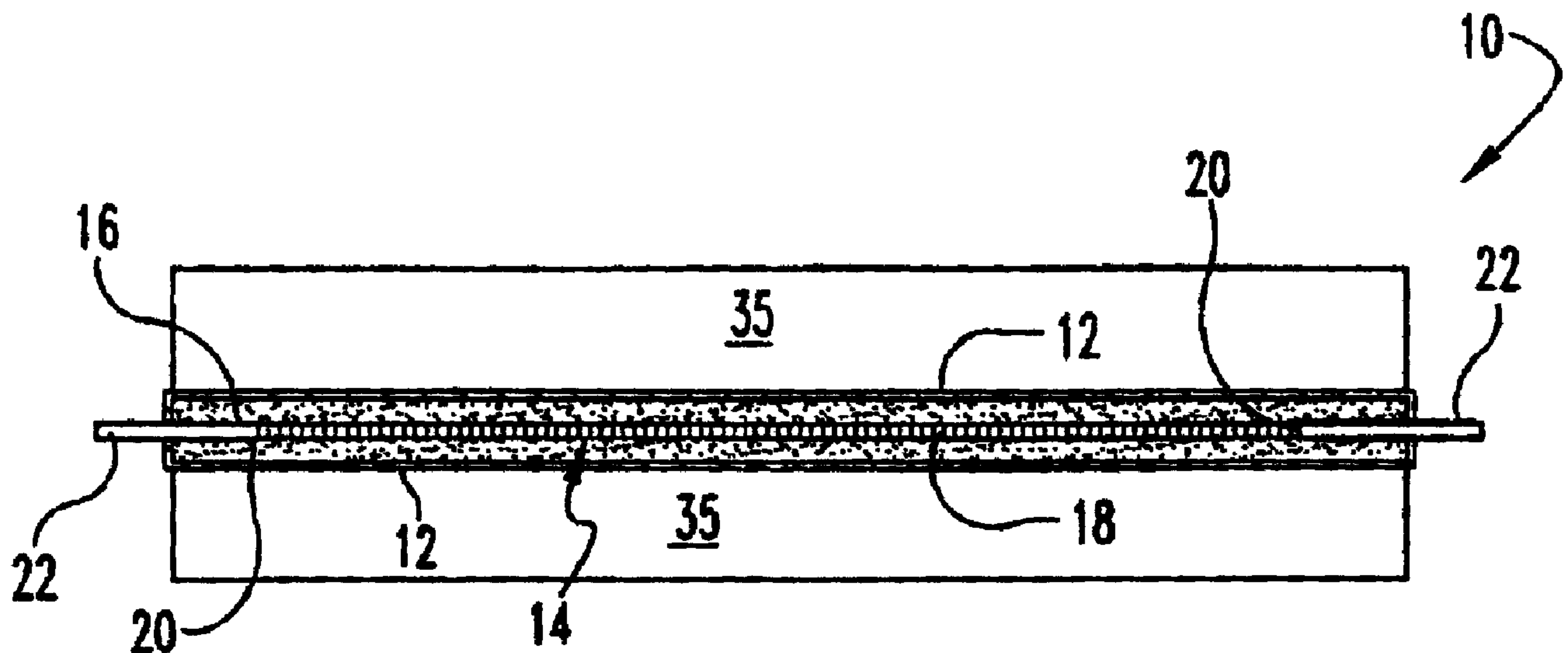




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(54) Title: CORRUGATED METAL RIBBON HEATING ELEMENT



(57) Abrégé/Abstract:

A sheathed electrical resistance heater (10) comprises a metal corrugated resistance heating element (14) located within a surrounding metal sheath (12) and separated from the sheath (12) by a compacted insulating material (16) (e.g., magnesium oxide). The corrugated resistance element (10) is a flat strip corrugated by passing the strip through the nip of a pair of gears.(24) The corrugated strip resistance element (14) is thicker than a foil and can provide sheathed electrical resistance heaters where it is too difficult to wind large diameter wires on a small arbor to form a coiled resistance element.



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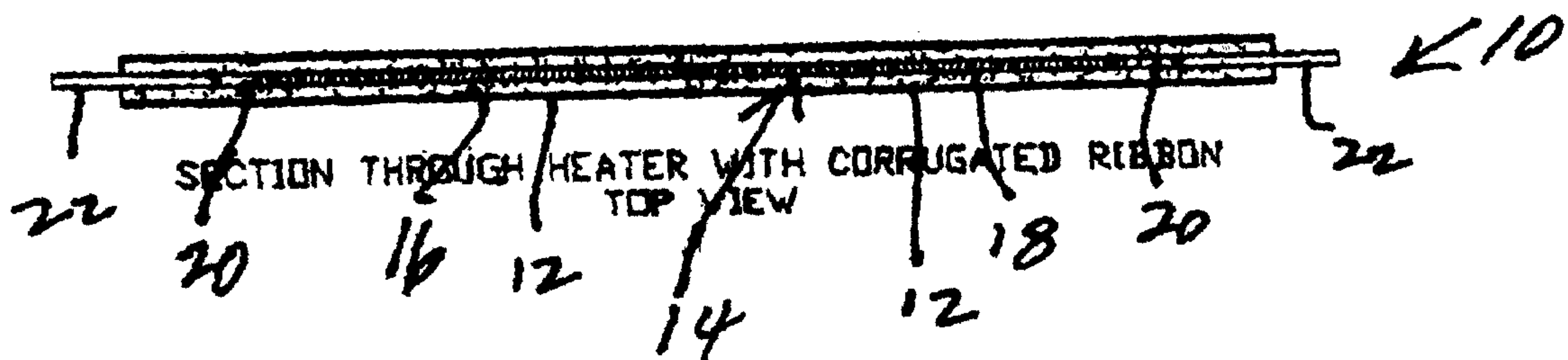
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(54) Title: CORRUGATED METAL RIBBON HEATING ELEMENT



