

June 2, 1964

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3,135,883

PROTECTOR

Filed Nov. 6, 1961

2 Sheets-Sheet 1

FIG. 1

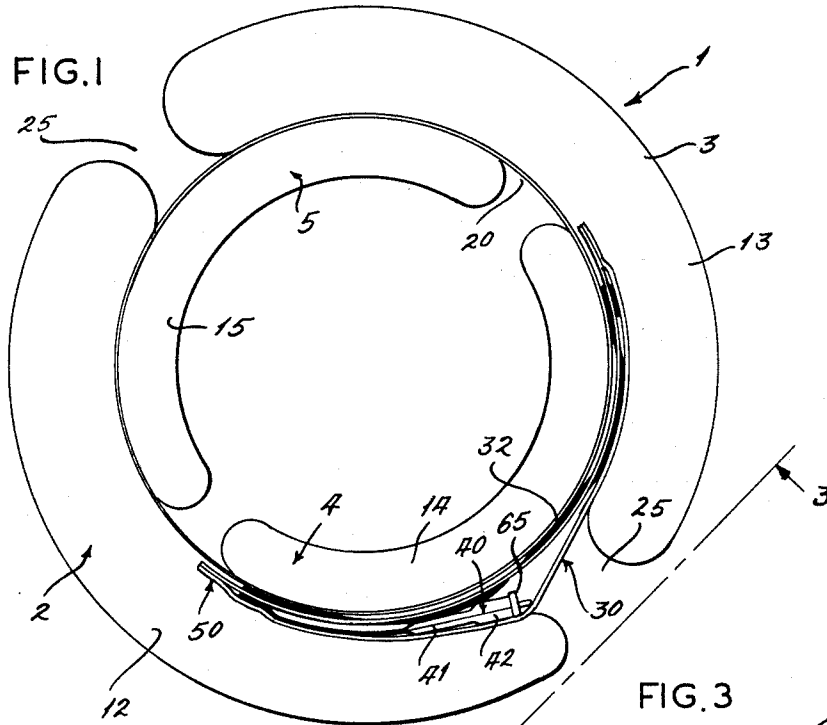


FIG. 2

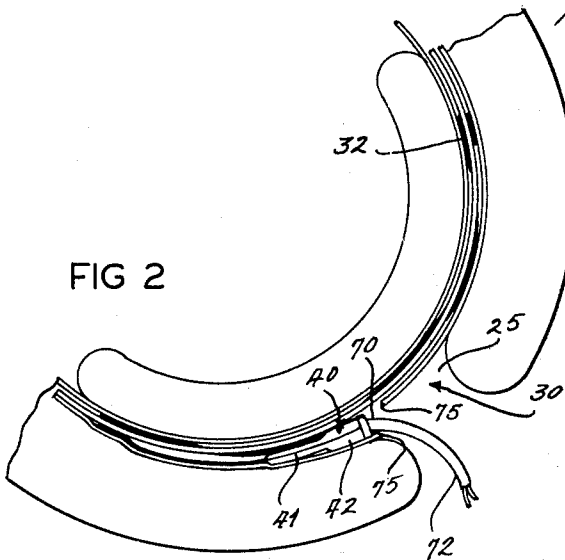
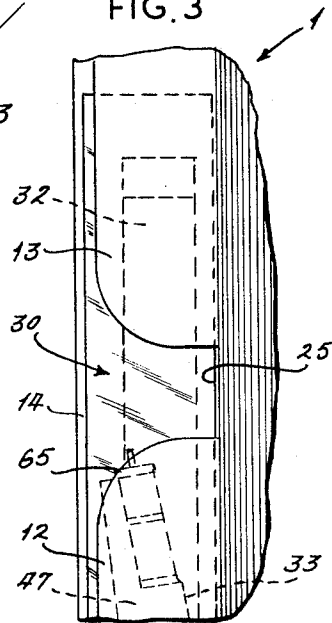


