June 2, 1925. 1,540,693

C. I. HALL

THERMAL RESPONSIVE DEVICE

Filed March 22, 1923

Fig. 1.

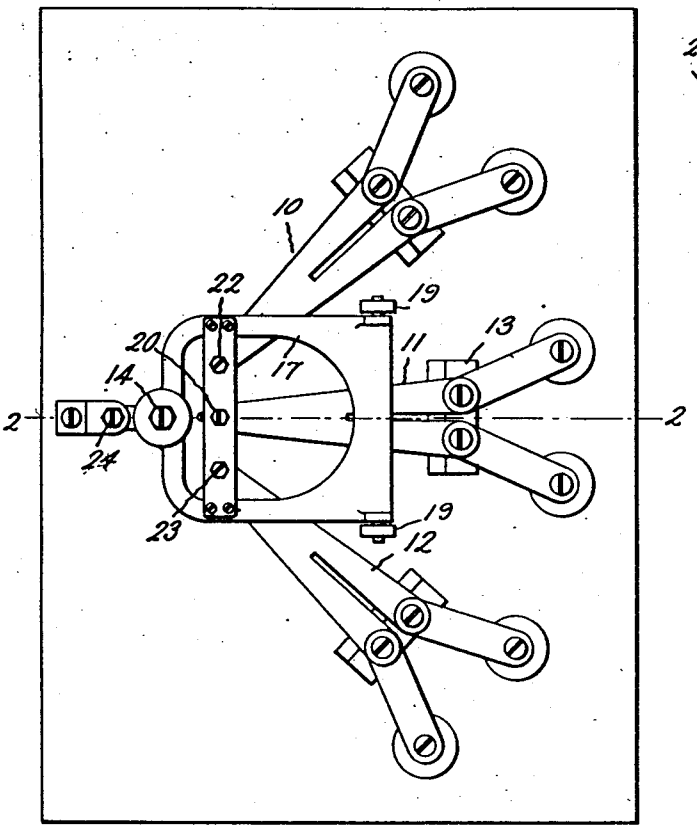


Fig. 3.

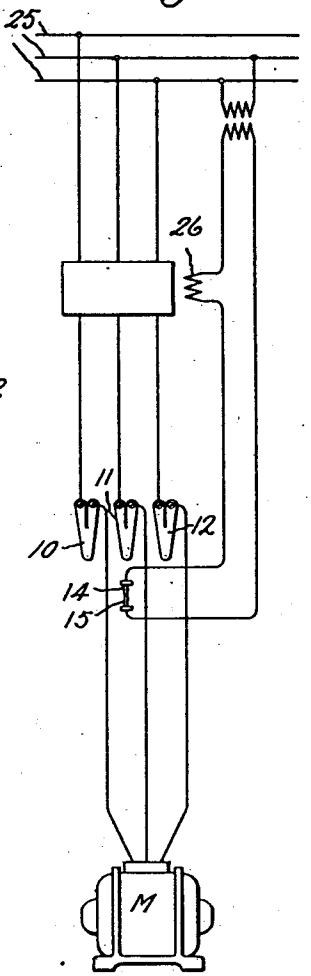
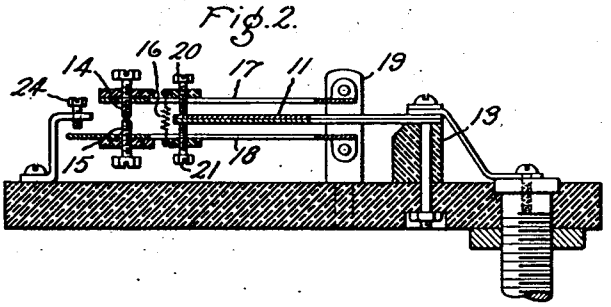


Fig. 2.



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UNITED STATES PATENT OFFICE.

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THERMAL RESPONSIVE DEVICE.

Application filed March 22, 1923. Serial No. 626,906.

