Aug. 13, 1929. F. W. GAY 1,724,758

THERMAL RELAY

Filed Aug. 24, 1928

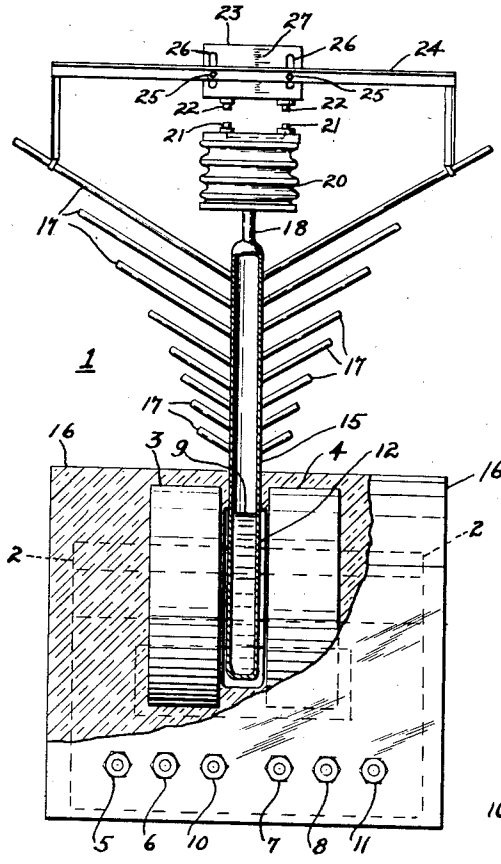


FIG. 1

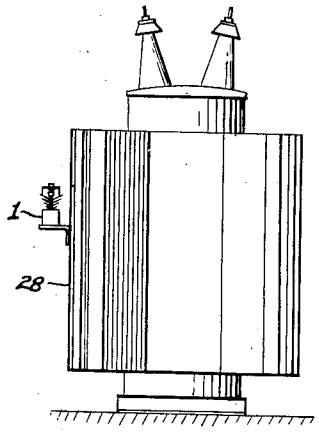


FIG. 3

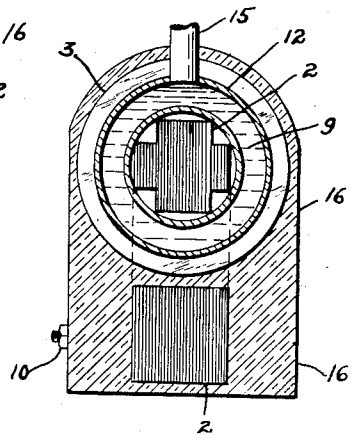


FIG. 2

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THERMAL RELAY.

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This invention relates, generally, to thermal relays for controlling electrical circuits and apparatus; and the invention has reference, more particularly, to a novel construction of thermal relay which has a wide range of application and is adapted to accurately limit currents to any desired value.

It is an object of this invention to provide a thermal relay of the above character wherein a heater element produces heat in proportion to the square of the current flowing in the controlled circuit or apparatus and which heat is utilized to effect an operation of said relay at a rate that is proportional to the square root of the rate of heat generation and in direct ratio to the current flowing in the controlled circuit or apparatus.

Another object of the invention lies in the provision of a thermal relay of the above character, which will function accurately and reliably.

A third object of the invention is to provide a thermal relay of the above character which may be operated under atmospheric conditions similar to those surrounding the protected apparatus and will permit the protected apparatus to operate under maximum possible load conditions commensurate with such atmospheric conditions.

Still another object of the invention is to provide a thermal relay of the above character that has a substantially uniform calibration scale.

Other objects of this invention, not at this time more particularly enumerated, will be clearly understood from the following detailed description of the same.

With the various objects of this invention in view, the same consists, primarily, in the novel construction and arrangement of thermal relay hereinafter set forth; and, the invention consists, furthermore, in the novel arrangements and combinations of the various devices and parts, as well as in the details of construction of the same, all of which will be hereinafter more fully described and then finally embodied in the claims appended hereto.

The invention is clearly illustrated in the accompanying drawings in which:—

Figure 1 is a view in elevation with parts broken away of the novel thermal relay of this invention; and

Figure 2 is a side elevation with parts broken away of the structure shown in Fig. 1;

Figure 3 is a diagrammatic representation of the novel thermal relay and one type of protected apparatus, namely a transformer.

Similar characters of reference are employed in both of the hereinabove described views, to indicate corresponding parts.