FIG. 3



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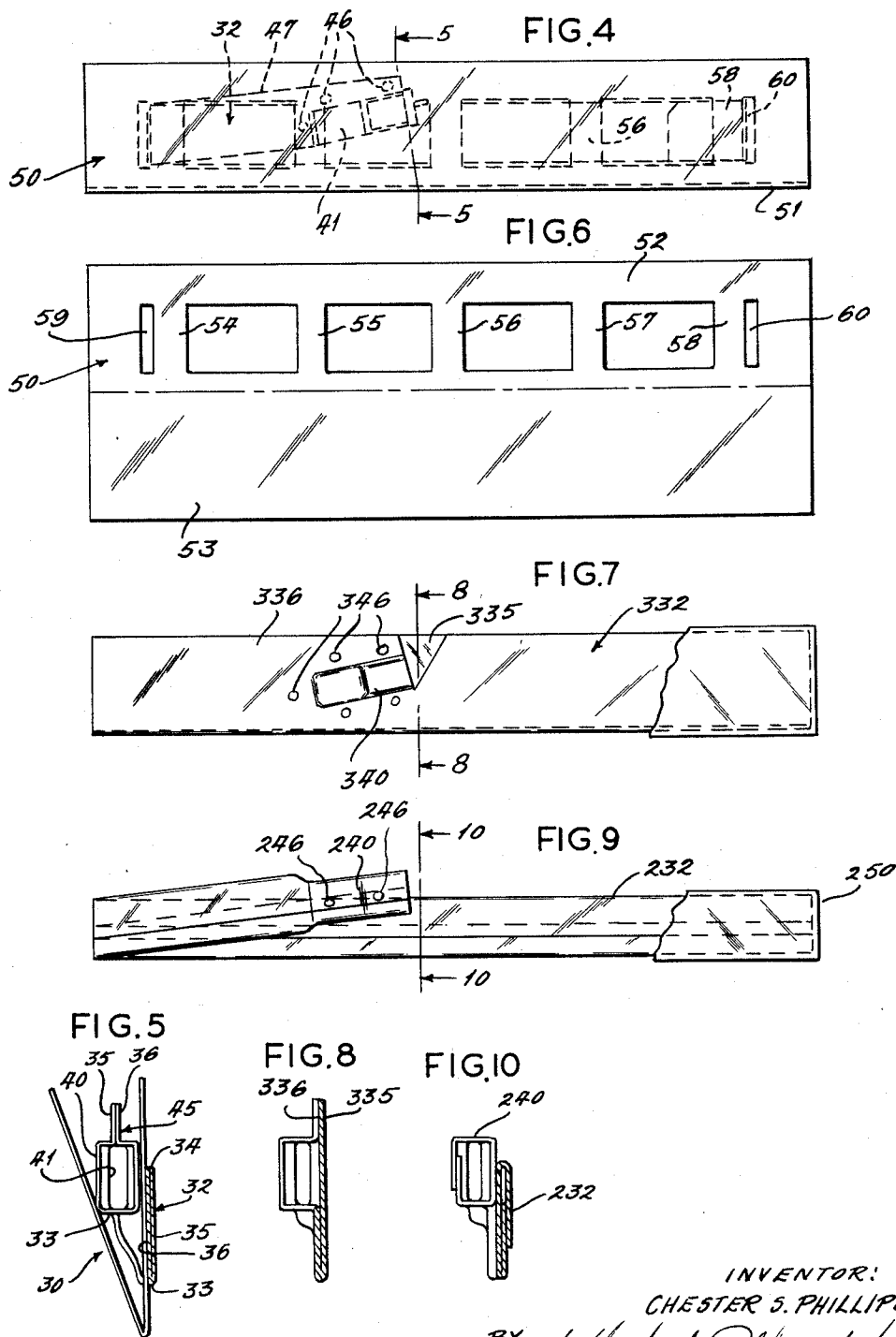
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1

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PROTECTOR

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11 Claims. (Cl. 310—68)

This invention relates to a protector, of the type used to guard against dangerous rise in the temperature of the windings of a dynamoelectric machine. It has particular but not exclusive application to hermetic motors.

Millions of hermetic motors are used in electric refrigeration systems. It is highly desirable, in such systems, to provide a thermal protector which is simple and economical to manufacture and install, sensitive to winding temperature, compact, efficient, and consistent in its operation.

