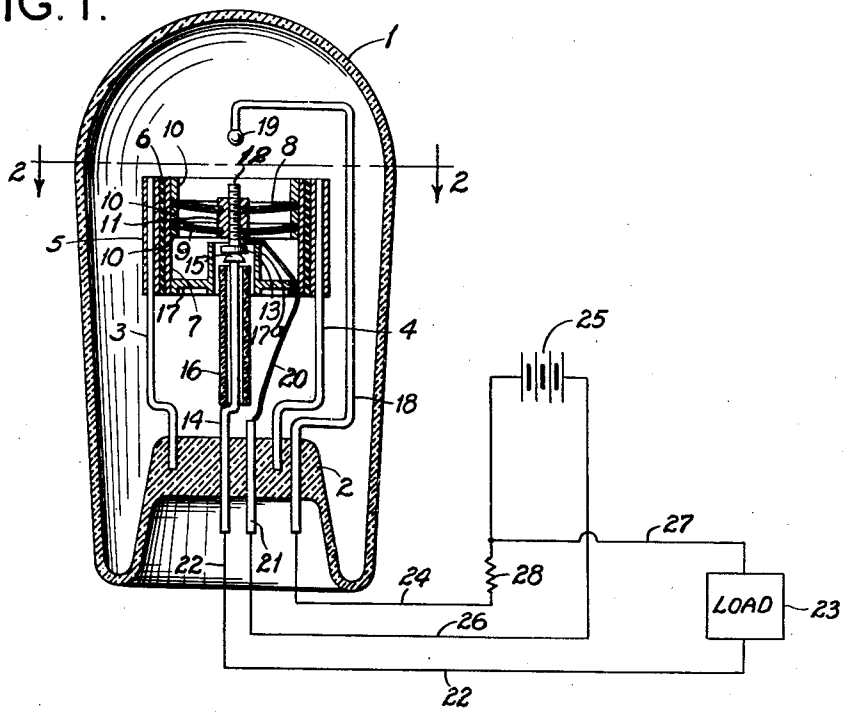


FIG. 2.

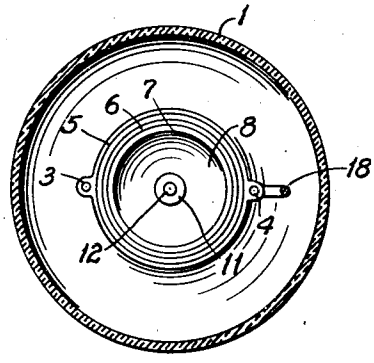
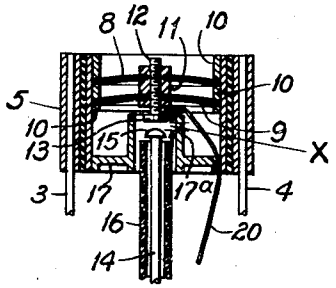


FIG. 3.



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2,292,976

THERMAL RELAY

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5 Claims. (Cl. 250—27.5)

This invention relates to thermal relays, and with regard to certain more specific features, to thermal relays enclosed in and operating in an ionizable gaseous atmosphere.

Among the several objects of the invention may be noted the provision of a thermal relay which requires very little electrical energy to operate, but which is capable of handling relatively large amounts of electrical power; the provision of a thermal relay which acts quickly in response to given external conditions; the provision of a thermal relay utilizing the so-called "short-path" principle in relation to the make and break of its electrical contacts; and the provision of a relay which is easily and economically manufactured, and which is effective and reliable in operation. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing, in which is illustrated one of various possible embodiments of the invention:

Fig. 1 is a cross-section of a relay embodying the present invention, and also shows a circuit diagram;

Fig. 2 is a horizontal section taken substantially along line 2—2 of Fig. 1; and,

Fig. 3 is a fragmentary section similar to a part of Fig. 1 but showing a different operating position.

Similar reference characters indicate corresponding parts throughout the several views of the drawing.

In the present invention, the thermal element and switch parts are mounted in a gas-tight enclosed container, such as a glass or metal envelope of the type customarily used in the electron discharge art. These parts are surrounded with neon, helium, or some other inert but ionizable gas capable of having a glow discharge passed through it, and then by means of the proper anode and cathode connections, the thermal element is heated by a glow discharge playing directly on it. In this manner, very little electrical energy is consumed in the heating, since the glow discharge is highly efficient and needs little energy to maintain it. Further, most of the heat available from the glow discharge is expended directly upon the thermal element and little is used to heat any mass except that of the thermal element, the gaseous flow discharge itself having no mass from a practical standpoint. Furthermore, when the glow discharge stops, there is no heated mass to cool such as there is when a resistance wire heater is used, except that of the thermal element, and thus the element cools rapidly to give quick response.

