Dec. 15, 1936. H. C. BRUNNER 2,063,981

PROTECTIVE SYSTEM FOR POLYPHASE MOTORS

Filed May 19, 1934

Fig. 1.

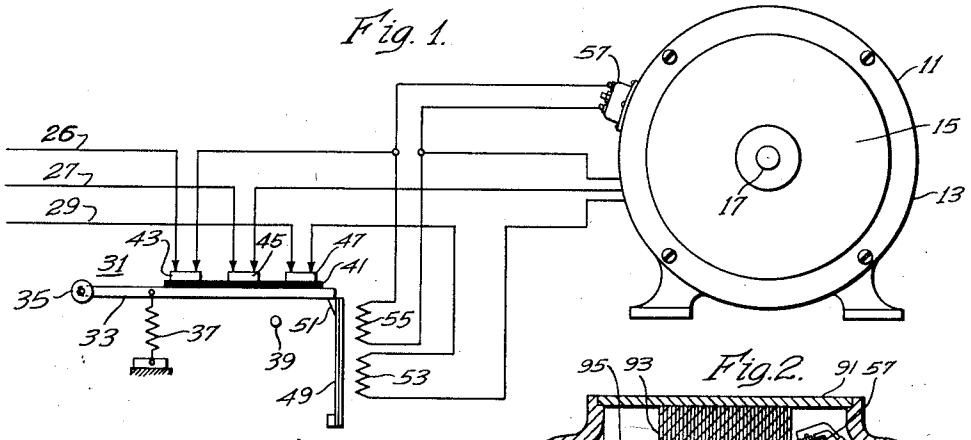


Fig. 2.

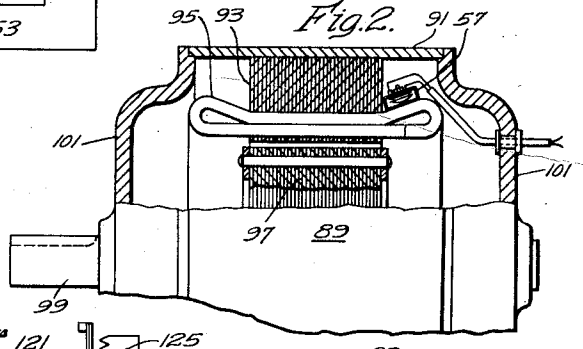


Fig. 3.

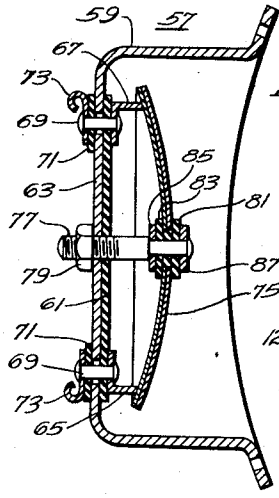


Fig. 5.

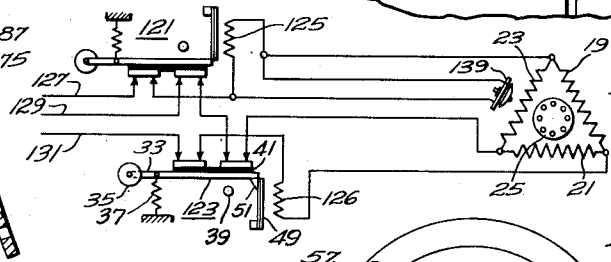


Fig. 4.

