Aug. 2, 1949. T. J. MESH 2,478,117

HEAT CONTROLLED SWITCH

Filed Feb. 13, 1946

Fig. 1.

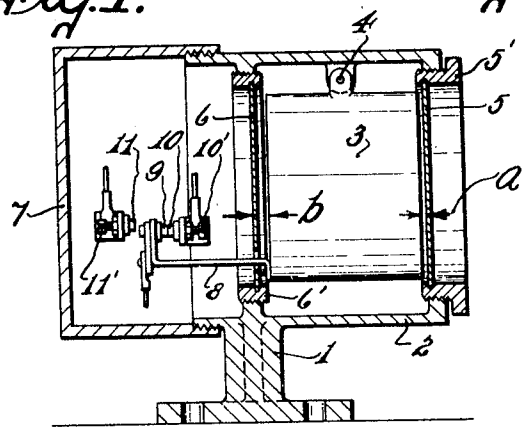


Fig. 3.

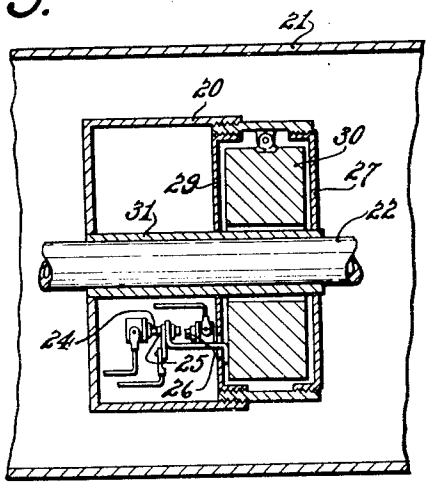


Fig. 2.

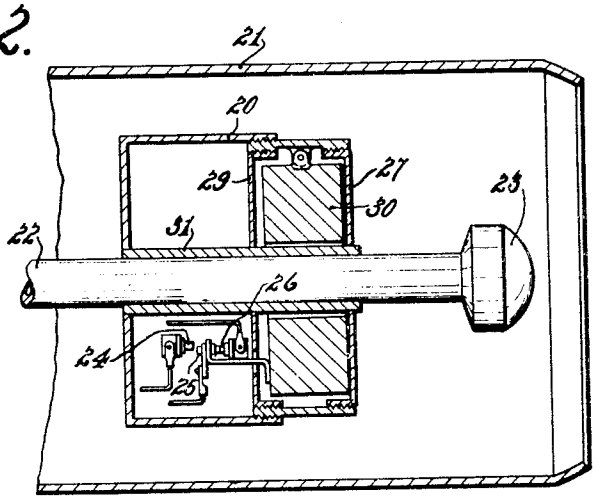
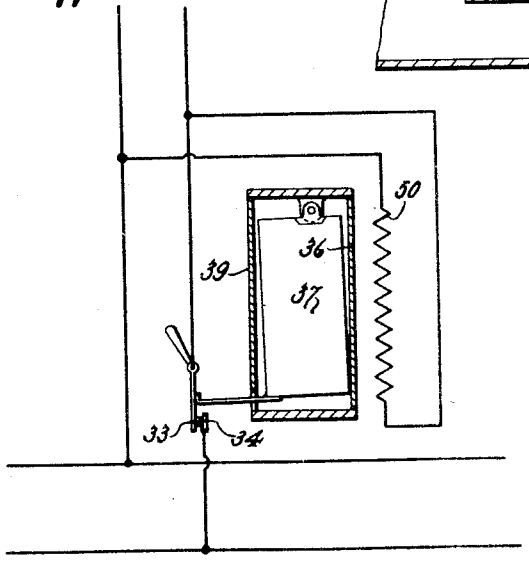


Fig. 4.