To all whom it may concern:

Be it known that I, CHESTER I. HALL, a citizen of the United States, residing at Fort Wayne, county of Allen, State of Indiana, have invented certain new and useful Improvements in Thermal Responsive Devices, of which the following is a specification.

One of the objects of my invention is to provide a thermal protective device, particularly adapted for use with alternating current circuits to protect a translating device connected to the circuit from conditions caused by unbalancing of the phases.

A further object of the invention is to provide an improved thermal protective device for protecting a translating device connected to an electric circuit from overloads or other conditions which would cause overheating.

A still further object of the invention is to provide a protective device for protecting a translating device connected to an electric circuit from conditions caused either by an unbalancing of the phases of the circuit or from overloads or other conditions which would cause overheating.

These and other objects of the invention are attained in the device which is illustrated in very diagrammatic form in the accompanying drawing and which is hereinafter fully described.

In carrying the invention into effect in one form, I provide a protective device having a plurality of thermally sensitive or thermally responsive elements which are so arranged as to be energized responsively to the current in the separate phase conductors, so that the elements will be heated in accordance with the current in the respective phase conductors and the respective heating effects or their respective movements due to their heating effects will therefore be proportional to the square of the current values flowing in the conductors of the multiphase circuit. If the current in one phase differs by some predetermined amount from the current in other of the phases, the differences between the heating effects or the difference between the deflections or the difference between the movements of a portion of the elements will be a predetermined value. Switch mechanism is arranged to be controlled by the thermal responsive elements so as to protect the controlled circuit. The arrangement is preferably such that a pair of switch contacts which are normally closed will be opened in response to a predetermined relative movement of the thermal responsive elements when the phase unbalancing occurs. The controlling switch contacts may be arranged so as to automatically effect the opening of a controlled circuit or to give a signal whereby an attendant may open the circuit. Furthermore, the arrangement may be such that the permissible degree of unbalancing of the phases may be adjusted. In general, the device may with advantage be set for a phase unbalance of 10 per cent to 25 per cent at full load on the translating device protected. The arrangement will be such that the controlling contacts of the device will be maintained closed in case the unbalance of the phases with full load in the circuit is not greater than the predetermined amount. A greater unbalance than the predetermined amount will cause the contacts to open in a certain length of time, this time varying inversely with the differences of the squares of the respective current values in the thermal responsive elements. The length of time required at a given load or percentage unbalanced condition will of course depend upon the thermal time lag of the device. This will ordinarily be made as short as practicable, although it may be also made to duplicate the thermal characteristics of the machine. Upon complete phase unbalance, that is, single-phase operation of a polyphase machine, a portion of the elements will be completely deenergized, and the remainder of the thermal responsive elements will be caused to deflect or move in response to something more than the full load current, so that opening of the contacts will occur very promptly. The device may be also used to protect a translating device from conditions caused by overheating as well as to protect the device from phase unbalance conditions, and in accordance with this feature of the invention, the arrangement is preferably such that a predetermined simultaneous movement of the thermal responsive elements will effect the opening of the contr lled contacts, so as to thereby either automatically disconnect the translating device from the supply circuit or to

give an indication of the fact that the translating device should be disconnected from the supply circuit.

For a better understanding of the invention, reference is had to the accompanying drawing in which Fig. 1 is a plan view of a protective device in accordance with the invention; Fig. 2 is a cross section taken on the section line 2—2, Fig. 1; Fig. 3 is a very simplified diagram showing the protective device in accordance with the invention used for the protection of a polyphase alternating current electric motor.