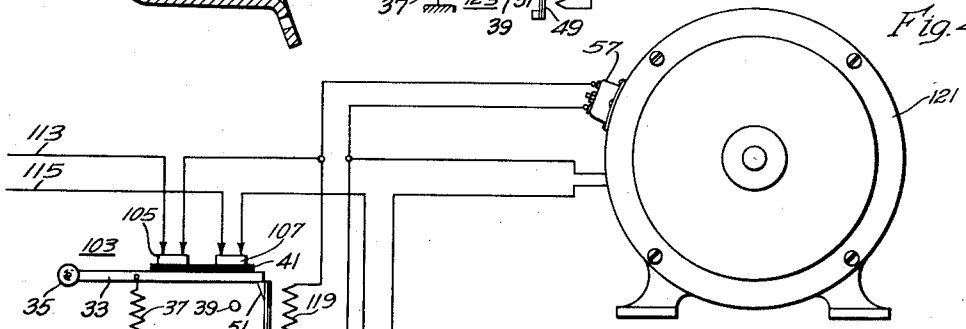
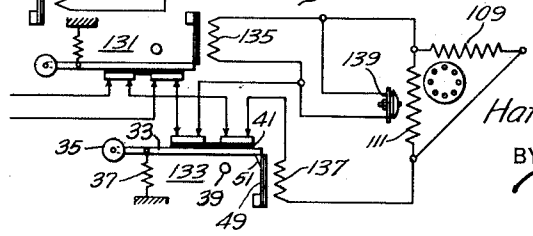


Fig. 6.



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PROTECTIVE SYSTEM FOR POLYPHASE MOTORS

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13 Claims. (Cl. 175—294)

My invention relates to electric motors, and particularly to thermal protective systems therefor.

An object of my invention is to provide a relatively simple and effective temperature control system to be applied to an electric motor to limit the temperature rise thereof.

Another object of my invention is to provide a motor-deenergizing means selectively responsive to frequent momentary peak overloads and to long-continued heavy overloads.

Another object of my invention is to provide a motor-temperature-controlling means having different time delays in response to different kinds of overloads.

Other objects of my invention will either be evident from the following description of several embodiments of my invention, or will be specifically pointed out hereinafter.

In practicing my invention, I provide a manually closable circuit-controlling switch biased to its open position, a thermally-actuable latch to hold the switch in closed position, and two heating elements in heat-transferring relation to the latch to actuate it to release the switch, both of the heating elements being permanently connected in circuit with the energizing winding of the motor and one of the heating elements being normally short circuited by a thermal switch mounted on the motor and operated in response to temperature rise thereof.

In a modified system embodying my invention I provide two double-pole switches of the same general kind as described above, except that only one auxiliary heating element in heat-transferring relation to the thermal latch, is provided.

In the single accompanying sheet of drawing:

Figure 1 is a schematic view of a system embodying my invention as applied to a motor shown in end elevation;

Fig. 2 is a fragmentary view of a motor in side elevation with parts thereof cut away to show a different location of a thermal switch from that shown in Fig. 1 of the drawing;

Fig. 3 is a view in section through a thermostatic switch constituting one element of my invention;

Fig. 4 is a view similar to Fig. 1 but showing a different type of motor;

Fig. 5 is a diagrammatic view of a motor and a modified form of control system embodying my invention, and

Fig. 6 is a diagrammatic view of the modified form of control system as applied to another type of motor.

It is highly desirable in electric motors to properly protect the motor, and particularly the energizing windings thereof, against excessive temperature rise. This temperature rise may be caused by three different kinds of overloads. First, by a number of momentary peak overloads, such as are encountered when a motor drives an appliance or device in which the load may vary sharply and repeatedly; second, where for various reasons, a long-continued heavy overload occurs; and, third, in the event of extreme overloads, such as may occur in the case of a locked rotor. It is further desirable, for obvious reasons, to maintain the motor in an energized and an operative condition for as long a time as may be possible with respect to the temperature of the energizing windings not exceeding a maximum permissible value. It is, of course, obvious that in addition to the percent or amount of overload on the motor, the length of time during which the overload is on the motor is of interest, but it is further obvious that the effect of frequent momentary peak overloads will not be as great as will be the effect of very heavy continued overloads. It may even be possible that the frequency of the momentary peak overloads is such that the motor can continue in operation without excessive temperature rise but it is further obvious that in case of an extreme overload, such as is represented by locked motor conditions, the motor temperature will rise very quickly. In general, the current traversing the energizing windings of an electric motor under locked rotor conditions is on the order of 6 to 8 times normal load, so that the energy loss in the motor windings with locked rotor, is from 36 to 64 times the normal copper loss.