It has been common practice to insert a thermostatic switch in the windings of motors, and it has also been known to use a heat collecting strap in conjunction with such a switch (Cobb, No. 1,947,078 and Dubberley, No. 2,909,719). However, such prior art devices have had certain disadvantages. The thermostatic switch without a strap is responsive to its immediate environment, but is likely to be insensitive to hot spots which develop at a place within the same coil, which is physically spaced from the heat responsive element of the switch. The strap type arrangement has given protection to a wider area of coil, but it has either been responsive primarily only to heat collected in the strap, which leads to some lag in response, or has been difficult to install.

One of the objects of this invention is to provide a thermal strap type protector which is economical to manufacture, easy to install, sensitive to winding temperature, quickly responsive, consistent in operation, and which occupies such a small amount of space as to require no provision for the mounting, beyond what is provided for the motor without the device.

Other objects will become apparent to those skilled in the art in the light of the following description and accompanying drawing.

In accordance with this invention, generally stated, a strap type thermal protector is provided for a motor having a plurality of radially imposed coils, in which a heat conducting strap extends circumferentially and between two sets of the imposed coils, wherein the strap is characterized by having a pocket adapted to receive the heat responsive elements of a thermostatic switch, and which pocket is mounted between radially imposed coils.

Preferably the strap is mounted in an envelope of insulating material to form a package insertable in the windings as a unit. One part of the envelope is cut away and the strap is mounted in such a way as to expose the strap on one side of the envelope and to shield the strap on the other side of the envelope. This is particularly important when the strap is to be positioned between the main windings on the one side and an insulating barrier separating the main and auxiliary windings, on the other. In this situation, the insulating barrier on the one side and the intact envelope on the other substantially equalize the amount of thermal insulation between the strap and the main winding, and the strap and the auxiliary winding.

In any event, the thermal-responsive element in the thermal-element-receiving pocket of the strap is positioned between radially imposed coils, with an open end of the pocket extending generally tangentially of the radially inner coils. When the preferred form of envelope is used, a dummy "thermostatic switch" is inserted in the pocket of the strap, the strap is mounted in the envelope to form a package, the package is first

2

inserted between the windings, then the intact side of the envelope is slit transversely to expose the open end of the pocket, the dummy is removed and the thermostatic switch is inserted, thermal responsive element end first, into the pocket, with the leads projecting into a circumferential space between adjacent coils.

In the preferred embodiment of strap, the strap is a simple V-folded sheet, elongated in the direction of the trough, the two leaves of which are of equal size. The two leaves, through most of their length, are folded tight against one another. At one end, a pocket is formed along the trough, to receive the heat-responsive element of the thermostatic switch. The pocket and the leaves are of such relative sizes that a flat meeting surface is provided on the two leaves, between the pocket and the outer longitudinal edge of the strap, within which area the leaves may easily be secured together.

In the preferred embodiment of envelope, the envelope is made of a simple V-folded sheet of insulating material, elongated in the direction of the trough, with the two leaves of equal size. One of the leaves, as the package is inserted, is intact. The other of the leaves is cut away to form a "ladder" through which the strap is threaded, while the pocket is positioned between the strap and the intact leaf.

In the drawing, FIGURE 1 is a top plan view, somewhat diagrammatic in character, of the stator of a two-pole motor equipped with one illustrative embodiment of thermal protector of this invention, at an intermediate stage in its installation;

FIGURE 2 is a fragmentary portion of the view shown in FIGURE 1, showing the thermal protector in its final stage of installation;

FIGURE 3 is a fragmentary view in side elevation taken along the line 3—3 of FIGURE 1;

FIGURE 4 is a view in side elevation of the protector shown in FIGURES 1-3, immediately before its installation;

FIGURE 5 is a sectional view taken along the line 5—5 of FIGURE 4;

FIGURE 6 is a plan view of an envelope blank from which a part of the embodiment of protector shown in FIGURES 1-5 is made;

FIGURE 7 is a view in side elevation of another embodiment of thermal protector of this invention, immediately before installation, with its envelope partly broken away;

FIGURE 8 is a sectional view taken along the line 8—8 of FIGURE 7;

FIGURE 9 is a view in side elevation of still another embodiment of thermal protector of this invention, immediately before installation, with its envelope partly broken away; and

FIGURE 10 is a sectional view taken along the line 10—10 of FIGURE 9.