Referring to the drawings, it will be seen that the protective device is shown as a device for the protection of three-phase alternating current circuits, but it will be understood that my invention is not necessarily limited to a three-phase protective device, since the invention is applicable to the protection of other polyphase circuits. The device as shown comprises three thermal responsive elements 10, 11 and 12 which are arranged so that one end of each element is fixed, and the other end of the element is free to move and is positioned adjacent the free ends of the other elements. Thus, the element 11 is secured at one end in the insulating block 13, and the free end of this element is adjacent the free ends of the elements 10 and 12. These elements may be each in the form of thermostatic strips as customary in the art, that is, the elements may be each composed of two bi-metallic strips suitably joined together, so when the element is heated a deflection is produced due to the unequal expansion of the one part of the strip with respect to the other part of the strip, although the invention is not necessarily limited to the employment of thermostatic strips. Bi-metallic thermostatic elements and thermal responsive elements in general are well known in the art, and it is believed that no further description thereof is herein necessary. It will be observed that each of the thermostatic elements is arranged so as to be a conductor which may be included in one of the phase conductors of the circuit, or to be otherwise energized in accordance with the circuit in a respective phase conductor, as, for instance, by being energized from the secondary of a current transformer, the primary of which is included in the phase conductor, or by being connected across the terminals of a resistor included in the phase conductor. In accordance with the invention, any arrangement whereby the heating of the individual themostatic elements is in accordance with the current in a separate phase conductor will be satisfactory for carrying into effect the general idea of the invention.

A pair of circuit controlling contacts 14 and 15 are arranged so as to be under the control of the thermostatic elements, so as to either give a visible indication of the fact that the phases are unbalanced or overloaded, or to automatically disconnect the translating device from the supply circuit when the abnormal conditions to be protected against occur. These contacts are preferably normally biased into circuit closing position by means of the spring 16. The contact 14 is secured to but insulated from the pivotally mounted member 17, and the contact 15 is secured to and insulated from the pivotally mounted member 18. The members 17 and 18 are each pivotally mounted on the posts 19, only one of which is shown in Fig. 2, and the device as a whole is mounted on the insulating base shown.

The adjustment of the permissible degree of phase unbalance is accomplished by means of an adjusting device for each of the thermostatic elements. By reference to Fig. 2, the adjusting device for the element 11 is shown as of a form in which an adjusting screw 20 is connected with the pivoted member 17 and an adjusting screw 21 is connected with the pivoted member 18, and these adjusting screws are arranged to cooperate with the free end of the element 11. These adjusting screws 20 and 21 may be adjusted so as to be separated by a predetermined amount so as to thereby permit the free end of the element 11 to move or deflect relatively to the other elements without effecting any relative movement between the member 17 or the member 18, and thus without having any movement of the circuit controlling contacts 14 and 15. However, when the relative deflection of element 11 exceeds a predetermined amount, the free end thereof engages either with screw 20 or screw 21 depending upon the direction of deflection and thereby moves either the member 17 or the member 18 to separate the contacts 14 and 15, the other member 18 or 17 being held by the elements 10 and 12. A similar adjusting device 22 is provided for the element 10, and a similar adjusting device 23 is provided for the element 12. These adjusting devices make possible an adjustment of all three of the elements to precisely the same condition, so that a predetermined relative movement of any element with respect to another is required to effect relative movement between the members 17 and 18 and the consequent separation of contacts 14 and 15.

With the adjustment so made that the two sets of screws are practically in contact with the thermostatic metal strips 10, 11 and 12, on both sides thereof, a very slight unbalance will cause the opening of the circuit controlling contacts 14 and 15. However, if the contacts are adjusted so that the two sets of adjusting screws are quite far apart,

then a very large unbalance in the circuit will be required to open the contacts 14 and 15. Variations of load without a sufficient percentage of unbalance to cause separation of the contacts 14 and 15 will permit the three thermostatic metal strips or elements to deflect back and forth, moving the two pivotally mounted members 17 and 18 simultaneously and moving the adjusting device and the contact mechanism freely as a unit, and there will thus be no separation of the contact mechanism until the phase unbalance is greater than the predetermined value. It will thus be seen that in the protection of a translating device, as long as there is substantially similar movement of the thermostatic elements, there will be no operative effect of the device, but when the relative movement of the thermostatic element is greater than a predetermined amount the relative movement will effect the opening of the contacts controlled by the device.