Referring first to Fig. 1 of the drawing, I have there illustrated a motor 11 which is to be understood as being illustrative of any kind of polyphase electric motor and which is provided with a frame 13, end or bearing brackets 15, and a rotor which is illustrated generally only by an end view of the shaft 17. In this particular embodiment of the motor, as noted above, it is provided with polyphase windings, and reference to Fig. 5 of the drawing will show the three-phase delta-connected energizing windings 19, 21, 23, as well as a rotor 25.

The motor is energized from a suitable source of supply of electric energy comprising leads or circuits 26, 27 and 29, these circuits being connected to the junctions of the phase windings 19, 21 and 23 through a circuit controller or switch 31. Preferably I make this switch a man-

ually reclosable switch or breaker biased to its open position and normally held in its closed position by a thermal element. For illustrative purposes, I have shown a pivotally mounted arm 33 which is manually actuable by a knob 35 and which may be actuated in a given direction, here shown as in a clockwise direction, by a spring 37, against a stop pin 39, to open the circuit of the motor. The arm 33 is provided with a plate 41 of electric insulating material on which are mounted three contact segments 43, 45 and 47. Suitably fixed circuit terminals, two for each of the respective phase circuits, cooperate with the respective segments 43, 45 and 47 to close the circuit to the windings of the motor.

A thermal latch, here shown as a bimetal strip 49, having a suitably shaped lug 51 at its free end, cooperates with the arm 33 when the same is turned in a counter-clockwise direction to engage the substantially fixed contact members, to thereby hold the switch in closed position. When the thermal element 49 is heated it will turn in a clockwise direction to release the arm 33 which will then be moved quickly by the action of spring 37 to open the circuit of the motor-energizing windings.

The thermal element 49 is energized by a plurality of auxiliary heating elements 53 and 55, respectively, which are connected in series circuit with the motor energizing windings in either one of the circuits, or preferably in two different circuits, and I have shown heating element 53 as being connected in series circuit in supply circuit conductor 29, while heating element 55 is connected in series circuit with supply circuit conductor 26.

I further provide means initially or normally short-circuiting heating element 55, and a device 57 for performing this function is shown as being mounted on the outside of motor frame 13 in Fig. 1 of the drawing and is further shown in section in Fig. 3 of the drawing.

This thermostatic switch includes a suitable thin metal casing 59, the edges of whose open side are so shaped as to closely engage the outer surface of the frame 13 of the motor against which it may be secured by any suitable means. A disc 61, of electric-insulating material such as mica, is located against the inner face of the intermediate portion 63 of member 59, against which are secured a pair of fixed contact members 65 and 67, which are held in proper operative position by rivets 69, additional small insulating washers 71 being provided against the outer face portion 63 to properly insulate terminal members 73 from the metal member 59.

A bimetallic disc 75, which is preferably of the kind disclosed and claimed in Patent No. 1,448,240 to J. A. Spencer, is supported on a stud 77 which has screw threaded engagement with the central portion of part 63 and which may be locked in any desired adjusted position by a lock nut 79, as shown. The bimetal disc 75 is insulatedly supported on stud 77 by insulating washers 81 and 83 which surround one end portion of stud 77 of reduced diameter, metal washers 85 and 87 cooperating with washers 81 and 83 to hold the disc loosely thereon, so that it can move from the position shown in Fig. 3 of the drawing, where it is in engagement with the two fixed arcuate contact members 65 and 67, to a position where it is out of engagement therewith, and where it is dished in the opposite direction from that shown in Fig. 3 of the drawing. I have shown the outer end of stud 77 as hammered over against washer 87, but it is obvious that any other holding means may be employed.