Referring now to the drawing and particularly to FIGURES 1-6 for one illustrative embodiment of this invention, reference numeral 1 indicates the stator of a single phase two-pole hermetic motor, with main windings 2 and 3, and auxiliary windings 4 and 5. The main winding coils 2 and 3 have end turns 12 and 13 projecting axially from the stator core. The auxiliary windings 4 and 5, have end turns 14 and 15 respectively, radially imposed with respect to the end turns 12 and 13 of the main winding, except at the circumferential centers of the auxiliary windings, in which area there is a circumferential gap 25 between the end wires 12 and 13 of the windings 2 and 3.

An insulating barrier 20 encompasses the end wires 14 and 15 of the auxiliary windings, radially inboard of the end wires 12 and 13 of the main windings.

A thermal protector 30 of this invention is positioned

radially outboard of the insulating barrier 20 and inboard of end wires 12 and 13.

The protector of this, the preferred embodiment consists of a heat collecting strap 32 in the form of a sheet of copper V-folded to form a trough edge 33, a free edge 34 and two equal sized leaves 35 and 36. At one end, the strap is chamfered at the free edge 34. At the other end, the strap is provided with a pocket 40, along the trough edge 33, and with its long axis generally in the direction of the long axis of the strap 32, though at a small acute angle to it.

The pocket 40 is of such a widthwise dimension relative to the width of the strap 32, as to provide a substantial flat meeting area 45 between the pocket and the free edge 34. Spot welds 46 serve to prevent deformation of the pocket 40. The pocket, in the embodiment shown, has a relatively thin inner, heat responsive element receiving section 41, and an outer thick section 42. The pocket 40 is formed integrally with the leaves 35 and 36 of the strap, which results in a narrowing of the strap at the pocket end, and a slight angular offset from the long axis of the strap. This angular offset is no disadvantage, and is, in fact, used to advantage in bringing out the terminal connections from a thermostatic switch 70 mounted in the pocket. In all of the embodiments, the pocket is located between radially imposed portions of end wires of several coils, with the open end of the pocket in the general direction of an open space between circumferentially spaced coils. As a matter of convenience, it is desirable that the pocket be directed with its open end cocked axially outwardly far enough to permit easy insertion of the thermostatic switch.

In order to accomplish this cocking in the preferred embodiments shown, the strap is doubled back to form a short section 47 at an angle to the remaining long section of the strap, as shown particularly in FIGURES 3 and 4. It can be seen that if the pocket is offset 5° from the line of the trough edge 33, in the course of its manufacture, and the short section of the strap is bent back at an angle of 5°, the total cocking of the pocket with respect to the axis of the long section of the strap is 10°.

The strap 32 is mounted in and on an envelope 50 of insulating material. When the strap 32 is first mounted in and on the envelope 50, the envelope consists of a rectangular sheet of bendable insulation, such as Mylar, V-folded to form a trough edge 51 and two equal sized leaves, a ladder leaf 52 and an intact leaf 53. The ladder leaf 52 is cut away to form a series of transverse rungs 54, 55, 56, 57 and 58. The rungs 54 and 58 are defined on their axially outboard sides by slots 59 and 60 respectively.

As is shown particularly in FIGURE 4, the strap 32 is threaded initially from the space between the leaves 52 and 53 out through slot 59, around the outside of the rung 54, around the inside of rung 55, the outside of rung 56, the inside of rung 57, the outside of rung 58, and in through the slot 60. The chamfered end of the strap is bent back upon itself, to hold the strap against longitudinal shifting. In this position, the doubled-back short section 47 of the strap closely embraces the edge of the rung 54 defining an edge of the slot 59, so that the strap cannot move in either longitudinal direction with respect to the insulation.

In making a motor equipped with the device of this invention, after the strap has been made, the pocket formed, and the pocket end welded, a dummy switch 65 is inserted in the pocket to ensure against the pocket's being mashed, and the strap is bent and threaded through the rungs of the ladder leaf 52. The bending to the appropriate angle may be done either before or after the threading of the strap, and the angle can be made almost any convenient one. This flexibility of adjustment is one of the advantages of this embodiment.