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HEAT CONTROLLED SWITCH

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This invention relates to an improved form of heat controlled switch. It may be used as a thermostat, a flame detector, a time switch, and for other specific switch uses. In these specific uses the new switch is competitive with many known forms of automatic switches. One idea of the improvement is to provide a new switch and mode of operation for a generally old result, i. e. an automatic switching operation under heat control. Some advantages of the new structure and mode of operation are in its simplicity, its rugged character, its economy of manufacture, and its adaptability for use under circumstances where known heat controlled switches are not so useful for one reason or another.

For example the so-called "electric-eye" or photo-electric switch device is sometimes employed as a flame detector. The theory of such an application is good but the practice has some objections. In oil burner work the plan is to have an "electric eye" shut off the burner when the flame is not detected within a predetermined time interval after the burner starts. This is then an emergency switch operation to avoid feeding oil in the absence of a flame to consume it. As is well known, the electric eye and more particularly the electronic tube generally used in conjunction with it both have an uncertain limited life and are subject to breakage, burnout, and other causes of failure. In any event, they require periodic replacement. Every such failure renders the burner inoperative, requiring the services of a repairman, subjecting the user to the periodic failure of his heating plant.

An example of the utility in the present invention will be seen by comparing its operation with the "electric eye" operation. The new switch will have the convenience of "electric eye" operation but without nearly as much liability of failure. The new device may be delicately adjusted for sensitive operation, but there is nothing delicate about the tangible features of its operation. It is rugged, will not get out of order, and may be depended upon for more certain operation than the "electric eye" device.

The principles of operation and illustrative examples of the new structure as applied for use will be disclosed with the accompanying drawings,

Fig. 1 is a general form of the switch device;

Fig. 2 is an example of its application as a flame detector in an oil burner;

Fig. 3 is an example similar to Fig. 2 with parts in a different operative position; and

Fig. 4 is an example of its application as a time switch.

The drawings are generally diagrammatic to give a disclosure to one skilled in the art. The finished commercial designs may take many forms. The principles of construction, mode of operation, and results of the invention will be understood from these drawings and their explanation.

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In Fig. 1 a switch is shown with its operating means, to disclose the idea and its practice broadly. A stand 1, supports a brass cylinder 2, which holds internally a permanent magnet 3 on pivot 4. This magnet has two opposed flat polar faces. Magnet 3 is free to swing on its pivot. An arm 8 carries a contact 9 to work with contact 10. These contacts make and break a circuit not shown. A cover 5 is screwed onto one end of tube 2. It is adjusted to make the gap *a* between its inside face and the right hand face of magnet 3 a predetermined amount, called gap *a*. A similar cover 6 is screwed into the other end of tube 2 to make a similar gap between its inside face and the magnet 3, called gap *b*. The covers 5 and 6 are preferably mounted in brass holders 5' and 6'. These covers serve as armatures one for each polar face of the magnet.

These covers 5 and 6 are made of a magnetic alloy whose magnetic permeability decreases with increase in temperature. For example, it may have a permeability of about 180 units at room temperature and decrease about .45 of a unit for each degree Fahrenheit increase in alloy temperature. Such an alloy is available on the market, for example from Carpenter Steel Company. I refer to what the trade calls "Temperature Compensator 30, Type 1" as one alloy suitable for my purpose. I understand it is a ferrous alloy containing about 30% nickel. I prefer to use the alloy in thin sheet form, for example about .030 inch in thickness, for covers 5 and 6. I will refer to covers 5 and 6, since the parts are indicated as covers. But I mean to include within the terms "cover" or "covers" such things as plates or diaphragms or the like regardless of their exact structure or mountings.

Magnet 3 may take many forms and may be magnetized in numerous different ways, but it is generally desirable that no additional member be necessary to complete the magnetic circuit or circuits other than diaphragms as provided by covers 5 and 6 positioned with gaps *a* and *b*. A permanent magnet is very well suited to my purpose and is the kind indicated. Because of the relatively low magnetic permeability of the alloy of covers 5 and 6, it may in some instances be desirable to use multiple magnets or a plurality of magnets to produce the required forces of attraction between magnet 3 and each of the covers 5 and 6.

