

ELONGATE ELECTRICAL ASSEMBLIES

This invention relates to elongate electrical heater which are suitable for use in the circuits which (a) are described and claimed in Application No. 83 10334, from which this application is divided, and (b) contain a two-phase or three-phase power source. Reference should be made to Application No. 83 10334 for details of the ways in which the heaters of this invention are preferably employed.

As disclosed in the parent application, we have discovered that substantial improvements can be made in the performance of elongate self-regulating electrical heaters comprising two elongate electrical connection means and a plurality of electrical elements which are connected in parallel between them, by connecting the power supply to one of the electrical connection means at one end of the device and to the second electrical connection means at the other end of the device. When the device is connected in this way, the resulting balancing of the potential drop over the length of the device leads to substantially improved performance. In particular, the problem of current inrush is substantially reduced, and substantially longer circuit lengths can be employed as compared to conventional circuits in which power is fed to both connection means at the same end of the heater. When the power supply is a two-phase or three-phase power supply, particularly useful results can be obtained by employing

two or three self-regulating heaters which are connected to each other in a circuit such that power reaching one end of each heater has first passed through another heater; the heaters can be physically positioned, for example, end-to-end, as is usually preferred, or side-to-side. Such circuits can most conveniently be assembled from elongate devices which contain all the required elongate components, and the present invention is concerned with such devices.

In its first aspect, the present invention provides an elongate composite device which comprises

- (1) an elongate self-regulating heater comprising
 - (a) a first elongate connection means;
 - (b) a second elongate connection means; and
 - (c) a plurality of electrical elements which are connected in parallel between the first and second connection means;
- (2) a third elongate electrical connection means;
- (3) a fourth elongate electrical connection means;
- (4) a fifth elongate electrical connection means;
and
- (5) a connecting body of insulating material which physically secures the device (1) and the connection means (2), (3) and (4) to each other;

the heater, the connection means (2), the connection means (3) and the connection means (4) being electri-

cally insulated from each other along the length of the device.

In its second aspect, the present invention provides an elongate composite device which comprises

- (1) an elongate self-regulating heater comprising
 - (a) a first elongate connection means;
 - (b) a second elongate connection means; and
 - (c) a plurality of electrical elements which are connected in parallel between the first and second connection means;
- (2) a third elongate electrical connection means which is a round metal wire, a flat metal strip, or an elongate self-regulating heater comprising two elongate connection means and a plurality of electrical elements connected in parallel between them;
- (3) a fourth elongate electrical connection means which is a round metal wire, a flat metal strip, or an elongate self-regulating heater comprising two elongate connection means and a plurality of electrical elements connected in parallel between them; and
- (4) a connecting body of insulating material which physically secures the device (1) and the connection means (2) and (3) to each other;

the heater, the connection means (2) and the connection means (3) being electrically insulated from each other along the length of the device.

The devices of the present invention are usually physically located so that one end of the device is nearer to the power supply than the other. Accordingly, for ease and clarity in describing and claiming the invention, the terms "near end" and "far end" are used in this specification to identify the ends of the elongate connection means and the devices containing them. It is to be understood, however, that the invention includes devices which have been arranged, e.g. in a loop, so that the "far end" is closer to the power supply than the "near end" or so that the near and far ends are equidistant from the power supply.

The invention is illustrated by the accompanying drawings, in which

Figures 1 to 5 are circuits in which two conductive polymer PTC heaters are connected to a two-phase power source to form circuits as claimed in the parent application;

Figures 6 to 9, 17 and 18 are circuits in which three conductive polymer PTC heaters are connected to a three-phase power source to form circuits as claimed in the parent application;

Figures 10 to 16 are cross-sections through composite devices suitable for use in Figures 1 to 9, 17 and 18.

For brevity and clarity in describing the present invention, the term "elongate parallel device" is used in this specification to denote an elongate self-regulating heater which comprises

- (a) a first elongate electrical connection means;
- (b) a second elongate electrical connection means; and
- (c) a plurality of electrical elements which are connected in parallel with each other between the first and second connection means.

