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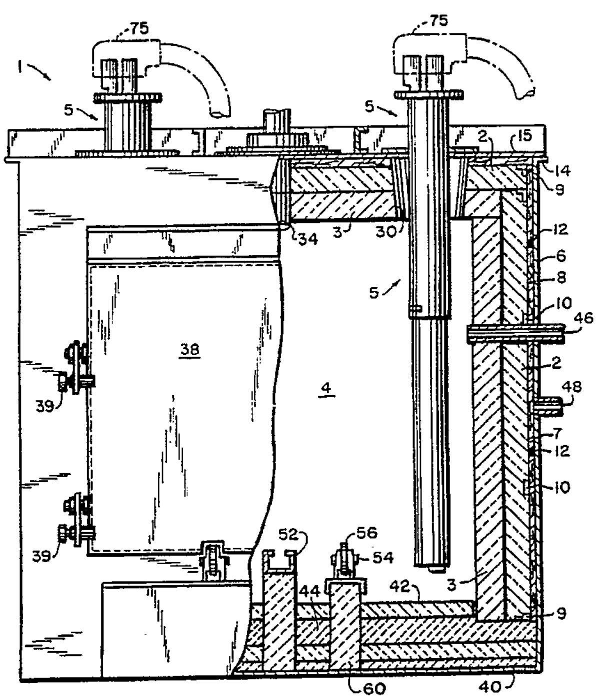
## (54) Electric heating device.

(57) A low voltage electric heating device for application in a furnace which comprises: a cylindrical outer housing or sleeve replaceably disposed within a carburizing integral quench furnace and electrically connected to a first electric terminal; and a current path element disposed within the outer housing, the current path element being electrically connected to a second electric terminal and electrically insulated from a substantial part of the outer housing.

FIG.I

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The present invention provides a novel electrified single-ended tube heating device which can be replaceably disposed within a carburizing integral quench furnace. Furthermore, the present invention relates to electric heating furnaces, and more particularly to electrical resistance heating type heat treating or melting furnaces in which the heating device is incorporated.

## BACKGROUND OF THE INVENTION

Conventional refractory furnaces for the processing of steel, etc. have included both electric and gas heating elements. Early furnace designs included a plurality of relatively small heating elements in spaced relation in a furnace heated by the flow of electric current therethrough. Such elements require a relatively high voltage, which results in electric insulation problems and current leakage through the refractory lining of the furnace. High voltage is also responsible for damage to workpieces which come into contact with the heating elements or injury to personnel who accidentally touch the elements.

Another difficulty encountered is control of the desired heat distribution in the furnace and particularly in a heat treating furnace in which hot gases in the treating chamber are circulated by gravity or by a fan or the like.

In an effort to overcome the above disadvantages, relatively large flat heating elements were extended over a large area of the furnace wall to produce a uniform heating effect. The heating elements were formed by corrugated sheets or strips mounted adjacent to the furnace walls. These corrugated heating elements are set forth in U.S. Patent No. 2,896,004 (Duffy et al.), issued July 21, 1959.

The corrugated heating elements, as noted above, resulted in a maintenance problem, wherein replacement required entering the furnace and removing the elements from the furnace walls. In order to overcome this maintenance problem, U-tube heating elements were developed. A typical U-tube heating element is disclosed in U.S. Patent No. 4,332,552 (Seelandt), which issued on June 1, 1982. The U-tube heating elements solved the maintenance problems associated with the corrugated heating elements by permitting removal of the elements through the roof of the furnace.

The U-tube heating element operates on extremely low voltage, which permitted disposition of the element directly in a carbonaceous atmosphere. Since there is no need to isolate the element from the atmosphere, the element is free to radiate directly within the heat chamber, thereby lowering element operating temperatures. The elements are plug-mounted in the roof for ease of service. Four elements are utilized, two per sidewall, for maximum radiating area and extend above, below and beyond the workpiece.

Unfortunately, U-tube heating elements require very large openings in the furnace roof and are not interchangeable with gas fired, "single-ended" radiant tubes; that is to say, straight tubes requiring only that a single small roof opening be provided, contrasted with U-shaped elements. Therefore, the present inventor undertook the development of a unique electrified single-ended tube heating device which is easily replaceable and can be interchanged with the aforesaid gas fired, single-ended radiant tubes.