(57) Abstract: A sheathed electrical resistance heater (10) comprises a metal corrugated resistance heating element (14) located within a surrounding metal sheath (12) and separated from the sheath (12) by a compacted insulating material (16) (e.g., magnesium oxide). The corrugated resistance element (10) is a flat strip corrugated by passing the strip through the nip of a pair of gears (24). The corrugated strip resistance element (14) is thicker than a foil and can provide sheathed electrical resistance heaters where it is too difficult to wind large diameter wires on a small arbor to form a coiled resistance element.

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CORRUGATED METAL RIBBON HEATING ELEMENT**Field of the Invention**

This invention relates to sheathed electrical resistance heaters having an outer metal sheath
5 surrounding an internal resistance heating element and a compacted insulating material between the metal sheath and the internal resistance heating element, where the heater has a low resistance value.

Background of the Invention

10 The conventional sheathed heating element uses a coiled wire as the resistance element that is able to elongate and contract as the electric element is turned on and turned off. The coiled wire is able to expand and contract in the manner of a coiled spring because of its
15 coils without unduly stressing the resistance element itself or its connection with an electrical terminal which is usually a welded connection. The coiled resistance element accommodates different thermal - expansion coefficients of the different metals used for
20 the sheath and for the heating resistance element. Typically, the sheath will be made of stainless steel, copper or aluminum while the resistance element will be an alloy having nickel, chrome or the like therein. Moreover, the external sheath and the internal
25 resistance wire operate at different temperatures with the internal resistance element operating at a higher temperature than the outer sheath which is being cooled by the medium in which it is immersed whether the medium is air, a liquid, or other material. The resistance
30 element operating at a higher temperature typically expands more than the outer protective sheath and hence the coil accommodates this difference in expansion between the sheath and the resistance element.

The conventional manner of making such coiled
35 resistance elements comprises winding the resistance

element wire on a mandrel and removing the wound wire coil from the mandrel, welding terminals to the ends of the wire coil and bringing the coiled wire and an.
5 external sheath tube together within a loading machine at which the insulating material is loaded between the internal coiled wire and outer sheath. Typically the insulating material is a granular or powdered material such as magnesium oxide. The filled tube is then
10 extruded with the diameter of the sheath tube being reduced substantially and the length of the tube and internal coiled wire being increased greatly. The extruding pressures compact the insulating material greatly. When the coil wire is of fine gauge, it
15 stretches easily during the extruding process, but as the wire diameter becomes large it becomes difficult to stretch the wire coils with conventional extruding pressures.

Also, as the diameter of the wire becomes larger,
20 it is also more stiff and cannot be easily wrapped about a small diameter mandrel. For example, using conventional coiling equipment, wire diameters of 0.0285 inch are difficult to wind and wire diameters of 0.032 inch or larger are too stiff to be wound on the
25 small diameter arbor selected for the size of coil desired. Given this limitation in size of the round wire diameters and using conventional resistance element wires, the largest wire that was able to be wound on the mandrel size needed for this application wire had a
30 resistance of about .12 ohm/inch in the extruded, finished heating device. Some applications require a resistance lower than .12 ohm/inch. For example, in a very long heater, e.g., 200 inches or more which is to be operated at 120 or 240 volts, the resistance of the
35 heating element in the final heater is desired to be about 0.05 ohm/inch which is substantially below the 0.12 ohm/inch of the largest coiled wires type of heating element for this mandrel diameter of heater assembly.

Heretofore, for these applications, requiring a lower ohm/inch heater than can be produced with coiled wire for the cross-sectional diameter of the heating element, a straight, uncoiled wire of larger diameter was used. This straight wire, sheathed heater is commonly referred to as mineral insulated or MI cable. A shorter length of wire is use in the MI cable. A significant shortcoming of this MI cable is that it does not accommodate thermal expansion of the heater very well and hence tends to stress the resistance element itself and also to stress the welded terminal joints, either of which can lead to a premature failure of the heater. Long life is an expected and necessary characteristic of sheathed, electrical resistance heaters and premature failures are unacceptable from a commercial marketing of the heater.