Referring now to Fig. 2 of the drawing, I have there illustrated a motor 89 embodying the usual stator housing 91, a stator 93, a stator winding 95, and a rotor 97 mounted on a shaft 99 and supported in the usual bearing brackets 101. A thermostatic switch 57 is here shown as being mounted, in any suitable manner, in direct heat-receiving relation to the stator winding 95, wherein it differs from the device 57 shown in Fig. 1 of the drawing, which may be mounted either on the housing 13 or on the stator of motor 11 equivalent to stator 93 of Fig. 2 of the drawing.

Referring now to Fig. 4 of the drawing, I have there shown a circuit controller 103 which is substantially the same as circuit controller or switch 31 except that only two contact segments 105 and 107 are provided, since the motor which is to be controlled thereby has two energizing windings only, indicated at 109 and 111 in Fig. 6 of the drawing, and energized from supply-circuit conductors 113 and 115. Insofar as the other details of the switch are concerned, they are substantially the same as was hereinbefore described in connection with Fig. 1 of the drawing, and I also provide two small auxiliary heating elements 117 and 119 in heat transferring relation to a bimetal latch 49, heating element 117 being connected in series circuit with supply-circuit conductor 115 and heating element 119 being connected in series circuit with supply-circuit conductor 113. A thermostatic switch 57 is again shown as being mounted on the frame of motor 121 and initially normally short-circuiting auxiliary heating element 119.

Referring now to the modification shown in Fig. 5 of the drawing, I have there illustrated the use of two manually-closable two-pole thermal circuit breakers 121 and 123 for use with a three-phase motor as already described. Each circuit breaker embodies the same elements as was hereinbefore described in connection with breaker 103 of Fig. 4 of the drawing, except that only a single auxiliary heater 125 and 126 is provided for the thermal latch. The cooperating fixed and movable contact members in the two switches are connected in circuit with the respective junctions of the phase windings so that lead 127 includes one break or cooperating set of contacts, lead 129 includes two such sets—one from each switch, while lead 131 includes one set only.

Referring to Fig. 6 of the drawing, I have there illustrated two manually-closable double-pole thermal switches 131 and 133—each embodying a thermal latch and a single auxiliary heater in heat-transferring relation to the latch.

In this system each of the supply circuit leads includes two series-connected breaks. Each switch includes auxiliary heating elements 135 and 137, respectively.

Auxiliary heater 125 of Fig. 5 is initially short-circuited by a thermal switch 139 located in heat-receiving relation to the motor and a similar thermal switch is provided in the system shown in Fig. 6 to cooperate with auxiliary heater 135.

Referring to the auxiliary heaters provided to actuate the thermal latch 49, I prefer to make the current-carrying capacity of the normally short-circuited heating element, (that is, either heating element 55, 119, 125 or 135) less than the normal full load current capacity of the motor. For illustrative purposes I may make the heater

55 of 7.5 amperes capacity if the full load current in each of the three supply-circuit conductors of Fig. 1 is 10 amperes. I do not, however, desire to be strictly limited to this percentage relation since it may vary with the character of the load on which the motor is to operate. As has already ben set forth, this heating element is initially short-circuited and is, therefore, normally ineffective.

Referring now to heating elements 53, 117, 126 and 137, these are made of a somewhat higher current-carrying capacity than the normal full load current of the motor energizing conductors and, as has already been set forth, these heaters are continuously in circuit.

It will be obvious, first of all, that the effect of heater 53 on the thermal latch 49 will be negligible so long as the motor load and current does not exceed the normal full load value. It is further obvious that the heating effect of heating element 53 on the thermal latch is also negligible in case of moderate overloads, say on the order of 125% or even 150% normal load. It is also obvious that in the case of very heavy overloads such as may occur under locked rotor conditions, where the current is on the order of 6 to 8 times normal full load current, the energy loss in resistor 53 is very greatly increased, so that it will quickly transfer heat to the thermal latch and cause it to move in such a direction as to cause the switch to open. The same comments apply to the auxiliary heaters 117, 126 and 137.

