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THERMALLY-RESPONSIVE BIMETALLIC STARTING SWITCH FOR MOTORS

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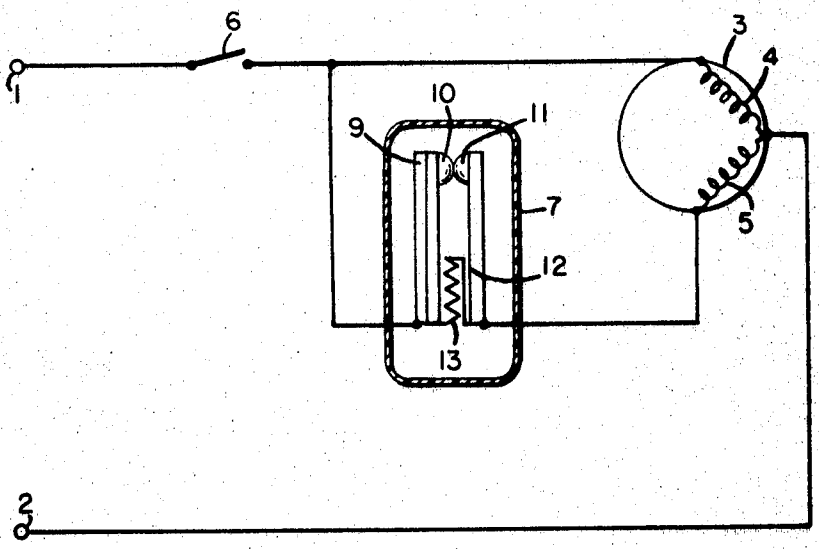


FIG. 1

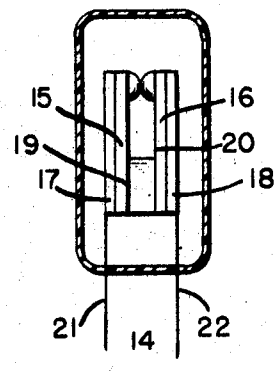


FIG. 2

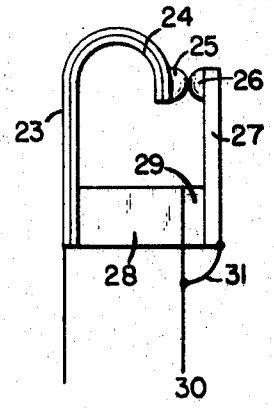


FIG. 3

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THERMALLY-RESPONSIVE BIMETALLIC STARTING SWITCH FOR MOTORS

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Int. Cl. H02p 1/44
U.S. Cl. 318—221 1 Claim

ABSTRACT OF THE DISCLOSURE

A compact, sensitive and highly positive acting and highly stable thermally-responsive starting switch for induction motors. A positive temperature coefficient of resistance resistor directly heats at least one of the contacts, which is a bimetallic strip contact, to maintain the open position of the contacts and prevent intermittent closing and opening thereof. The heating resistor shunts the contacts and has applied thereto the vectorial difference voltage between a voltage across a main winding of the motor and a voltage across a starting winding thereof. The vectorial voltage difference is substantially zero when the switch contacts are closed and the heat resistor is substantially not heated and functioning. The switch opens under control of current flowing through the bimetallic strip contact and the motor starting winding, which is in series with the contacts and the heating resistor. When the switch opens the vectorial voltage difference applied to the heating resistor will have a value such that a current flow therethrough is substantially more constant than the main winding current which is dependent on motor load and the mains voltage. the PTC-resistor has a large current flow when the switch opens and its resistance is relatively low which assists in a positive operation of the bimetallic elements; the resistance increases after opening of the contacts and a balance or stable condition is rapidly achieved and less current will flow through the starting winding. This reduced starting winding current has a fractional value of the current flow at the moment the switch opens.

This invention relates generally to starting devices for single-phase asynchronous motors and more particularly to thermally-responsive starting devices for such motors.