Summary of the Invention

In accordance with the present invention, there is provided a new and improved sheathed, electrical resistance heater having an internal corrugated ribbon heating element having a lower resistance value, e.g., .12 ohm/inch or less than a round wire resistance element. Also, the percentage of the mass of the resistance heating element to the total mass of the resistance heater is less when using the corrugated ribbon than when using a round wire. The corrugations act as a spring to accommodate thermal expansion of the ribbon-shaped, heating element as well as contraction without placing undue stress on the ribbon itself or on terminal connections connecting the wire to terminals.

In accordance with a preferred embodiment of the invention illustrated and described hereinafter, the sheath of the heater is an aluminum tube with spaced, integral thin fins for conducting or radiating heat to the surrounding medium. A metal, corrugated ribbon, of resistance elements thicker than a thin foil (i.e. 0.003 inch to 0.010 inch) is provided

in the sheathed heater and has a resistance of at least
as low as 0.12 ohm/inch or lower. The insulating material
ismade of magnesium oxide or the like and it is compacted
5 about the internal corrugated ribbon with a reduction in
the cross-sectional area of the heater; but without the
substantial increase length change of the conventional
coiled wire heaters. The illustrated and preferred
corrugated ribbon is formed by running a straight, flat
10 wire strip through a nip of a pair of meshed gears. The
present invention is not limited to this specific
sheathed heater which is being described to provide one
example or embodiment of the invention.

In accordance with the present invention, the
15 corrugated ribbon, sheathed resistance heater is made by
a process that comprises providing a corrugated ribbon
heating element, placing the corrugated ribbon in an outer
hollow sheath, filling the space between the corrugated
ribbon and the outer sheath with an insulating material
20 and pressing the filled sheath tube with sufficient
pressure to compact the insulating material and to reduce
or reshape the cross-sectional area of the filled
sheathed tube without increasing substantially the length
of sheath tube. In the preferred method, a sheath is
25 provided with integral, spaced fins which are projecting
outwardly and the pressing is done with a press formed
to accommodate the projecting fins.

Brief Description of the Drawings

FIG. 1 is a plan cross-sectional view of a
30 sheathed, electrical resistance heater having a
corrugated heating element and constructed in accordance
with the invention;

FIG. 2 is a side elevational view of the heater of
FIG. 1;

35 FIG. 3 is an enlarged view of the corrugation in
the electrical resistance heating element constructed in

accordance with the illustrated embodiment of the invention;

FIG. 4 illustrates a flat strip being corrugated by gears;

5 FIG. 5 is a perspective view of a finned, electrical resistance heater having a corrugated ribbon resistance element;

FIG. 5A is an enlarged end view thereof, omitting the end mounting brackets shown in Fig. 5; and

10 Fig. 6 is a cross-sectional view of the pressing die compacting the sheath around the filler and resistance element, not a corrugated ribbon.

Detailed Description of the Preferred Embodiment

As shown in the drawings, the invention is embodied in a sheathed, electrical resistance heater 10 having an
5 outer sheath tube or sheath 12 made of metal such as steel or aluminum. Within the sheath 12 is an internal electrical resistance heating element 14 made of a conventional metal such as an alloy having nickel, chrome or the like therein. Between the sheath 12 and the
10 electrical resistance heating element 14 is an insulating material 16 such as a compacted magnesium oxide powder.

In some applications of the sheathed, electrical resistance heaters 10, the heater length desired may be
15 quite long, e.g., 200 inches in length for the illustrated heater 10 shown in FIG. 5 with a very low resistance value of 0.05 ohm/inch when being operated at 120 or 240 volts. The cross-sectional area of the heater element may be quite small.

20 In accordance with the present invention, the sheathed electrical resistance heater 10 is provided with corrugations 18 in the electrical resistance element 14 to accommodate thermal expansion and contraction to avoid over stressing the element itself or
25 its connections 20 to electrical terminals 22, which may be welded kind of connections between the terminals and the electrical resistance heater elements. Herein, the electrical resistance is an elongated ribbon having corrugations 18 extending substantially the entire
30 length of the element and is preferably formed by passing a flat, metal strip 23 (FIG. 4) of metal into the nip of a pair of gears 24 that form the corrugations in the flat metal strip or ribbon that is thicker than a

foil (from 1/64 inch to 3/8 inch). These resistance heaters usually operate at 120 to 240 volts. It will be appreciated that the corrugated ribbon has a relatively
5 broader or larger surface than a circular cross-sectional wire and less mass and hence it heats faster to its operating temperature and cools down faster from its operating temperature than a comparable round wire.

Turning now in greater detail to the illustrated
10 embodiment of the invention shown in FIG. 5, the outer sheath 12 is made of aluminum, in this instance, although it could be made of various other metals such as steel, copper or other alloys. Herein, the sheath tube is hexagonal in shape, although the sheath could be
15 circular or have other shapes. In the illustrated heater of FIG. 5, the sheath was originally a round 0.375 inch tube that was pressed into a hexagonal shape that is about 0.345 inch across the flats 30, 31. The corrugated ribbon has a resistance of about 0.05 ohm/inch in the
20 final heater 10. The illustrated heater has integral fins 35 that project outwardly from the sheath. The fins are spaced evenly. The illustrated heater 1C is about 200 inches long.