In describing the present invention, an embodiment is shown which has for certain of its mechanical parts a thermally sensitive device constructed according to the principles disclosed in the copending application of Harold M. Wilson, Serial No. 150,242, filed June 25, 1937, now Patent 2,203,558. This is a device using thermostatic snap-acting elements mounted so as to give no response when both elements are affected equally in temperature, but which do respond when one of the elements is heated at a predetermined rate faster than the other.

Referring now more particularly to Fig. 1, numeral 1 indicates a glass or metallic envelope or bulb (such as is used in the radio industry) with an inwardly projecting stem 2 which is used as a means of evacuating and, later, of filling the tube with the proper gas. The stem 2 also supports the various parts of the relay which are mounted within the tube 1. Mounted on the stem 2 in a manner well known in the lamp industry are two supporting wires 3 and 4 carrying at their upper ends a metal or ceramic cylinder 5 whose purpose is to support the various parts of the thermal relay. Lining the inside wall of cylinder 5 is a cylinder 6 of mica (or other insulating medium) which serves as an electrically insulating shield. Within cylinder 6 is mounted a metallic cylinder 7 which serves as a mount proper for two thermal elements 8 and 9.

Thermal elements 8 and 9 are snap-acting composite thermostatic metal discs of the type disclosed and claimed in John A. Spencer Patent No. 1,448,240, dated March 13, 1923. The discs 8 and 9 are mounted at their rims by means of rings indicated severally at 10. Rings 10 can be welded or otherwise fastened in a suitable manner to the cylinder 7 and are so spaced axially that the rims of the discs 8 and 9 are held thereby in a substantially free, yet firm manner. A spacer 11 with suitable abutments and shoulders is provided between the discs at their centers, of such length that the discs are held apart at their centers substantially the same distance as they are held apart at their rims. A screw 12 (see Fig. 3) is threaded through spacer 11, and

a contact button 13 is welded or otherwise fastened to screw 12 at one end to form electrical connection therewith. The discs and spacers etc. are so mounted that, when heated, the two discs 8 and 9 tend to snap in opposite directions. Consequently, with the centers spaced apart by the spacer 11 substantially the same distance as the rims, the combination of the two discs forms a thermally sensitive device which is compensated against ambient temperature changes which affect both discs equally.

This relay is fully described in the aforesaid Wilson application, and, briefly, it works as follows: The two discs 8 and 9 have different temperatures at which they snap when heated, and also different temperatures at which they snap when cooled. Assuming that disc 8 has a higher temperature at which it snaps when heated than disc 9, then the force exerted by disc 8 in what may be called the positive direction is proportional to the difference between ambient temperature value and the temperature at which disc 8 snaps when heated. On the other hand, the force exerted by disc 9 in a negative or opposite direction against the force exerted by disc 8, is proportional to the difference between the ambient temperature value and the temperature at which disc 9 snaps when cooled. Consequently, regardless of ambient temperature value, there is a net force proportional to the difference of the above two forces, tending to keep the assembled two discs stable in one position. For example, suppose that the snapping temperatures of disc 8 are 150° on heating and 130° on cooling, and the snapping temperatures of the disc 9 are 120° on heating and 100° on cooling. Now assume that ambient temperature value is 70°. According to the above, the force exerted by disc 8 is proportional to 150° minus 70°, or 80°. This is in one direction. The force exerted by disc 9 to oppose disc 8 is proportional to 100° minus 70°, or 30°. This force is in an opposite direction, and consequently the net force exerted by the disc system is proportional to 80° minus 30°, or 50°. Now suppose the ambient temperature rises to 80°. The force exerted by disc 8 is now proportional to 150° minus 80°, or 70°, and the force exerted by disc 9 is proportional to 100° minus 80°, or 20°. The net result is still a force proportional to 50°. This same proportionality applies regardless of what value the ambient temperature has. However, to cause the two discs to snap into an opposite position (Fig. 3) it is necessary to heat disc 8 sufficiently more than disc 9 so that this 50° difference becomes zero, and consequently, regardless of ambient temperature value, the discs as a system will always react in a substantially constant time for a given amount of heat applied to disc 8.

The temperatures at which the two discs snap are so arranged that when disc 8 is heated, the system of the two discs together snaps upwardly so that, as shown in Fig. 3, the contact button 13 is lifted upwardly. Of course, the two discs can be so arranged that the combination will snap downwardly when disc 8 is heated, if so desired. Since the two-disc relay is not per se the basis of this invention, its working will not be further described here.