The envelope, with the strap mounted on and in it, is next inserted, trough side first, between the main wind-

ing, one end side and the insulating barrier 20 on the other side, with the intact leaf 53 of the envelope against the main winding and the ladder leaf 52 (and the exposed parts of the strap 32) against the insulating barrier, and with the pocket 40 sandwiched between the end wires 12 of the main winding 2 and the end wires 14 of the auxiliary winding 4. As can be seen from FIGURES 1 and 2, the pocket 40 opens in the direction of the gap 25 between the end wires of the main windings 2 and 3.

In this preferred method, the end wires are now blocked, and the intact leaf 53 is slit transversely at or near the open end of the pocket 40, as indicated by numeral 75. This permits the intact leaf beyond the open end of the pocket to fold substantially flat against the ladder leaf 52, exposing the open end of the pocket. While the leaf 53 might be slit before the end wires are blocked, or before the package is inserted between the end wires, or even before the strap is mounted in the envelope, it has been found that the slitting after the blocking step is easily accomplished, and the maintenance of the integrity of the intact leaf during the blocking step helps to prevent displacement of distortion of the strap and pocket.

The dummy 65 can now be withdrawn, more or less tangentially, through the gap 25, and the thermostatic switch 70 inserted, heat responsive element end first, into the pocket. The pocket is made so that the thermostatic switch is securely frictionally mounted within the pocket. The switch can be removed for replacement, with little difficulty, but fits tightly enough so as not to be displaced in use. Terminal leads 72, from the switch 70, extend into the gap 25. It can be seen that in the axial direction, as well as in the radial direction, the protector occupies no additional space beyond what is already available, so that no provision in the standard mounting of the motor need be made. The end wires are laced with the protector in place, after which the protector is barely detectable in the winding.

The performance of the protector of this invention is excellent. It responds more quickly to temperature rise in the coils than do those protectors which are dependent entirely upon a strap for heat collecting. At the same time, it responds to the presence of hot spots physically removed from the heat responsive element of the thermostatic switch but within the compass of the strap, at least as efficiently as the strap type protectors known heretofore, and more effectively than the strapless types. Being buried in the coils, the thermostatic switch responds more quickly to the heat generated in the coils since the cooling effect of the surrounding atmosphere is less pronounced within the coils than in the gap between adjacent coils. It follows then that the temperature lag of the sensing element located in the coils is less than that of a sensing element located in the gap between coils.

A second embodiment of protector is shown in FIGURES 9 and 10. This protector is particularly adapted to motors in which no insulating barrier is positioned between radially imposed coils. It is operative in the kind of motor shown in FIGURE 1, in which an insulating barrier is provided, but, as can be appreciated, since there are two thicknesses of insulation between the strap and the auxiliary winding and only one between the strap and the main winding, the protector is more quickly sensitive to temperature rise in the main winding than it is to temperature rise in the auxiliary winding.

In this embodiment, a strap 232, which may be narrower than the strap 32 of the first embodiment, is made of a sheet of copper the two long margins of which are infolded to form a flattened tube which, except for a short overlap of the intumed margins, can be considered a double leaved strap. At one end, the strap or tube 232 is opened and formed to provide a pocket 240, and welded, at 246, to maintain the pocket shape. The strap is enclosed through and slightly beyond its length within an insulating envelope 250, which also can be in the form of a flattened tube.

5

This embodiment of protector can be inserted between radially imposed end wires, with the open end of the pocket extending toward the gap 25, without the necessity of subsequent slitting of the envelope. It can also be adjusted when bent back, for angularity, just as the preferred embodiment can be. However, in addition to the problem of double insulation, when an insulating barrier is used, this embodiment presents some difficulties in manufacture, since a welding anvil must be inserted in the formed pocket to permit the overlapped margins to be welded at the pocket end. Since this anvil is necessarily as small as the heat responsive element end of the thermostatic switch, it has a short life in practice. In the preferred embodiment, the welding is done on a flat surface, where no such problem arises. It can be seen that a combination of the strap of this embodiment with the envelope of the embodiment shown in FIGURES 1-6 can be used, which eliminates the double insulation problem, but the increased difficulty of manufacture of the strap of the embodiment of FIGURE 9 remains.