The illustrated heating element 14 is made from a
25 flat ribbon of metal that is passed through the nip of gears 24 to form corrugations 18 (FIG. 3).

The preferred embodiment of the invention shown in FIG. 5 is made by a method of corrugating the ribbon and placing it inside the tubular sheath and loading the
30 magnesium oxide insulating material in a loading machine between the sheath 12 and the corrugated resistance element. A pair of dies 45 and 46 (FIG. 6) compress the sheath with sufficient pressure to reshape the tube from a circular shape into the hexagonal shape shown in FIG

5. The fins 35 are integral and are accommodated in the press dies 45 and 46. Herein the sheath is compressed and reduced in cross-sectional area by about 20 percent without a substantial elongation of the tube. An example of a press for this embodiment is shown in Fig. 6.

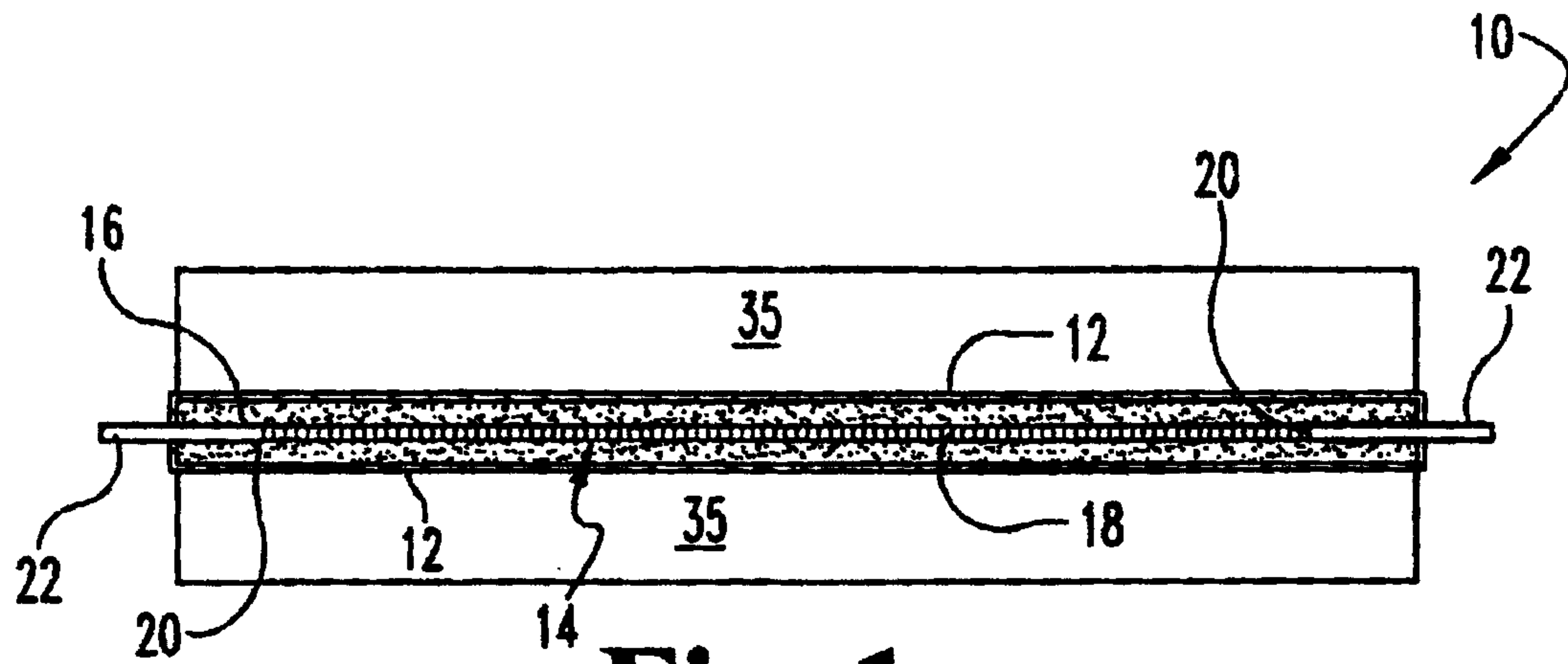
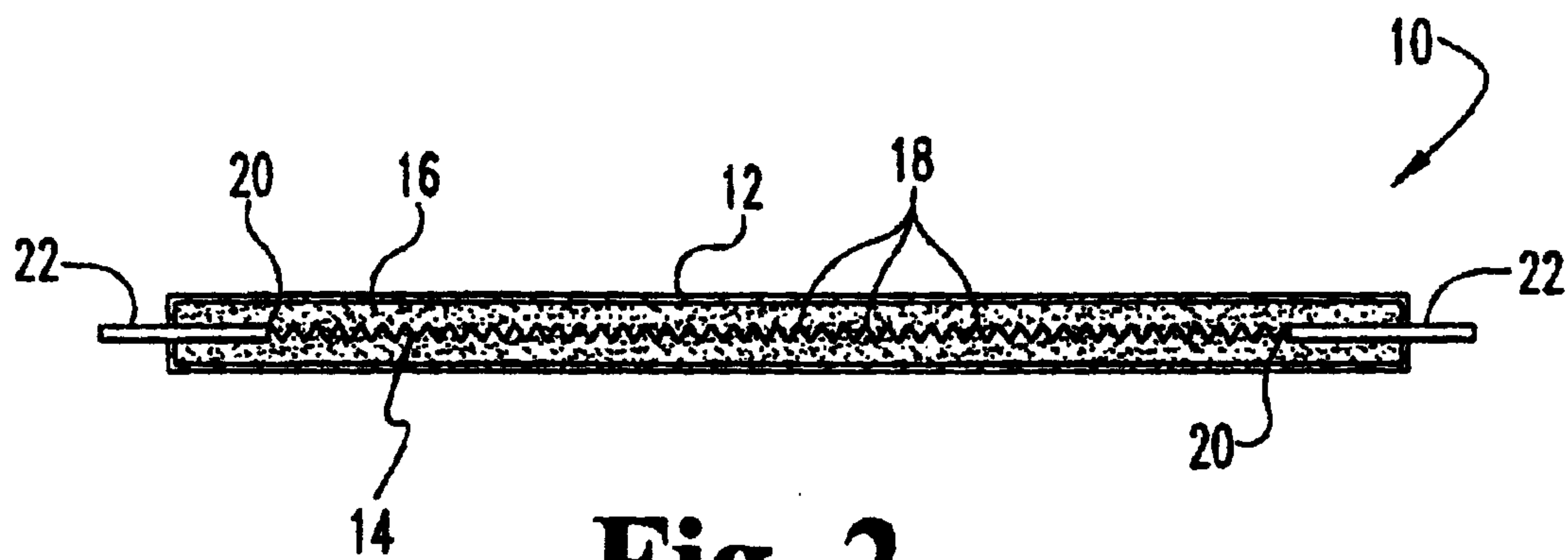
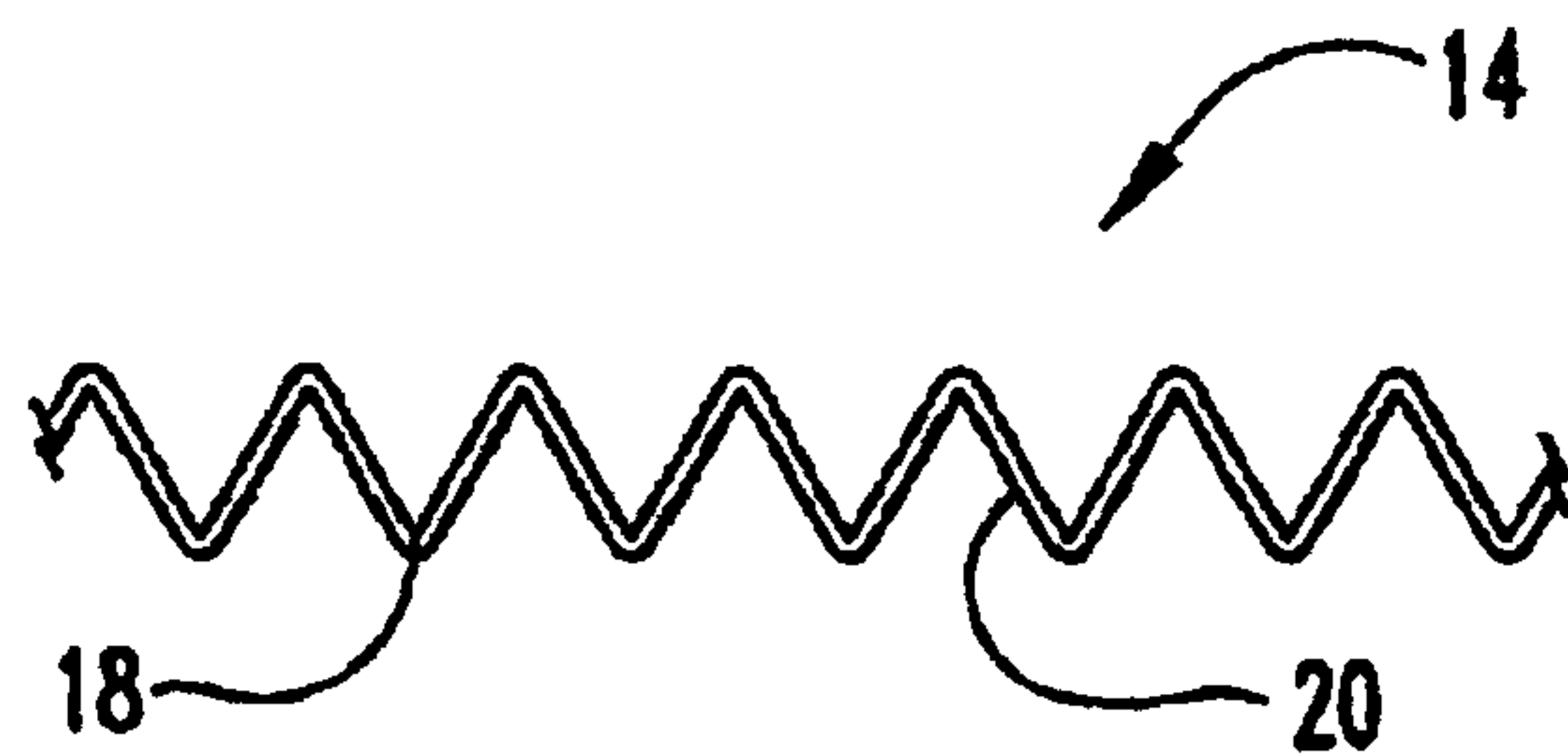
The desired low resistance of about 0.05 ohm per inch mentioned above for a very long heater, would also be applicable in a case where it is desired to connect several shorter heaters in series, instead of a single long heater.