Mounted on stem 2 is an electrically conducting rod 14 with a contact button 15 suitably fastened at its top end. Contact buttons 13 and 15 co-act to open and close an electrical circuit. A glass or other electrically insulating material sleeve 16 is mounted around the rod 14 and is substantially the same length as the rod, so that no part of the rod is exposed except the contact button 15. A plate 17 with an upwardly extending sleeve 17*a*, through which the glass sleeve 16 passes, is fastened to the cylinder 7. This completes the structure of the relay itself.

Likewise mounted on stem 2 is a metallic or otherwise electrically conducting rod 18 which terminates at the upper end of the glass tube 1 in a downwardly aimed point or small ball 19. Between this point 19 and the properly prepared surface of the disc 8 there is passed a glow discharge through the gas in the tube in order to heat disc 8. The upper surface of the disc 8 is prepared with a proper coating such as the oxides of barium, strontium or caesium, for example, as is well known in the electron discharge tube industry, so that a glow discharge can be obtained between disc 8 and the point 19. A flexible electrically conducting wire or ribbon 20 is electrically connected at one end to contact button 13, passes down through plate 17, and is electrically connected to a rod 21 in stem 2.

If desired, the tube 1 can be suitably mounted in a base such as customarily provided on radio tubes for making connections by means of a plug-in-socket. It is not shown here since it is not essential to the present invention.

Electrical connections are made as follows: A wire 22 connects the lower end of rod 14 with one side of a load 23. A wire 24 is connected at one end to rod 18 and at the other end to one pole of a source of voltage 25. A wire 26 is connected at one end to the rod 21; at the other end to the other pole of voltage source 25. If necessary, a resistor 28 to limit the current which passes between the point 19 and the disc 8 may be inserted in the circuit of wire 24. Wire 27 connects the other side of the load with wire 24. As thus connected, a potential is impressed across the disc 8 and point 19; and the contacts 13 and 15 connect the potential across the load.

The envelope 1 is carefully evacuated and then filled with, say, about 17 mm. pressure of neon or some other ionizable inert gas such as helium. This filling is done when the bulb is hot in order to degasify the various parts in the tube, and when the tube cools down, there is a resulting 12 mm. (approximately) pressure in the bulb.

There is known, in the theory and practice of electrical discharge in gases, the fact that for an electrical discharge to take place between two electrodes of opposite polarity, at a given gas pressure, the separation of the two electrodes must be equal to or greater than a minimum distance depending on the type of gas, its pressure, and the voltage used. If the separation is less than this minimum distance, then substantially no discharge can take place between the electrodes. In fact, in the latter case the discharge will only take place from one electrode to a point on the other electrode structure remote from the electrode point itself, where the length of the discharge is equal to or greater than said minimum distance. If electrical contacts are separated under the above conditions a distance less than this minimum distance, substantially no discharge, or destructive arcing will occur. This principle is known as the short-path principle.

In the present relay, the separation of the contacts 13 and 15 is such that when the contacts are separated to open the electrical circuit, the length of path X (Fig. 3) between them is less

than the minimum distance required for arcing. For example, for a pressure of 10 mm. of neon, this contact separation should be less than 1 mm., approximately, at 250 volts. However, unless some means are provided to insulate the rod 14 from any discharge, the discharge would take place from contact 13 to some part of the rod 14 whereby the length of discharge would be equal to or greater than 1 mm. Consequently, one purpose of the glass sleeve 16 and sleeve 17a, is to insulate rod 14 in such manner that at no point on it can a discharge take place whereby the length of discharge will be equal to or greater than the minimum distance required for arcing. Discharge will not take place from contact 13 to cylinder 7 or plate 17 since they are all of the same polarity.

The operation of the device is as follows: When a potential or electromotive force is impressed between wires 24 and 26, the potential is impressed between the point 19 and the disc 8. This causes a glow discharge to take place between point 19 and disc 8 in the gas with which the tube is filled. Disc 8 consequently heats up. Meanwhile, contacts 13 and 15 have been closed, thus closing the circuit between 22 and 23 and any control mechanism or load 23 connected through this switch presumably is operating. When disc 8 heats up, it does so at a more rapid rate than disc 9 and consequently the disc system as a whole will ultimately snap upward, thus breaking the connection between contacts 13 and 15. However, as already explained, this contact separation is predetermined so that it is less than the minimum distance required for a discharge to take place in the gas with which the tube is filled and at the voltage impressed across contacts 13 and 15, and at the gas pressure used. Consequently, substantially no arcing can take place between contacts 13 and 15. This means that large current-interrupting capacity can be had with a relatively small relay and relatively small contacts 13 and 15. If it were not for the use of the short-path principle, discharge might take place between contacts 13 and 15 with resulting disruption and destroying of the contacts and failure of the relay.