In order to provide for protection against overloads, I have provided the adjustable stop 24 which cooperates with the pivoted member 18 and the adjustable contact 15. In case the thermostatic elements should move the switch contacts 14 and 15 as a unit greater than a predetermined amount, the end of the pivoted member 18 will engage the adjustable stop 24 so as to arrest the further movement of the contact 15. A continuation of the deflection of the thermostatic elements will cause the contact 14 to be separated from the contact 15, even though there is no unbalancing of the phases. Overloads are thereby protected against.

Referring to Fig. 3, it will be seen that I have shown my protective device used for the protection of an alternating current motor M which is arranged to be connected to the three-phase source of supply 25 by means of the circuit breaker shown very diagrammatically. The thermostatic elements 10, 11 and 12 are each included in a phase conductor, so that the heating of the respective elements will be in accordance with the current in the respective conductors. The contacts 14 and 15 are arranged to be included in the coil circuit of a holding electromagnet 26 on the circuit breaker, and the arrangement is such that the circuit breaker will be held closed under the control of the electromagnet 26. When the contacts 14 and 15 separate, the electromagnet 26 will be deenergized and the circuit breaker will be permitted to automatically open in a manner well understood by those skilled in the art. The motor M will thus be protected from phase unbalancing, from phase failure and from overload, as will be understood from a consideration of the description of the device shown in Figs. 1 and 2.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. A protective device for electric circuits comprising circuit controlling switch mechanism, a plurality of thermal responsive movable elements for controlling the said switch mechanism, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit and the said elements arranged to operate the said switch mechanism in response to the relative movement of said elements.

2. A protective device for electric circuits comprising circuit controlling switch mechanism, a plurality of thermal responsive movable elements, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit, and means operatively connecting said elements with said mechanism to operate the same responsively to relative movement of said elements.

3. A protective device for electric circuits comprising circuit controlling switch mechanism, a plurality of thermal responsive movable elements for controlling the said switch mechanism, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit and the said elements arranged to jointly operate the said switch mechanism in response to the movement of said elements due to a predetermined value of current in the said conductors.

4. A protective device for electric circuits comprising circuit controlling switch mechanism, a plurality of thermal responsive movable elements, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit, and means operatively connecting said elements with said mechanism to operate the same responsively to relative movement of said elements and to joint movement of said elements.

5. A protective device for electric circuits comprising circuit controlling switch mechanism, a plurality of thermal responsive movable elements for controlling the said switch mechanism, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit and the said elements arranged to operate the said switch mechanism in response to the relative movement of said elements due to an unbalancing of the current in the respective conductors of the protect-

ed circuit, and means for adjusting the degree of unbalancing of the current in the conductors of the controlled circuit necessary to effect the operation of said switch mechanism.

6. A protective device for electric circuits comprising a plurality of thermal responsive elements, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit, the said elements arranged to move substantially simultaneously in response to substantially similar variations of the current in the conductors of the protected circuit and movable relatively to each other in response to an unbalancing of the current in the conductors, and circuit controlling switch mechanism operated by the relative movement of the said elements.

7. A protective device for electric circuits comprising circuit controlling switch mechanism, a plurality of thermal responsive movable elements for controlling the said switch mechanism, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit and the said elements arranged to operate the said switch mechanism in response to either the relative movement of the elements due to an unbalancing of the current in said conductors or in response to the combined movement of said elements due to a predetermined value of current in the said conductors.

8. A phase unbalance protective device for electric circuits comprising a plurality of thermal responsive movable elements, each of said elements energized responsively to the current in a separate conductor of the circuit controlled by the device, and switch contact mechanism operated by the relative movement of the said elements for opening the electric circuit in response to a predetermined unbalancing of the phases.