What is claimed is:

1. A sheathed electrical resistance heater having a
5 low resistance value comprising:
an internal resistance heating element made of
metal ribbon having a predetermined rate of expansion
and for operating over a predetermined operating
range of temperatures, having corrugations therein to
10 accommodate thermal expansion of the heating element
and to reduce stress on the heating element and
joints, and having a resistance value of less than
0.12 ohms/inch;
a surrounding insulating material;
15 a surrounding tubular outer metal sheath having
a different coefficient of expansion than the
coefficient of expansion of the internal heating
element;
the outer metal sheath having been pressed to
20 compact the insulating material without substantial
longitudinal extension of the sheath, the sheath
having one or more integral longitudinal fins
extending radially outwardly.
- 25 2. A sheathed electrical resistance heater in
accordance with claim 1 wherein the corrugations
extend substantially the entire length of the heating
element.
- 30 3. A sheathed electrical resistance heater in
accordance with claim 1 wherein the internal heating
element is an elongated flat strip that has
corrugations therein.
- 35 4. A sheathed electrical resistance heater in
accordance with claim 1 wherein the heating element
has a resistance of 0.05 ohm per inch or less.

5. A sheathed electrical resistance heater in accordance with claim 1 wherein the sheath is made substantially of aluminum and the internal corrugated conductor is made of a metal alloy that does not have aluminum as a substantial constituent therein.

6. A method of making a sheathed electrical resistance heater having an outer elongated sheath and an internal, metal resistance heating element separated from the sheath by an insulating material, the method comprising: providing an elongated metal ribbon, electrical resistance heating element that is corrugated over substantially its entire length; disposing the corrugated heating element and the outer sheath; and pressing the sheath with sufficient pressure to reduce substantially the cross-sectional area of the sheath thereby compacting the insulating material within the sheath without substantially elongating the length of the elongated sheath by providing integral fins projecting outwardly therefrom, wherein the heating element has a resistance value less than 0.12 ohms/inch.