In order to cause the relay to close the circuit again, all that is necessary is to remove the potential across wires 24 and 26 so that the glow discharge between point 19 and disc 8 ceases. Disc 8 will then cool down and the disc system will snap downwardly to close contacts 13 and 15. Inasmuch as no electrical heater has been used which has any heat mass associated with it, the cooling of disc 8 will be much more rapid than if a heating wire or means other than the gas discharge were used to furnish heat.

The resistor 28 can be made of the proper size so that the glow discharge between 19 and 8 will not overheat disc 8, and may even be adjustable to control the length of time required to heat disc 8 to the snap point.

While I have embodied my invention in a relay using two snap-acting discs, nevertheless a single disc can be used if ambient compensation is not desired. Likewise, any other form of thermostatic element can be used without departing from the spirit of my invention.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A thermal relay comprising a hermetically sealed envelope filled with an ionizable inert gas, a composite thermostatic metal element mounted in said envelope, said element comprising a pair of snap-acting composite thermostatic metal thermostats, means mounting said thermostats with their tendency to move in opposite directions, and means connecting the movable portions of said thermostats together, with the system comprising the two thermostats substantially stable in one position, regardless of ambient temperature value, so long as said thermostats do not differ in temperature more than a predetermined amount, a movable contact connected to the movable portion of said element, a fixed contact mounted in said envelope adjacent said movable contact, means for causing one of said thermostats to respond to changes of ambient temperature more quickly than the other thermostat comprising a region on the surface thereof coated with a material adapted to promote a gaseous glow discharge, and an electrode mounted in said envelope adjacent said region, the distance between said movable and fixed contacts when in their position of maximum separation being less than the minimum distance required for arcing.

2. A thermal relay comprising a hermetically sealed envelope filled with an ionizable inert gas, a composite thermostatic metal element mounted in said envelope comprising a pair of snap-acting thermostatic discs, means mounting said discs with their tendency to move in opposite directions, and means connecting the movable portions of said discs together with the system comprising the two discs substantially stable in one position, regardless of ambient temperature value, so long as such discs do not differ in temperature more than a predetermined amount, a movable contact connected to the movable portion of said element, a fixed contact mounted in said envelope adjacent said movable contact, and an electrode mounted in said envelope adjacent said element, the distance between said movable and fixed contacts when in their position of maximum separation being less than the minimum distance required by arcing.

3. A thermal relay comprising a hermetically sealed envelope filled with an ionizable inert gas, a thermally sensitive element mounted in said envelope, comprising a pair of snap-acting thermostatic discs, means mounting said thermostatic discs with their tendency to move in opposite directions, and means connecting the movable portions of said thermostatic discs together with the system comprising the two thermostatic discs substantially stable in one position, regardless of ambient temperature value, so long as such thermostatic discs do not differ in temperature more than a predetermined amount, a movable contact connected to said element, a fixed contact mounted in said envelope adjacent said movable contact, said element having a region on the surface thereof coated with a material adapted to promote a gaseous glow discharge, and an electrode mounted in said envelope adjacent said region.

4. A thermal relay comprising a hermetically sealed envelope filled with an ionizable inert gas, a composite thermostatic metal element mount-

ed in said envelope, said element comprising a pair of snap-acting thermostatic discs, means mounting said thermostatic discs with their tendency to move in opposite directions, and means connecting the movable portions of said thermostatic discs together with the system comprising the two thermostatic discs substantially stable in one position, regardless of ambient temperature value, so long as said thermostatic discs do not differ in temperature more than a predetermined amount, a movable contact connected to the movable portion of said element, a fixed contact mounted in said envelope adjacent said movable contact, means for causing one of said thermostatic discs to respond to changes of ambient temperature more quickly than the other thermostatic disc comprising a region on the surface thereof coated with a material adapted to promote a gaseous glow discharge, and an electrode mounted in said envelope adjacent said region, the distance between said movable and fixed contacts when in their position of maximum separation being less than the minimum distance required for arcing.

5. A thermostatic electric switch comprising a hermetically sealed envelope filled with an ionizable inert gas, a composite metal thermostat mounted in said envelope, comprising a pair of snap-acting thermostatic elements, means mounting said thermostatic elements with their said tendency to move in opposite directions, and means connecting the movable portions of said thermostatic elements together with the system comprising the two thermostatic elements substantially stable in one position, regardless of ambient temperature value, so long as such thermostatic elements do not differ in temperature more than a predetermined amount, a movable contact connected to the movable portion of said thermostat, a fixed contact mounted in said envelope adjacent said movable contact, the distance between said movable and fixed contacts when in their position of maximum separation being less than the minimum distance required for arcing.

JOHN A. SPENCER.