Cover 6 has an opening to pass bendable arm 8 carrying contact 9. Cap 7 on cylinder 2 may be used as a second cover beyond cover 6 to carry and protect contacts 10 and 11, the latter contact being used in the event the circuit wiring makes it useful. No such wiring is shown but of course is implied from the parts shown.

The structure of Fig. 1 may be used in many ways similar to an "electric eye" particularly for detecting radiant heat conditions and operating a switch according to such conditions. The cover 5 faces the direction from which radiation is expected. When such radiation or heat waves strike cover 5 its temperature will rise and this will cause the combination to operate.

An example of the operation will be given. Assume that contacts 9 and 10 will give the desired circuit before the rise in temperature occurs and that contacts 9 and 11 will give the desired circuit after the rise in temperature occurs. Assume that gap *a* is enough less than gap *b* that magnetic attraction acts to hold gap *a* as indicated with contacts 9 and 10 closed. This will be the normal condition of the device with the parts at one temperature. The attraction across gap *a* will be greater than that across gap *b* and the pressure between contacts 9 and 10 will be a function of the difference of these forces.

When cover, or detector plate 5, facing whatever starts to cause a rise in temperature, is heated, its magnetic permeability decreases. This causes a drop in magnetic attraction between magnet 3 and its adjacent plate 5. But there is no corresponding drop of attraction between magnet 3 and its adjacent cover 6 across gap *b*. The reason is that cover 5 is heated and cover 6 is not heated under the conditions stated. As this drop in the attraction of parts across gap *a* continues, the attraction across gap *b* remains substantially constant. The attraction across gap *a* will gradually become less than that across *b*, whereupon magnet 3 will swing on pivit 4 and snap toward cover 6 to open contacts 9 and 10 and close contacts 9 and 11. This effect is what is wanted when the rise in temperature occurs at the right hand part of the structure with cover 5 facing the source of radiation or heat as an electric eye device would face it. The device is thus seen to respond to difference in temperature of covers 5 and 6, whether caused by radiation or other means not shown. Of course the temperature on all sides may rise gradually while that on one side of cover 5 rises faster than on the other side. The effect will not be different on this account.

When the device operates as just described, contacts 9 and 11 may be kept together or contacts 9 and 10 kept apart. The magnetic attraction between magnet 3 and plate 6 will then hold the switch in the operated position because the gap between will be less than the gap between magnet 3 and cover 5 after the operation closes contacts 9 and 11. When an automatic return of the parts to their original position is desired, however, the following arrangement may be made. Covers 5 and 6 and stop element 11 are so adjusted that gap *a* will always be less than gap *b*. Contacts 10 and 11 are indicated as axially adjustable by nuts 10' and 11'. With this adjustment, and with covers 5 and 6 at the same temperature, magnet 3 can never reach the balance or neutral position midway between them and will snap back toward cover 5 after the temperature differential is lost between covers 5 and 6. Under these conditions, if plate 5 be heated as previously described, the switch will be operated as before stated, except that when temperature equilibrium is restored, either by permitting 5 to cool off, or alternately by raising the temperature of 6, magnet 3 will snap back toward cover 5 thus effecting the desired automatic return. The switch contacts 10 and 11 as well as plates 5 and 6 are indicated as adjustable. The contacts 10 and 11 may

be made to function conveniently as adjustable stops or limits for the operating variations in the dimensions of gaps *a* and *b*. The plates 5 and 6 may be held in threads of casing 2 so as to determine the base lines of gaps *a* and *b* with relation to the opposite faces of magnet 3. Further variations may be made by providing for adjusting the pivot 4 of the magnet.