The heater is preferably at least 330 feet long.

The various electrical connection means will often be simple conductors, which can be composed of the same or different materials, e.g. round metal wires (which may be solid or stranded) or flat metal strips, and are sometimes simply referred to herein as conductors. It is to be understood, however, that any form of electrical connection means can be used. Generally it is desirable that in the (or each) elongate parallel device, (a) the first and second conductors are substantially the same as each other; (b) each of the conductors has substantially the same cross-section throughout the length of the device; (c) the resistance of the conductors is as low as is consistent with other factors such as weight, flexibility and cost; and (d) the conductors are at a constant distance from each other (they may be for example, straight or spiralled).

The electrical elements (c), which are connected in parallel with each other between the first and second connection means, will usually be the same as each other, but this is not necessary. In one preferred embodiment of the invention, at least some of the elements (c) comprise a PTC element, which can be composed of a conductive polymer, or a ceramic. The PTC element can itself be the sole heating element; alternatively it can have a ZTC resistive heating element in series with it. The elements (c) can be in the form of at least one element composed of a conductive polymer, for example a continuous strip or web of conductive polymer or a plurality of segments of conductive polymer. The composition of the conductive polymer element may be the same throughout, or can vary; thus the conductive polymer element can comprise two or more longitudinally extending components which have different electrical characteristics. Suitable conductive polymer elements include

- (a) elements which consist essentially of a conductive polymer which exhibits ZTC behavior; and
- (b) elements which comprise a PTC conductive polymer element such that the device is a self-regulating heater, e.g. an element which consists essentially of a PTC conductive polymer or an element which comprises a ZTC component element and at least one PTC component element, for example at least one PTC component element which surrounds one of the elongate conductors.

In another preferred embodiment of the invention, the elements (c) are in the form of one or more heating wires which are connected at intervals to the two conductors, e.g. as in a conventional zone heater, with the connections to at least one of the conductors being through a PTC component.

A wide variety of different effects can be obtained by correlating the electrical characteristics of the elongate parallel device and of the electrical connection means which connects the power source and the far end of the second electrical connection means of the elongate parallel device. The impedance of the connection means can be purely resistive or part or all of the impedance can be inductive or capacitative; for example the connection means can be a SECT (skin effect current tracing) heater.

As indicated above, a number of particularly useful circuits comprise a two or three phase power supply and two or three elongate parallel devices as defined; these devices are preferably the same, but can be different. Many, but not all, of these circuits comprise a neutral, and when they do, the neutral is preferably provided by an elongate electrical connection means. However, it is also possible to use a floating neutral. Various circuits of this kind are shown in Figures 1 to 9, 17 and 18, in which the neutral connection which is preferably present is shown as a broken line. Preferred circuits (because they are balanced) are those shown in Figures 1, 4 and 17. In these Figures, and in the other Figures, the various heaters are shown as conductive polymer heaters, but the same circuits and

devices are very suitable for use with self-regulating zone heaters and other self-regulating elongate parallel heaters.

Composite devices of the invention which can be used in the circuits comprising a two-phase or three-phase power source include those defined in paragraphs (1) and (2) below. Cross-sections of particular Examples of such devices are shown in Figures 10 to 16, in each of which a tube 41 of insulating polymeric material physically connects at least one PTC conductive polymer heater (101, 102 and 103) having an insulating polymeric jacket and at least one wire conductor (111, 112, 113 and 114) having an insulating polymeric jacket.