Thermally-responsive starting devices, for use on single-phase induction motors, are known which use a thermal or heating resistor in series with the bimetal switch or bimetallic contacts thereof. The heating element can be heated to achieve exact timing of the opening of the bimetal switch for deenergizing a starting winding, for example, of an induction motor. When the heating element is deenergized the switch is closed. However, this type of starting switch is hardly ever used for single-phase asynchronous motors and it is therefore necessary to use an element capable of keeping the bimetallic switch open in order to maintain the starting winding deenergized once the motor is up to speed.

Thermally-responsive starting devices are also known in which a heating resistor is influenced by the main winding. In such devices the switch is dependent on the current in the main winding. This kind of switch is not very accurate since the main winding current is on the one hand dependent on the load of the motor and on the other hand dependent on the applied or mains voltage which can fluctuate. Thus it is not possible to use this type of starting switch in those places where it is desired to exactly adjust the starting switch because such switches cannot be exactly adjusted since large temperature variations or differences will occur within the permitted tolerance range of the supply voltage.

It is a principal object of the present invention to provide a thermally-responsive starting device or switch for use in starting single-phase asynchronous motors and which can be accurately adjusted to carry out the desired operation of the switch.

The thermally-responsive switch in accordance with the invention uses a heating element, a ceramic resistor, energized by the vectorial voltage difference between the voltage of the main winding and the voltage of the auxiliary or starting winding. The switch contacts, which are strip contacts in series with the motor starting winding, are directly shunted by the resistor which has a large positive temperature coefficient of resistance. When the starting switch is closed the vectorial voltage difference is approximately zero and the heating resistor is essentially not functioning. The switch opens in response to current flow through the strip contacts, one of which is bimetallic, and through the starting winding. When the starting switch is open the additional heating element is energized by a large vectorial voltage difference between the two winding voltages. This voltage difference will have, during all operating conditions in which the switch is open, a value such that the current flowing through the heating resistor is more constant in value than the current flow through the main winding which as indicated heretofore is dependent on the load and the mains voltage applied to the motor.

Moreover, the heating element or resistor will have a large or high current flow when the switch first opens since it has a positive temperature coefficient of resistance and accordingly its initial resistance is quite low. The large current flow through the resistor upon opening of the switch tends to lend assistance to the opening of the bimetallic contacts and imparts strength to the separation thereof so that the switch is positively opened. After a short interval of operation with the switch open a balance is achieved in which the resistance increases or has increased such that a very reduced current flows through the starting winding which is only a fraction of the current flowing therethrough at the time or moment when the starting switch opens.

The switch constructions according to the invention made it possible to use the switch of the invention for very large voltage ranges, for example 110 volts and 220 volts. Moreover, the operation of the switch is not subject to the main voltage fluctuations in the open condition since the heating resistor automatically adjusts its resistance value and emission of heat for maintaining the starting switch open.

The positive temperature coefficient of resistance resistor is mounted with at least one of the contacts, the bimetallic strip contact, mounted directly thereon near an end portion or foot of the strip contact. Thus there is immediate direct heating of the bimetallic strip when the switch opens and the fact that the connection between the resistor and the bimetallic contact is made at the foot end portion thereof leaves the remainder of the bimetallic strip free to carry out deflection without impediment from the resistor connection.

The starting device in accordance with the invention comprises preferably two parallel strip contacts, at least one of which is a bimetallic strip, for opening button contacts thereon. The secured ends of the strip contacts are directly fastened to the ends of the PTC-resistor which acts in this way as a load element for the starting device and the strip contacts can be molded directly on the ends of the heating resistor.

Another feature of the invention is that the input conductors for applying the starting current to the motor through the motor windings are preferably thin conductors. These thin conductors will then avoid partial

cooling of the PTC-resistor so that it is less subject to thermal shock and avoid cracking or splitting thereof since the resistor is a ceramic element. When a voltage is applied to the heating resistor a large and positive effect develops therefrom. The bimetallic switch elements are heated by the current flow therethrough without subjecting the resistor to voltage shocks and thermal shocks so that there is an absence of a tendency to split the resistor.