**Fig. 1****Fig. 2****Fig. 3**

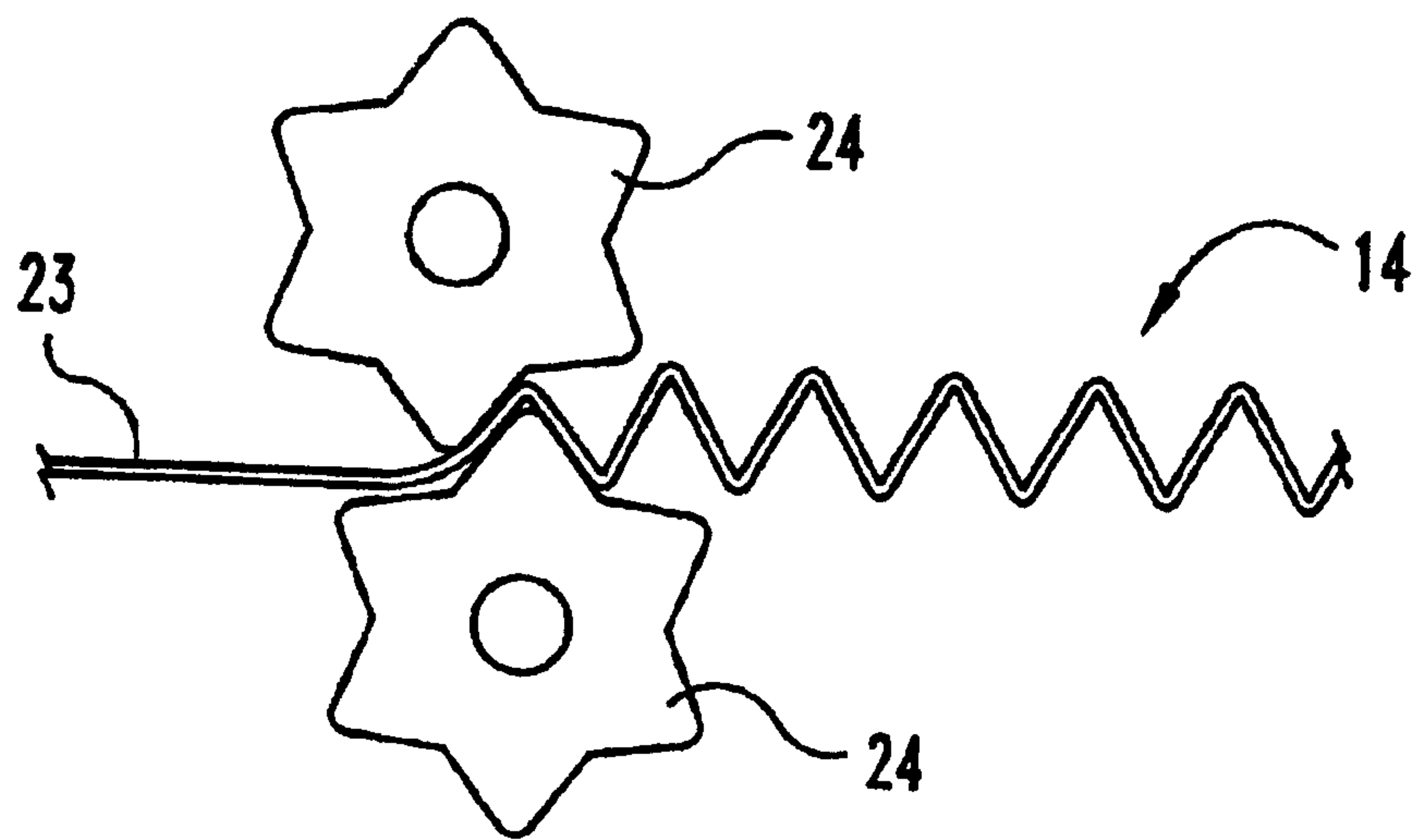


Fig. 4