Referring now to the said drawings, the reference character 1 indicates the novel thermal relay as a whole. This relay comprises a laminated closed core 2 similar in construction to a transformer core upon one leg of which is mounted two spaced coils 3 and 4. The coils 3 and 4 are wound with suitable insulated magnet wire and the ends of these coils are connected to terminal screws 5, 6 and 7, 8 respectively. Taps may be taken from these coils if desired and connected to suitable terminal posts as 10 and 11. The coils 3 and 4 are adapted to be associated with the circuit which the thermal relay is intended to control in such manner that the current passing through these coils is proportional to that flowing in such controlled circuit. These coils are connected by means of the terminal posts 5 to 8 or 10 and 11 into the desired controlled circuit in such manner that current from said circuit flows through these coils in either the same or in opposite directions.

An annular metallic tubular member 12 is positioned between and adjacent the coils 3 and 4 and surrounds the leg of core 2 upon which coils 3 and 4 are mounted. The upper portion of member 12 is connected to an upwardly extending pipe or radiator tube 15. The interior of the annular tubular member 12 contains a volatile liquid 9. The space within the radiator tube 15 above the volatile liquid 9 is filled with an inert gas. The core 2, coils 3, and 4 and tubular member 12 are surrounded by and moulded in insulation 16. Radiator tube 15 extends above the insulation 16 and has welded, brazed or otherwise secured to its outer exposed surface a plurality of radially and slightly upwardly extending metallic tubes or small radiator tubes 17. Tubes 17 are hermetically sealed and are partially filled with a volatile liquid. These tubes 17 are arranged in vertically spaced horizontal rows. For simplicity of illustration, only those tubes 17 that lie in the plane of the paper are shown in figures

of the drawings. The tubes 17 in any horizontal row are all of the same length but the lengths of tubes 17 in successively higher horizontal rows increase in proportion to the square of the height of any such row above the upper surface of the insulation 16. In other words the successively higher horizontal rows of tubes 17 are made of such lengths that their outer ends lie in the surfaces of similar imaginary paraboloids which have as one of their axes the axis of the radiator tube 15. This variation in length of the successively higher horizontal rows of tubes 17 causes the radiating area of such tubes to vary as the square of their respective distances from the top of the insulation 16.

The upper end of the radiator tube 15 is connected as by a nipple 18 to a metal bellows or sylphon 20. The inert gas within the radiator tube 15 extends into and fills the bellows 20. The upper surface of bellows 20 carries a pair of electrically connected contacts 21 for cooperating with a pair of electrical contacts 22 which are contained within a trip circuit associated with the controlled circuit. Contacts 22 are mounted upon a vertically adjustable block 23 that is carried by a frame 24 which may be supported upon certain of the tubes 17. Clamp bolts 25 extending through apertures in frame 24 and through vertical slots 26 in block 23 provide for the vertical adjustment of block 23. Block 23 is calibrated at 27 and this calibration may be directly in current units, as for example, amperes. By setting or positioning the block 23 so that any desired calibration is horizontally aligned with a fixed reference point such as the upper surface of frame 24, then the thermal relay 1 will operate in a manner to be described to open the controlled circuit when the current in such circuit attains a value corresponding to that at which the block 23 is set.

In operation, as the current in the controlled circuit and in the coils 3 and 4 increases, the induced current in the annular member 12 also increases proportionally. The heat loss in the member 12 is proportional to the square of the induced current in this member and therefore this heat loss is proportional to the square of the current in the controlled circuit. Insulation 16 prevents this heat from readily radiating from member 12 and the volatile liquid 19 within this member is consequently vaporized. The pressure of vaporization of the volatile liquid 9 causes its vapor to drive the inert gas in radiator tube 15 upwardly. This increased pressure also causes the bellows 20 to expand, thereby moving contacts 21 toward contacts 22. As the vapor of liquid 9 moves upward in tube 15 it is cooled by contact with the walls of this tube. Heat absorbed by the walls of tube 15 is conveyed by conduction to the small radiator tubes 17. The volatile liquid within tubes 17 absorb this heat and is vaporized, thereby conveying the heat rapidly along and to the outer ends of these tubes from which it is conveyed to the surrounding air. The vapor of the liquid 9 is consequently condensed as it moves upwardly in the radiator tube 15 and the higher it moves upwardly the more rapidly it is condensed owing to the increasing lengths of the tubes 17. Since these tubes increase in length as the square of their respective distances from the top of the insulation 16, the vapor in radiator tube 15 will rise at a rate substantially proportional to the square root of the heat developed in the annular member 12 or in direct ratio with the current in the coils 3 and 4 and the controlled circuit or apparatus. As the vapor rises in radiator tube 15 the bellows 20 is distended proportionally, causing the contacts 21 to also move upwardly in proportion to the increase in current in the controlled circuit. When the current in the controlled circuit reaches the value for which the thermal relay is set to operate, the bellows 20 will have distended sufficiently to cause the contacts 21 to engage contacts 22, thereby closing the trip circuit and opening the controlled circuit. With the opening of the controlled circuit, the passage of current in coils 3 and 4 ceases, permitting the volatile liquid and its vapor in the radiator tube 15 and annular member 12 to cool sufficiently to effect the opening of contacts 21 and 22 whereupon the thermal relay is ready for another operation.