In one embodiment of the invention a free end of a bimetallic strip is bent arcuately with the structure tending to increase the contact pressure between the contacts during the heating of the bimetallic element and immediately after disconnection of the contacts a highly positive opening of the switch will occur.

The use of a PTC-resistor connected in the manner of the invention has the effect of substantially eliminating cyclic variations, i.e. frequent connections and disconnections after the first opening of the switch because the resistor has at the time of starting a substantial heating effect which is immediately applied to the bimetallic contact and forces it to open positively.

Other features and advantages of the starting switch in accordance with the present invention will be better understood as described in the following specification and appended claims in conjunction with the following drawings in which:

FIG. 1 is a circuit diagram of a starting switch in accordance with the invention in combination with a single-phase asynchronous motor;

FIG. 2 is a fragmentary diagrammatic illustration of a switch in accordance with the invention; and

FIG. 3 is a fragmentary third embodiment diagrammatically illustrated of a starting switch in accordance with the invention.

As illustrated in FIG. 1 terminals 1, 2 are connected to an alternating current source or supply mains, not shown, for supplying power to a single-phase asynchronous motor **3** having a main winding **4** and a starting winding **5** in a split-phase configuration. A switch **6** is provided for starting and stopping the motor **3**. A starting switch **7**, in accordance with the invention, is connected in series with the starting winding **5** as illustrated and is provided with a bimetallic strip contact **9** having a button contact **10** in electrical and physical contact with a button contact **11** mounted on a conductive strip contact **12**. The strip contacts are constructed to separate by bending apart when current flow flows therethrough and the bimetallic contact is heated after the switch **6** is closed and the motor is started. At the moment the contacts open, however, a heating resistor **13** which is directly connected to the two strip contacts **9, 12** supplies heat thereto capable of keeping the bimetallic contact bent and thus the switch contacts in an open condition.

The transition time for effectively heating the switch and maintaining it open is critical in certain motor systems. It is advantageous to use a positive temperature coefficient resistance resistor. Such a resistor has a low resistance while in a cold state and when current flows therethrough it will change to a much higher resistance value and in this way automatically limit current flow through the starting winding **5**. An advantage of using a PTC-resistor as in the invention is that the bimetallic strip contact after opening the switch does not tend to straighten out and periodically connect and disconnect the contacts.

When a thermally balanced condition obtains the bimetallic strip **9** will be in its bent position and this is automatically regulated by the PTC-resistor. In this way an automatic effect or regulation is carried out in that in the disconnected or open condition of the switch a low constant current flows through the resistor and the starting winding is essentially deenergized. However, when it is necessary to have a fairly large current to support the opening function of the switch such a current flows through the resistor. Thus a starting switch in accordance with the invention is independent of the voltage from the supply mains and does not depend thereon and can be used for motors of both 110 volts and 220 volts.

FIG. 2 illustrates diagrammatically a construction or embodiment of a starting switch in which a ceramic PTC-resistor **14** is a direct load element for two bimetallic strip contacts made of dissimilar metals **15, 17,** and **16, 18.** This construction achieves very good thermal contact between the bimetallic strips and the heating resistor **14** and is constructed such that end portions of the strip contacts are in direct physical and electrical contact with the resistor **14** and the free portions thereof are free to deflect. The mounting of the strip contacts directly on the resistor, resulting in good thermal contact, makes it possible to use a much smaller heating resistor so that the starting switch can be made more compact and the thermal voltage shocks to which the resistor is subjected are reduced. The bimetallic strips have inner surfaces **19, 20** of the end portions directly mounted on the resistor.

The switch is connected by conductors **21, 22** to a motor and supply circuit, not shown, in the manner of FIG. 1. The conductors apply current to the resistor through the strip contacts. These conductors are purposely thin conductors and are poor heat conductors. This feature results in extending the life of the PTC-resistor since the poor conductivity of heat of the conductors **21, 22** prevents temperature gradients in the PTC-resistor which might cause thermal splitting of the ceramic mass from which the resistor is formed. It being understood that the ceramic heating resistor **14** is of a known type, for example, one which is produced from selected oxides or rare earths.