- (1) Composite devices which comprise at least two elongate parallel devices as defined, and which can also include one or more elongate connection means. Figures 10, 11 and 12 show devices of this type. The device of Figure 10 is suitable for use in the circuit of Figure 1; it is to be noted that the neutral connection means 111 in Figure 10 (and likewise in Figures 12, 13 14 and 15) can be smaller than the conductors in the heaters themselves. The device of Figure 11 is suitable for use in the circuit of Figures 2 and 3. The device of Figure 12 is suitable for use in the circuit of Figure 7.
- (2) Composite devices which comprise at least one elongate parallel device as defined and at

least two elongate connection means. Figures 13, 14, 15 and 16 show devices of this type. The device of Figure 13 is suitable for use in Figure 14, and is also in Figure 5, with the smaller conductors not being used in the part of the circuit furthest from the power source. The devices of Figures 14 and 15 are suitable for use in Figure 17, and also in Figure 8, with one of the large conductors not being used in the part furthest from the power source, and also in Figure 18, with the small conductor not being used in the mid-section and with the small conductor and one of the large conductors not being used in the section furthest from the power source. The device of Figure 16 is suitable for use as the middle portion of the circuit of Figure 9.



CLAIMS

1. An elongate composite device which comprises

(1) an elongate self-regulating heater comprising

- (a) a first elongate connection means;
- (b) a second elongate connection means; and
- (c) a plurality of electrical elements which are connected in parallel between the first and second connection means;

(2) a third elongate electrical connection means;

(3) a fourth elongate electrical connection means;

(4) a fifth elongate electrical connection means;
and

(5) a connecting body of insulating material which physically secures the device (1) and the connection means (2), (3) and (4) to each other;

the heater, the connection means (2), the connection means (3) and the connection means (4) being electrically insulated from each other along the length of the device.

2. A device according to claim 1 wherein the electrical elements (c) comprise a continuous strip of a PTC conductive polymer.

3. A device according to claim 2, wherein the first and second connection means are metal wires which are



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in direct contact with the continuous strip of conductive polymer.

4. A device according to claim 1 wherein the heater is a zone heater.

5. A device according to any one of the preceding claims which is at least 330 feet long.

6. A device according to any one of the preceding claims wherein each of the third, fourth and fifth connection means is a round metal wire or a flat metal strip.

7. A device according to claim 6 wherein each of the third, fourth and fifth connection means is a round metal wire.

8. A device according to any one of claims 1 to 5 wherein at least one of the third, fourth and fifth elongate connection means is a second elongate self-regulating heater comprising two elongate connection means and a plurality of electrical elements connected in parallel between them.

9. A device according to claim 1 substantially as hereinbefore described.

10. A device according to claim 1 substantially as hereinbefore described with reference to and as illustrated in any one of Figures 11, 12, 14 and 15 of the accompanying drawings.

11. An elongate composite device which comprises



- (1) an elongate self-regulating heater comprising
 - (a) a first elongate connection means;
 - (b) a second elongate connection means; and
 - (c) a plurality of electrical elements which are connected in parallel between the first and second connection means;
- (2) a third elongate electrical connection means which is a round metal wire, a flat metal strip, or an elongate self-regulating heater comprising two elongate connection means and a plurality of electrical elements connected in parallel between them;
- (3) a fourth elongate electrical connection means which is a round metal wire, a flat metal strip, or an elongate self-regulating heater comprising two elongate connection means and a plurality of electrical elements connected in parallel between them; and
- (4) a connecting body of insulating material which physically secures the device (1) and the connection means (2) and (3) to each other;

the heater, the connection means (2) and the connection means (3) being electrically insulated from each other along the length of the device.

12. A device according to claim 11 wherein the electrical elements (c) comprise a continuous strip of a PTC conductive polymer.



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13. A device according to claim 12, wherein the first and second connection means are metal wires which are in direct contact with the continuous strip of conductive polymer.

14. A device according to claim 11 wherein the heater is a zone heater.

15. A device according to any one of claims 11 to 14 which is at least 330 feet long.

16. A device according to any one of claims 11 to 15 wherein each of the third and fourth connection means is a round metal wire.

17. A device according to any one of claims 11 to 16 wherein at least one of the third and fourth elongate connection means is an elongate self-regulating heater comprising two elongate connection means and a plurality of electrical elements connected in parallel between them.

18. A device according to claim 11 substantially as hereinbefore described.

19. A device according to claim 11 substantially as hereinbefore described with reference to and as illustrated in any one of Figures 10, 13 and 16 of the accompanying drawings.