Since the rate of cooling of the radiator tubes varies in accordance with the temperature of the external cooling medium, it will be apparent that the upward rate of movement of contact 21 is also proportional to the temperature of the air surrounding the thermal relay. Suitable control of this air temperature as by placing the thermal relay near the controlled circuit or apparatus will cause the thermal relay to function in accordance to the actual temperature conditions surrounding the controlled apparatus. The character of the radiating surfaces of the tubes 17 may be so chosen and these tubes similarly shielded from winds in the same manner as the apparatus protected so that the radiation of heat from these tubes is proportional to that from the apparatus protected. Thus in Figure 3, the thermal relay 1 is adapted to limit the load imposed upon a transformer 28. Thermal relay 1 is supported on a bracket secured to transformer 28 so as to operate under the atmospheric conditions prevailing at the transformer. Since the heat radiated from the thermal relay is proportional to the surrounding air temperature, as is also true of the trans-

former, and as such agencies as wind and rain will affect these members similarly, it is evident that the relay will permit the transformer to carry the maximum possible load commensurate with atmospheric conditions. Thus, for example, on cold days when the rate of heat radiation from the thermal relay and transformer is relatively high, the relay will permit the transformer to carry a much heavier load than would be permitted were the day a warm one.

In the event an artificial cooling means such as fans are used to cool the transformer 28 and thermal relay 1, then should such artificial cooling means cease to operate through inadvertance, thereby reducing the rate of cooling of the transformer, the rate of cooling of the thermal relay will correspondingly decrease so as to thereby lower the maximum permissible load that may be carried by the transformer.

Since the extension of the bellows 20 is proportional to the current flowing in the controlled current, the calibration scale 27 may be uniform.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A thermal relay comprising, current conducting means, a member inductively associated with said current conducting means and arranged to be heated by the current passing through said conducting means, movable contact means, and a transmission medium interposed between said inductive member and said contact means, said transmission medium acting to effect movement of said contact means at a rate substantially proportional to the square root of the rate of heat generation in said inductive member.

2. In a thermal relay, a solenoid, a member inductively associated with said solenoid and adapted to be heated by current passing through said solenoid, a radiator associated with said inductive member, movable control means connected to said radiator, and a fluid medium contained within said radiator and adapted to convey heat from said inductive member to said radiator and to effect movement of said control means, said fluid medium being cooled by said radiator at a rate substantially proportional to the square of the current passing through said solenoid.

3. In a thermal relay, a solenoid, a hollow member inductively associated with said solenoid so as to be heated by current passing through said solenoid, a radiator connected to said hollow member, a bellows connected to said radiator, a movable contact member mounted on said bellows, a stationary contact member adapted to cooperate with said movable contact member, and a volatile liquid contained within said hollow member and adapted to be vaporized by the heat produced in said hollow member, the vapor of said liquid passing into said radiator and causing said bellows to distend and move said movable contact toward said stationary contact at a rate substantially proportional to the rate of increasing current flow in said solenoid, and said radiator acting to cool said vapor at a rate proportional to the rate of heat generated in said hollow member.

4. In combination a transformer and a thermal relay adapted to be positioned adjacent said transformer so as to operate under physical conditions prevailing at said transformer, said thermal relay comprising, a heating element inductively related to the current passing through said transformer, control means adapted to be operated by heat developed in said heating element to limit the maximum load carried by said transformer, cooling means associated with said heating element and adapted to operate in accordance with the physical conditions prevailing at said transformer, said cooling means acting to regulate the operation of said control means.

In testimony, that I claim the invention set forth above I have hereunto set my hand this 21st day of August, 1928.

FRAZER W. GAY.