A third embodiment of a staring switch in accordance with the invention is illustrated in FIG. 3 in which a conductive bimetallic strip contact **23** is provided with an arcuate bend **24** having a button contact **25** thereon in contact with a button contact **26** mounted on a stationary strip contact **27** which is electrically conductive but which is not bimetallic. The two strip contacts are mounted with end portions on the ends or sides of a PTC-resistor **28.** The bimetallic strip **23** is directly secured thereto making intimate electrical, physical and thermal contact therewith and a spacer **29** insulates the resistor from the strip **27.** Electrical connection is provided directly to the one end of the resistor through a conductor **30** while another conductor is connected to the bimetallic strip **23** which is in direct physical and electrical contact with the resistor so that the bimetallic element acts as a terminal or connection to the thin leads of the type and in the manner heretofore described. A lead **31** provides electrical connection for strip **27** and the lead **30.** It being understood that the leads connect the switch to a motor, not shown, as in FIG. 1.

In this embodiment if current flows through the bimetallic strip **23** the largest free length portion of the bimetallic strip will bend to the left while on the other hand the bend **24** has a tendency of being urged to the right thereby increasing contact pressure between the button contacts **24, 25.** Since the mass of the bend **24** and its length is less than the other remaining lengths of the bimetallic strip **23** the bimetallic contact strip will bend to the left and immediately after opening the contacts the bend **24** is cooled down quite rapidly so that the distance between the two button contacts **25, 26** is increased and contributes to a positive opening or disconnection of the switch contacts.

The switch can be constructed with the bimetallic strips or strip contacts molded in one mass with the PTC-resistor with the resistor disposed between the two strip contacts. There are other known different ways of securing the strip elements to the resistor which are well-known in the art.

The switch in accordance with the invention has proved to be better than other constructions in which a resist-

ance-heat element, i.e. rather long bimetallic strips, are used due to the fact that the PTC-resistor prevents positively a chattering or rebounding connection of the contacts before a final stationary or stable condition obtains. Moreover, in accordance with the invention the PTC-resistor will act as a spark suppressor or extinguisher and thus improve the life of the switch and limit radio noise or interference.

While preferred embodiments of the invention have been shown and described, it will be understood that many modifications and changes can be made within the true spirit and scope of the invention.

What I claim and desire to be secured by Letters Patent is:

1. In combination with a single-phase motor having a main winding and a starting winding, means for disconnecting the starting winding after starting comprising, a thermally-operated switch in series with said starting winding and normally closed when said motor is deenergized, said switch having strip contacts comprising a bimetallic strip movable contact operable to an open position in response to heat, a positive temperature coefficient heating resistor shunting said contacts in series therewith for heating said contacts when open and thereby maintain them open, means physically connecting said resistor and at least said bimetallic strip contact, connections for applying an electrical voltage to said main winding and said starting winding including connections for applying current to said bimetallic contact in series with said starting winding, said windings being connected in a split-phase configuration so that there is a potential difference between said windings when said switch is open, said connections including connections comprising an end portion of said bimetallic strip contact for applying said potential difference to said heating resistor, said connections including conductors connected to said resistor through at least said bimetallic strip contact for minimum heat losses from said resistor therethrough, said bimetallic strip contact having a free end portion defining an arcuate bend, the other of said strip contacts comprising a stationary conductive strip, said bend including means shaped for bending when heated in a direction toward the stationary contact increasing contact pressure and the remainder of said bimetallic strip including means positively urging said bend away from said stationary contact when said contacts open and begin to cool thereby positively opening said contacts in operation, and when electrical voltage is applied to said main winding and starting winding said bimetallic movable contact is heated and opens, and said difference potential being sufficient to cause current flow through said resistor to be more constant in value than the value of current flow in said main winding.

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