Let it be assumed that instead of an extremely heavy overload on the motor, the motor is subjected to intermittent peak overloads of relatively short duration, so that if the peak values of the overloads are not too great, the motor can continue in operation for a relatively long time without dangerous temperature rise in the motor. The thermostatic switch 57 will then be subjected to very gradual increase of temperature, increment by increment resulting from each momentary peak overload, and not until its temperature has reached a predetermined value corresponding to a temperature of the rotor just short of the danger value will it open to energize or to make effective heating element 55. As soon as this low-capacity heating element is energized it will transmit an amount of heat to the thermal latch which will cause it to move in such a direction as to effect opening of the switch. The same comments apply to the auxiliary heaters 119, 125 and 135.

It is, therefore, obvious that while one of the plurality of auxiliary heating elements energizing a thermal latch has a short-time delay under certain operating conditions of the motor, the other auxiliary heating element has a much longer time-delay under other predetermined operating conditions of the motor.

The device and system embodying my invention thus distinguish between the two different kinds of overloads and, since the respective elements are proportioned for the respective different operating conditions, they will be properly operative with safety to themselves and to the motor at all times and will effect deenergization of the motor at the proper time to limit the temperaure rise of the motor to a safe value, irrespective of whether this temperature rise was caused by a short-time very heavy overload condition or by a relatively long-time subjection to intermittent peak or momentary overloads.

I desire it to be understood that the illustration of the circuit-breaker is general only but wish to point out that I have found a manually closable thermally latched circuit breaker to be a relatively inexpensive piece of apparatus as compared to electromagnetic circuit breakers which have been so frequently used heretofore in thermal protective systems applied to electric motors.

I further prefer to use a snap-acting disc of the kind hereinbefore described which has a relatively large temperature differential of operation. A disc of this kind which will open when the temperature of the motor is on the order of 95° C., may not reclose until a temperature on the order of 50° C. has been reached. It is to be noted, however, that even though thermal switch 57 or any one of the other equivalent switches may have been operated to its open position and may have effected a shut down of the motor, it is possible to restart the motor as soon as the thermal latch has cooled sufficiently to hold the switch in closed position. The motor may thus continue in operation after a brief shut down, particularly if it is possible to reduce the load on the motor until it has cooled down, it being well known that cooling is effected more quickly if the motor rotor is operating and is providing some ventilation.

The device and system embodying my invention thus provide a relatively simple and inexpensive temperature-control means applicable particularly to electric motors, which will distinguish between different kinds of overloads and will be operated in accordance therewith when the temperature rise of the motor reaches a predetermined maximum value.

Various further modifications may be made in the device and system embodying my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or are set forth in the appended claims.

I claim as my invention:

1. A thermal protective system for an electric motor having an energizing winding, comprising circuit-interrupting means for the energizing winding biased to open position, thermally-actuable latching means normally holding the circuit-interrupting means closed, a plurality of heating elements in heat-transferring relation to the latching means, and means responsive to the temperature of a selected part of said motor for governing the circuit connections of one of said heating elements to cause opening of the circuit interrupting means selectively responsive to different characters of motor overload.

2. A system as described in claim 1 in which said responsive means includes a thermal switch directly controlled by the temperature of a selected motor part for initially rendering ineffective one of the heating elements.

3. A thermal protective system for an electric motor having an energizing winding, comprising circuit-interrupting means for the energizing winding biased to open position, thermally-actuable latching means normally holding the circuit-interrupting means closed, a long time delay thermal energizing means and a short time delay thermal energizing means for the latching means controlled in accordance with the load on the motor to cause opening of the circuit interrupting means in accordance with intermittent short-time overloads and with long continued heavy overloads, said long time delay thermal energizing means including means thermally

associated with the motor to initially render it ineffective.