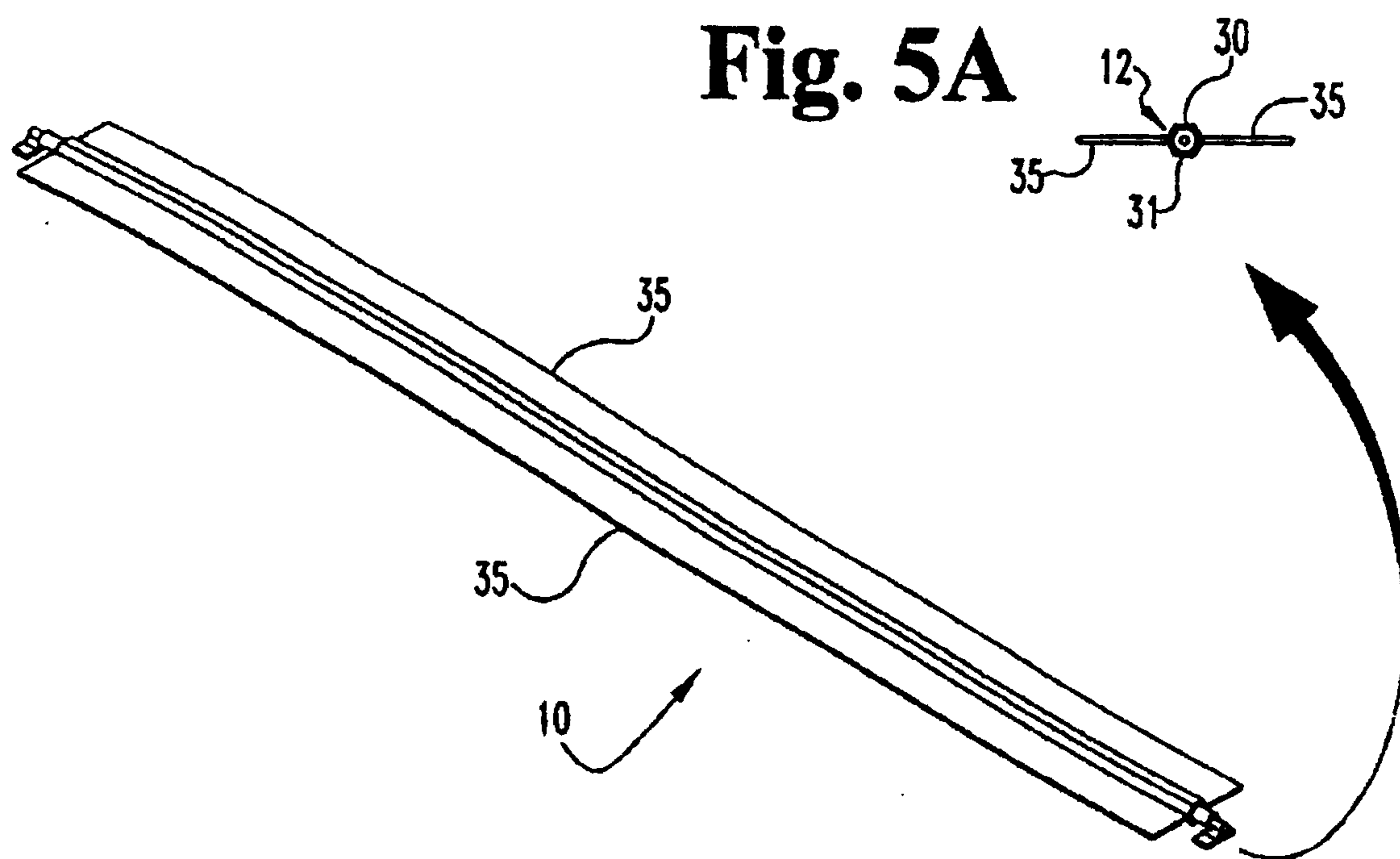


Fig. 5

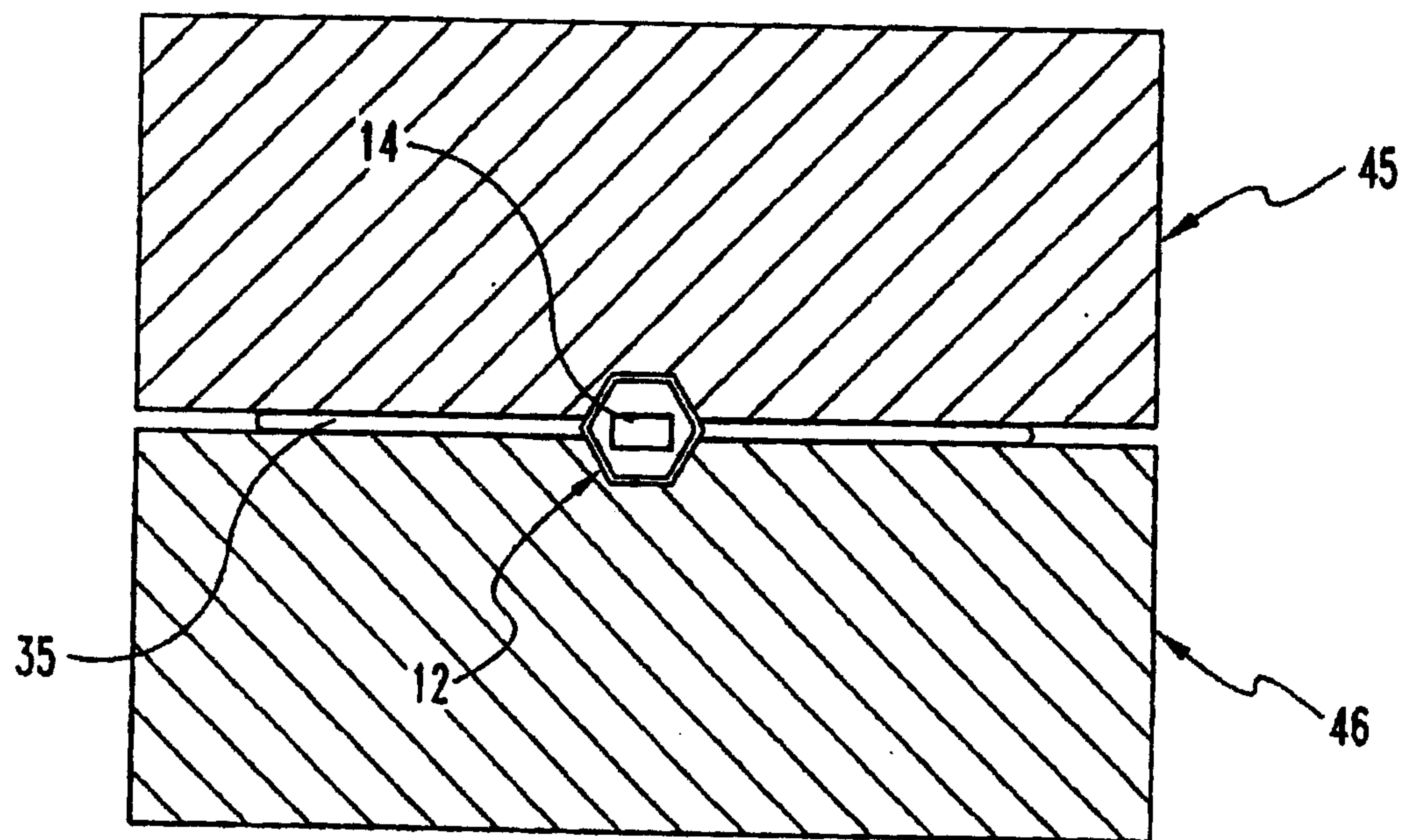


Fig. 6