9. A phase unbalance protective device for electric circuits comprising a plurality of thermostatic elements, each having a free end adapted to move in accordance with the heating effect of the current in a separate conductor of the circuits controlled by the device, and switch contact mechanism operated by the relative movement of the free ends of said elements for opening the electric circuit in response to a predetermined unbalancing of the phases.

10. A phase unbalance protective device for electric circuits comprising a plurality of thermal responsive movable elements, each of said elements energized responsively to the current in a separate conductor of the circuit controlled by the device, and a pair of switch contacts normally biased to closed position and movable in unison by the said elements when the current in the respective phases of the controlled circuit varies substantially similarly and movable relatively to each other in response to a predetermined unbalancing of the phases.

11. A phase unbalance and overload protective device for electric circuits comprising a plurality of thermal responsive elements, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit, the said elements arranged to move substantially simultaneously in response to substantially similar variations of the current in the phases of the protected circuit and movable relatively to each other in response to an unbalancing of the current in the phases, and circuit controlling switch mechanism arranged to be operated in response to either a predetermined simultaneous movement of the said elements or in response to a predetermined relative movement of the elements.

12. A phase unbalance and overload protective device for electric circuits comprising a plurality of thermal responsive elements, each of said elements adapted to be heated in accordance with the current in a separate conductor of the protected circuit, the said elements arranged to move substantially simultaneously in response to substantially similar variations of the current in the phases of the protected circuit and movable relatively to each other in response to an unbalancing of the current in the phases, and circuit controlling normally closed movable switch contacts connected to the said elements to be moved thereby as a unit through a limited distance and to be separated by either a relative movement of the elements or a simultaneous movement of the elements greater than the said limited distance.

13. A protective device for electric circuits comprising a plurality of thermostatic elements, each of said elements having one end fixed and the other end thereof free to move in accordance with the heating effect of the current in a separate conductor of the circuit to be protected, adjustable switch contacts arranged to be operated in accordance with the relative movement of the free ends of the said elements, and means for adjusting the percentage of unbalancing of the current in the conductors of the controlled circuit necessary to effect the operation of said contacts.

14. A protective device for electric circuits comprising a plurality of thermostatic elements, each of said elements having one end fixed and the other end thereof free to move in accordance with the heating effect of the current in a separate conductor of the circuit to be protected, a pair of normally closed adjustable switch contacts, and a pivotally mounted member for supporting each of the said contacts and cooperating with the free ends of the said elements to separate

the said contacts due to the relative movements of the free ends of the elements occasioned by an unbalancing of the currents in the said conductors.

15. A protective device for electric circuits comprising a plurality of thermostatic elements, each of said elements having one end thereof fixed and the other end thereof free to move in accordance with the heating effect of the current in a separate conductor of the circuit to be protected, a pair of normally closed adjustable switch contacts, a pivotally mounted member for supporting each of the said contacts and cooperating with the free ends of the said elements to separate the said contacts due to the relative movements of the free ends of the elements occasioned by unbalancing of the current in the said conductors, and means for adjusting the percentage of unbalancing of the current in the conductors of the controlled circuit necessary to effect the opening of said contacts.

16. A protective device for electric circuits comprising a plurality of thermostatic elements, each of said elements having one end thereof fixed and the other end thereof free to move in accordance with the heating effect of the current in a separate conductor of the circuit to be protected, a pair of normally closed adjustable switch contacts, a pivotally mounted member for supporting each of said contacts and cooperating with the free ends of the said elements to separate the said contacts due to the relative movements of the free ends of the elements occasioned by an unbalancing of the current in the said conductors, an adjusting device cooperating with each of the said pivotally mounted members for adjusting the percentage of unbalancing of the current in the conductors necessary to effect the opening of the said contacts, and an adjustable stop cooperating with one of said pivotally mounted members for limiting the movement thereof to effect the opening of the said contacts due to a predetermined simultaneous movement of the free ends of said elements.

In witness whereof, I have hereunto set my hand this 19 day of March, 1923.

CHESTER I. HALL.