It will be clear that it is desirable to bias the forces of attraction toward plate 5 in the preceding example. To accomplish this result, use may also be made of the force of gravity by hanging the magnet in some other position than in the vertical as shown, or else a small spring may be used to produce a similar effect. The object of such bias is simply to ensure the return of the magnet 3 to the starting position whenever covers 5 and 6 are at the same temperature, while still permitting operation as described when a temperature difference exists. In all cases it is desirable to limit the travel of magnet 3 to a small value, say $\frac{1}{32}$ inch more or less, so that when operation takes place the magnetic attraction between the magnet and covers will not increase or decrease excessively because of change in air gap dimension, and for the same reason it may be desirable to keep the air gap relatively large compared with magnet travel. I mention these things to indicate the many ways the simple structure may be varied for operation according to the main principles of the example given.

A useful feature of the Fig. 1 example is this. The pull across gap *a* and the opposite pull across gap *b* may differ by small amounts. Suppose the adjustments are made for them to differ by one ounce. The pull on magnet 3 toward cover 6 might be an eleven ounce pull and toward plate 5 a twelve ounce pull with the difference one ounce. Then when plate 5 is heated causing a drop in its magnetic permeability, a drop of a little more than enough to decrease the magnetic force by one ounce will cause the switch operation. After operation has occurred the change in position of magnet 3 will decrease gap *b* and thus increase the attraction across gap *b* slightly, holding the switch firmly in the operated position. Likewise, the gap *a* is increased and attraction across it decreased slightly, adding to the effect just mentioned. The switch is thus certain in operation and will not chatter or take up a position between the contacts 10 and 11. These relations and circumstances give considerable and very useful operating scope for the switch. I have operated it as a flame detector for oil burners. A crude model built to demonstrate the action operated on a temperature difference of 80 degrees F. between cover 5 "looking" at the flame and cover 6 protected from the flame so as to be heated slower than cover 5. It will be appreciated that cover 5 exposed to receive the radiant heat from an oil burner flame will vary 80 degrees F. without much delay between the time the flame goes on or goes off. This is only one use for such a switch but an important one to which I will refer in more detail below.

Another useful feature is seen in the fact that the switch device of Fig. 1 will operate at all temperatures. Consider the following circumstances. One example is to operate the switch automatically when there is a temperature difference of 80 degrees F. between covers 5 and 6. Assume that cover 6 is at a temperature of several hundred degrees and cover 5 is at the same temperature. There will be no switch operation. Assume that starting that way the temperature

of cover 5 increases about 80 degrees above that of cover 6. There will be a switch operation. This is to say that with a high temperature existing in all parts of the switch device, and with the temperature of covers 5 and 6 the same, there is no switch operation even though the temperature changes. But when there is a differential change of the temperature, when cover 5 becomes hotter than cover 6, or cover 6 becomes cooler than cover 5, in the example by 80 degrees F. for instance, there will be a switch operation. This feature may be stated by saying that changes in ambient temperature do not cause the switch device to operate. This is because ambient changes in temperature affect the magnetic permeability of covers 5 and 6 equally and their opposite effects on magnet 3 balance out leaving no operating effect. The relation of parts in this respect provide for large scope of useful adjustments regardless of ambient temperatures either high or low. The switch is useful for operations to indicate tendencies in high or low temperature operations.

The oil burner use diagrammatically indicated in Fig. 2 taken with the foregoing discussion shows all that one skilled in the art needs to put the invention in such practice. The air tube 21 of a conventional oil pressure atomizing burner carries an oil pipe 22 to nozzle 23 beyond which the air-oil mixture is ignited and burned in the usual way. A switch embodying this invention has the purpose to turn off the burner motor not shown, if the flame fails to start when it should or after starting fails to continue burning as it should. This is to say that the switch device here is used as a flame detector for oil burners. There are various kinds of flame detector switching devices. The flame detector is to move contact 25 over to contact 24 when the flame is well started. If the flame goes out when it should stay on then contact 25 is moved back to contact 26. The switch contact leads and circuits and general burner operations are so well known that only the new parts of the switch operating device with relation to the burner flame will be specifically described.