4. A thermal protective system for an electric motor having an energizing winding, said system comprising circuit-interrupting means for the energizing winding biased to open position, thermally-actuable latching means normally holding the circuit-interrupting means closed, a plurality of heating elements in heat-transferring relation to the latching means and connected in series circuit with the energizing winding to cause opening of the circuit-interrupting means under predetermined different load conditions and a thermally-actuable switch controlled by the temperature of the motor for initially rendering ineffective one of the heating elements.

5. A protective system for an electric motor having an energizing winding, comprising a switch in the circuit of the energizing winding biased to open position, a thermally-actuable latch normally holding the switch in closed position, and a pair of heating elements in heat-transferring relation to the latch and means responsive to the temperature of a selected part of said motor for governing the circuit connections of one of said heating elements to cause selective actuation of the latch in accordance with intermittent short-time overloads and with long-continued heavy overloads.

6. A protective system for an electric motor having an energizing winding, comprising switching means for governing the circuit of said winding, two actuating means for said switching means, and means responsive to the temperature of a selected part of said motor for governing the operation of one of said actuating means to thereby effect opening of the switching means respectively in accordance with different characters of motor overloads.

7. A protective system for an electric motor having an energizing winding, comprising a switch, a thermal latch for holding the switch in closed position, a plurality of motor-current energized heaters of different current-carrying capacities and having different time lags of operation, and means responsive to the temperature of a selected part of said motor for governing the connections of one of said heaters for selectively energizing said latch to open the motor circuit under different operating conditions.

8. A thermal protective system for an electric motor having an energizing winding, comprising a switch biased to open position, a thermally actuable latch normally holding the switch in closed position, and a plurality of heating elements in heat-transferring relation to the latch, said heating elements being connected to be traversed by the current traversing the motor energizing winding, and a thermal switch subjected to the temperature of the motor, initially short-circuiting one of said heating elements.

9. A thermal protective system for an electric motor having an energizing winding, comprising a switch in circuit with the energizing winding and biased to open position, a thermally-actuable latch normally holding the switch in closed position, a plurality of heating elements in heat-transferring relation to the latch and connected in series circuit relation with the energizing winding, and a thermal switch controlled in accordance with the motor temperature normally short-circuiting one of said heating elements to cause a relatively long-time delay in the opening of the switch under predetermined motor-load conditions.

10. A protective system for an electric motor having an energizing winding, comprising a switch in circuit with the energizing winding and biased to open position, a thermally-actuable latch holding the switch in closed position, an initially-ineffective heating element controlling the latch, means controlled by motor temperature to render the heating element effective and responsive to motor current, and a continuously effective heating element responsive to motor current and having a relatively short-time lag of operation under motor-overload operating conditions.

11. A thermal protective system for an electric motor having an energizing winding, comprising a manually-closable switch for the energizing winding biased to open position, a thermally-actuable latch normally holding the switch in closed position, and means for thermally energizing the latch to cause opening of the switch, said means including a heating element in heat-transferring relation to the latch and connected in series circuit with the energizing winding and a thermal switch normally short-circuiting said heating element, mounted in heat-receiving relation relatively to the motor and operative at a certain temperature of the motor to remove said short-circuit on the heating element.

12. A thermal protective system for an electric motor having an energizing winding, comprising a manually-reclosable switch in circuit with the energizing winding, means biasing the switch to its open position, a bimetal latch normally holding the switch in closed position, a heating element in heat-transmitting relation to the latch in circuit with the energizing winding, thermally-actuable means normally short-circuiting said heating element, said thermally-actuable means being mounted on the motor and adapted to remove the short circuit on the heating element at a certain motor temperature.

13. A system as set forth in claim 3 in which the long-time delay thermal energizing means includes a heating element in series with the energizing winding and having a current-carrying capacity less than that of the normal motor load and a thermal switch directly controlled by the temperature of the motor and initially rendering said thermal energizing means ineffective, and the short-time delay thermal energizing means includes a heating element in series circuit with the energizing winding and having a current-carrying capacity greater than that of the normal motor load.

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