Still another embodiment of protector of this invention is shown in FIGURES 7 and 8. In this embodiment, a rectangular strap 332 is formed from two leaves 335 and 336 which may or may not be part of a V-folded sheet. The leaf 336 is notched near its center, from its upper edge, and a pocket 340 is formed in the leaf 336 with its mouth along one edge of the notch, and its long axis at right angles to the notch. Five spot welds 346 serve to hold the leaves 335 and 336 together, and to hold the shape of the pocket 340. This strap can be mounted in an envelope similar to the envelope 50 of the first embodiment described, the two ends being bent back a short distance around the end rungs to hold the strap against longitudinal shifting, and located in the winding in the same manner as is shown in FIGURES 1-3, the envelope preferably being slit after blocking of the end wires. The protector of this embodiment has the advantage of being easily installed and of taking the least amount of copper for the width of strap, since there is little doubling back required. However, it does require that one leaf be notched, that the leaves be wide enough to accommodate the pocket, and, more importantly, it permits of no adjustment in the angular relationship of the pocket to the stator at the time of installation.

Merely by way of illustration and not by way of limitation, a protector, constructed in accordance with the embodiment shown in FIGURES 1-6, has been found entirely satisfactory when made as follows: the strap 32 was made of a sheet of copper .003 inch thick, $1\frac{1}{16}$ inches wide and 8 inches long, folded lengthwise to form a strap $1\frac{1}{32}$ inch wide and 8 inches long. The pocket 40 was .744 inch deep, with a thermal responsive element receiving pocket part about .094 inch thick, .283 inch wide and .389 inch deep, and an enlarged outer pocket part about .187 inch thick, .283 inch wide and .375 inch deep. The pocket snugly accommodated a Spencer type 7895 pilot circuit thermostatic switch. The envelope was made of a sheet of .005 inch thick "Mylar," $2\frac{1}{8}$ inches wide and 6 inches long, blanked out on one long half and V-folded to form a trough shaped envelope 6 inches long and $1\frac{1}{16}$ inches wide.

The assembled package was placed between the respective end wires of main and auxiliary coils of a two-pole, 6.3 inch, 5 horsepower single phase motor.

It is essential, to realize the superior characteristics of the protector of this invention, that the thermostatic switch-receiving pocket, or at least so much of it as houses the heat responsive elements of the thermostatic switch, be sandwiched between radially imposed coils, and that the heat collecting strap portion extend over a considerable area, preferably, in the type of motor shown, through most of the circumferential length of the end turns of one of the windings and through a substantial span of the circumferential length of two of the end windings which are radially displaced from the first mentioned winding.

6

It can be seen that, while the protector of this invention is excellently adapted for use with the type of motor illustrated, it also has application to other types, in which there are radially imposed coils, such, for example, as polyphase concentric coil types.

It can be seen that since the intact leaf provides the insulation between the strap and the main windings, while the amount of bare strap exposed to the regular insulating barrier largely determines the response of the strap to the temperature of the auxiliary windings, by varying the thickness or kind of insulating material from which the envelope is made, the sensitivity of the device to heat in the main windings can be varied without affecting its sensitivity with respect to the auxiliary windings, and by varying the size and number of the windows in the ladder leaf, the sensitivity of the device to heat in the auxiliary winding can be varied without affecting its sensitivity with respect to the main windings. Any suitable insulating material, such, for example as paper, may be substituted for the Mylar described. The dimensions of the various elements may be varied to suit different conditions and requirements. The strap can be made of two separate strips of copper or any other suitable heat conductive material, or they can be made of a seamless tube, though the V-folded embodiments have certain advantages over either of these variations.

The seamless tube modification is particularly applicable to the embodiment shown in FIGURES 9 and 10, because the seamless tube may be of a size just to accommodate the switch, the tube being formed to the switch contour on one end and flattened for the remainder of the length. This eliminates the necessity for inside welding, which is one of the disadvantages of that embodiment, productionwise. However, the cost of copper seamless tubing makes this modification presently less economic than the folded sheet. It can also be appreciated that the use of copper as the heat-conducting material from which the straps of the various embodiments have been described as made, is dictated by economic considerations. Other heat conductors, such as silver, could be used equally well as far as their operation is concerned.