The indication of Fig. 2 is that the flame has just started. Its radiant heat will immediately start to heat cover 27. This cover may be blackened on the outside and plated on the inside to get quicker heating action. Cover 29 may be plated on both sides if it is desirable to slow down the rate of rise of its temperature. As cover 27 heats up its permeability decreases. Attraction with magnet 30 is decreased while attraction between cover 29 and magnet 30 at first remains substantially constant. In a short time however covers 27 and 29 will both steadily rise in temperature but at a different rate, that of cover 27 being at a faster rate until for example upon a temperature difference of about 80 degrees F. between covers 27 and 29 will be established and then with this differential in temperature of the two covers magnet 30 will be snapped over toward cover 29, being stopped short of hitting when switch contacts 24 and 25 come together, see Fig. 3. These will be held together by the slight increase in magnetic attraction between cover 29 and magnet 30 resulting from the change in position of magnet 30 to a point closer to cover 29. When the flame goes out for any reason, covers 27 and 29 come to a uniform temperature. As they do this, magnet 30 moves back to its biased position because of the increasing attraction between cover 27 and magnet 30 resulting

from the increasing permeability of cover 27 as it cools off, aided by whatever method of bias has been chosen. Cover 27 is more rapidly cooled than cover 29 under flame failure conditions because the air stream cools the former more rapidly having more direct access to it than to cover 29. With normal shutdown of the burner, no air stream is present, and the two covers reach equal temperature more slowly. This characteristic is made use of in some well known burner control circuits to provide a delay between the time the burner stops and the time it may be restarted, commonly termed the "scavenging" period. With the parts back in the indicated position, the device is ready for another cycle.

The 80 degrees F. temperature difference mentioned above is intended only as an example. The device may be adjusted to operate on other temperature differences, and can be made more or less sensitive than this value. The temperature rise caused in the front cover by an oil burner flame depends chiefly on its distance from the flame. A rise of 60 degrees in 10 seconds was noted in one instance with the detector several inches behind the nozzle. The rise thereafter continued at a decreasing rate, with maximum rise about 130 degrees in the front cover 27. In one example, with the detector several inches behind the nozzle, the front cover rose 60 degrees in 10 seconds while the rear cover temperature did not rise at all in that short time. Then both covers increased their temperatures together but the front one faster than the rear cover. Thus the differential of temperatures between the two cover plates, at the end of 10 seconds was 60 degrees and since they both continued to rise together but at different rates the differential of temperatures was increased until it became an 80 degree difference. This difference in temperatures between the two plates caused the switch to operate in the given example. If the device of that example were placed closer to the nozzle of course the operating differential would be established sooner than it was when the device was several inches back of the nozzle. If however it is for any reason desirable to keep the device in the more remote position from the nozzle or flame, a change in the sensitivity could be made by adjustment as before described to make the switch operate with a differential of 60 degrees between the two cover plates.

It will be seen that the parts of Fig. 2 are essentially like those of Fig. 1. The magnet may be of annular shape to pass oil pipe 22. The casing part 20 may have part 31 for support on the oil pipe. The magnet 30 may be hung to swing more toward cover 27 than to cover 29 when the cover temperatures are the same. Contact 25 carried by an arm fastened to magnet 30 and passing through an opening to clear cover 29 has a circuit lead passing out of casing 20. The general plan of the oil burner circuits provides that upon turning on the burner everything will operate with contacts 25 and 26 together but only for a predetermined short time. The burner will automatically shut down unless within that time contact 25 is moved over to meet contact 24. The flame detector functions to move it over provided the flame is detected in operation and to move it back at any later time if the flame goes out so it can not be detected. It could be put in other positions than on the oil pipe indicated. For example it could be put in as a smoke stack switch for the heat of gases to heat cover 27 for its dif-

ference in effect when heated faster than cover 29.

Another use of the device is diagrammatically indicated in Fig. 4 as a thermal time delay switch. In this case assume that contacts 33 and 34 are to remain together until it is desired to move them apart after a predetermined time period. A heating coil 50 in a circuit operates to heat cover plate 36 when the circuit is closed. It will take a predetermined time to do this and meanwhile contacts 33 and 34 are in the positions wanted. After such a time interval cover plate 39 pulls the magnet 37 toward it and the contacts 33 and 34 are put in their other relative positions. It will be noted that they will stay in the latter positions until reset by hand. This may be done by a hand operated pivoted extension carrying the movable one of the contacts 33 and 34. This hand operation will move the magnet back to be held by attraction with cover plate 36. The reason the contacts are not automatically reset after the heat of coil 50 is turned off is that once the magnet is moved over to the opposite cover plate 39 it is closer to that plate than to cover plate 36 and no bias spring, magnetic unbalance, or other differential setting is present to cause its automatic return. In this it differs from the simple form of warp or bi-metallic time delay switch. There are circumstances of use where it is desired that the return of the switch to original position after automatic operation be made by hand to make sure that attention is called to the heat event which caused the automatic switch operation. The way to do this as shown emphasizes when taken with the operations of the other examples the wide scope for application to various uses of my new switch device.

Having disclosed my invention, I claim:

1. A heat-responsive switch, comprising, a permanent magnet having two opposed polar faces, two armatures each constructed of magnetic material having the characteristic that its permeability varies a material amount per degree of temperature change, means supporting said armatures spaced one from each of the polar faces of the magnet to provide a small air gap between each armature and the adjacent polar face of the magnet, means connecting said magnet and armature-supporting means for relative movement of the magnet back and forth between the two armatures, whereby the magnet exerts forces in opposite directions on the two armatures and is held in one position between the plates when said armatures are of equal temperature and whereby the magnet is movable relatively to the armatures to another position when the temperatures of the armatures become unbalanced from unequal heating of the armatures, and a switch member actuated by relative movement between the magnet and its armatures.

2. A heat-responsive switch, comprising, a permanent magnet having two opposed polar faces, two armatures each constructed of magnetic material having the characteristic that its permeability varies a material amount per degree of temperature change, means supporting said armatures spaced one from each of the polar faces of the magnet to provide a small air gap between each armature and the adjacent polar face of the magnet, means connecting said magnet and armature-supporting means for relative movement of the magnet back and forth between the two armatures, whereby the magnet exerts forces in opposite directions on the two armatures and is held in one position between the plates when said armatures are of equal temperature and whereby the magnet is movable relatively to the armatures to another position when the temperatures of the armatures become unbalanced from unequal heating of the armatures, and a switch comprising a stationary contact and a contact carried by the magnet and movable into and out of engagement with the fixed contact by the movement of the magnet relatively to the armature from one of said positions to the other, said contacts when engaged being held by a force equal to the difference between the attractive forces of the magnet on the two armatures.

3. A heat-responsive switch, comprising, a permanent magnet having two opposed polar faces, two armature plates each constructed of magnetic material having the characteristic that its permeability varies a material amount per degree of temperature change, means supporting said plates spaced one from each of the polar faces of the magnet, said magnet being mounted on said means for movement back and forth between the plates, said magnet exerting forces in opposite directions on said plates and assuming one position when the armatures are at equal temperature and being movable to another position when one plate is heated to a substantially higher temperature than the other plate, and a switch member actuated by the movement of said member from one of said positions to the other.

4. A heat-responsive switch, comprising, a tubular housing having as opposite end walls plates constructed of magnetic material having the characteristic that its permeability varies a material amount per degree of temperature change, a permanent magnet pivotally supported from the housing and located between the two plates, said magnet having two opposed polar faces located one adjacent each plate, whereby the magnet exerts forces in opposite directions on the two plates, said magnet assuming one position between said plates when the latter are at equal temperature and being movable to another position when one plate is heated to a temperature substantially higher than the other to change the magnetic attraction between said one plate and the magnet, and a switch member actuated by the movement of said magnet from one position to another.

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