Numerous other variations in the construction and installation of the protector, within the scope of the appended claims will occur to those skilled in the art in the light of the foregoing disclosure.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In an electric motor having a radially inner and a radially outer set of coils, both with projecting end wires, successive coils of each set being circumferentially spaced, leaving a gap between them, and the coils of the two sets being circumferentially staggered with respect to one another to provide areas at which the end wires of one coil of one group and the end wires of the two coils of the other group are radially imposed, the improvement comprising a thermal protector having an elongated heat conducting strap extending longitudinally circumferentially and between the respective end wires of two coils of one group and one coil of the other group which are radially imposed, said strap having an elongated pocket therein, opening at one axial end; a thermostatic switch mounted in said pocket, said thermostatic switch having a heat responsive element within said pocket and said heat responsive element and its enclosing pocket being buried between the end wires of two of said radially imposed coils, adjacent but out of a gap between successive coils, and electrical conductors extending from said switch into said gap.

2. In a motor having a plurality of radially imposed coils with an insulating barrier between the end wires thereof, the improvement comprising a thermal protector having a heat conducting strap, a heat insulating envelope having a ladder-like leaf through which said strap is woven to expose a portion of one side of said strap outside of said envelope, said thermal protector having a

pocket within which a thermostatic switch is mounted, said thermostatic switch having a heat responsive element within said pocket, said heat responsive element and its enclosing pocket part being positioned within said envelope between respective radially imposed end wires of the said coils, and said ladder-like leaf being positioned immediately contiguous the insulating barrier between the said end wires.

3. A thermal protector comprising an elongate, one-piece, two-leaved strap of heat conducting material having a thermostatic element receiving pocket formed integrally therein at one end thereof, said pocket being generally axially directed and said strap being doubled back intermediate its ends, and a thermostatic element in said pocket.

4. The thermal protector of claim 3 wherein the doubled-back portion of the strap makes an acute angle with the portion with which it is immediately integral.

5. The thermal protector of claim 2 wherein the pocket is intermediate the ends of the straps and at an acute angle to the long axis thereof.

6. A thermal protector comprising an elongated, one-piece, two-leaved strap formed from a single V-folded rectangular sheet of heat-conducting material, the two leaves engaging one another and being of the same size, said strap having a thermostatic element-receiving pocket formed integrally therewith between the leaves along the trough of the V, at one end, opening outwardly, the leaves of said strap being sufficiently wider than said pocket to provide a flat meeting surface between the pocket and the outer longitudinal edge of the strap, along which the leaves are secured together, and a thermostatic element in said pocket.

7. A thermal protector comprising an elongate strap in the form of a seamed tube flattened through most of its length but provided at one end with a thermostatic

element-receiving pocket, axially directed and opening at said end of the tube, said strap being doubled back intermediate its ends with the pocket-carrying part of the strap at an acute angle to the integrally contiguous part thereof, and a thermostatic element in said pocket.

8. The thermal protector of claim 7 wherein the strap is embraced along and beyond the ends of the strap by an envelope of insulation.

9. A thermal protector comprising an elongate strap of heat conducting material having two connected leaves, one of which is notched intermediate its ends, a pocket formed in said notched leaf, said pocket opening into said notch and having one wall defined by said other leaf, said pocket being oriented at an acute angle to the long axis of said strap and adapted to receive a thermostatic switch element, and a heat responsive element of a thermostatic switch within said pocket.

10. The thermostatic protector of claim 9 wherein the strap is mounted in and on an envelope formed of a V-folded sheet of insulating material, one of the leaves of which is intact with respect to the strap and the other is blanked out to provide strap-exposing openings.

11. A thermal protector comprising an elongate strap in the form of a tube of heat-conducting material, flattened through most of its length but provided at one end with a thermostatic element-receiving pocket, axially directed and opening at said end of the tube, said strap being doubled back intermediate its ends with the pocket-carrying part of the strap at an acute angle to the contiguous part thereof, and a thermostatic element in said pocket.

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