The present invention overcomes the high voltage and maintenance problems of conventional furnace heating elements. That is, the electrified single-ended tube heating device of the present invention is a low voltage heating device which permits operation directly in a carbonaceous atmosphere. Its unique design also facilitates field replacement or conversion to gas fired single-ended radiant tubes while minimizing the size of the roof openings.

The present invention also provides many additional advantages which shall become apparent as described below.

## SUMMARY OF THE INVENTION

A low voltage electric heating device for application in a furnace which comprises: a cylindrical outer housing or sleeve replaceably disposed within a carburizing integral quench furnace and, in one preferred embodiment, electrically connected to a first electric terminal; and at least one low resistance current path element disposed within the outer housing, the current path element being electrically connected to a second electric terminal and electrically insulated from the outer housing.

In another embodiment, the electric heating device may include a first current path element and a second current path element disposed within the outer housing or sleeve. The first current path element preferably traverses, or is coextensive with, the entire length of the outer housing and the second current path element traverses only a portion of the outer housing, the second element being electrically connected to the sleeve at the second element's lowermost point.

In either embodiment, the outer housing or sleeve radiates heat directly, and selectively, into the carbonaceous atmosphere during the processing of the workpiece. By "selectively" is meant that the radiated heat is concentrated where it is most needed; namely in an area removed from the entry opening in the furnace roof, rather than being concentrated close to the opening.

Other and further objects, advantages and features of the present invention will be understood by reference to the following specification in conjunction with the annexed drawings, wherein like parts have been given like numbers.

## BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic cross-sectional view of a carburizing integral quench furnace fitted with an electric heating device in accordance with the present invention;

Fig. 2 is a top front perspective view of an electric heating device in accordance with the present invention provided with two current path elements;

Fig. 3 is an exploded top front perspective view of the electric heating device of Fig. 2;

Fig. 4 is a cross-sectional view of an electric heating device in accordance with the present invention, having two current path elements;

Fig. 5 is a top plan view along line 5-5 of Fig. 4;

Fig. 6 is a cross-sectional view along line 6-6 of Fig. 4;

Fig. 7 is a cross-sectional view along line 7-7 of Fig. 4; and

Fig. 8 is a cross-sectional view along line 8-8 of Fig. 4.

Fig. 9 is a cross-sectional view of an alternate embodiment of the electric heating device of the invention.

## DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention can best be described while referring to the attached drawing, wherein Fig. 1 depicts a carburizing integral quench furnace assembly 1 which includes an exterior panel 2 and an interior panel 3. Panels 2 and 3 are typically formed of a fibrous material. The panels serve to enclose the furnace chamber 4 into which is inserted at least one single-ended electric heating device 5. The panels (2,3) are fitted within a steel or other type of furnace shell 6 so as to form a space 7 therebetween on the order of one inch, although the exact dimensioning will depend on the type of furnace and its corresponding dimensions. Space 7 may either be left unfilled or may have inserted therein a blanket of fibrous material (not shown) which is receptive to the passage of gas therethrough.

The side and rear wall assemblies 8 include a rectangularly shaped outer frame 9, a center bar (not shown) and a plurality of cross bars 10 which interconnect the center bar with frame 9. Wall assembly 8 is constructed by securing blocks of fibrous material to the center bar and cross bars 10 by use of clips, retainers, bolts or other conventional securing members so as to support at least an exterior Panel 2 and, under some circumstances, an interior panel 3, with a blanket of insulating material (not shown) being inserted between adjacent panels. Moreover, spacers 12 in the form of bolts and threaded rods can be used to either secure panel 2 to furnace shell 6 or to assure that proper spacing to form space 7 is provided. Furnace shell 6 also includes an outwardly extending flange 14 for cooperation with roof assembly 15 which also includes a frame 9 similar to the wall assemblies for securing exterior panel 2 and interior panel 3 thereto. Roof assembly 15 includes a plurality of tapered openings 30 within which heating device 5 is mounted.

Reference number 34 denotes an opening in roof assembly 15 for mounting of a gas circulation fan (not shown). Door assembly 38 includes a plurality of pins 39 attached thereto for cooperating with the furnace assembly. Floor assembly 40 includes a floor panel 42 of fibrous material mounted on a plurality of layers of brick insulation 44. Floor assembly 40 also includes a furnace snake chain guide assembly 52 used to transfer steel or other workpieces into furnace chamber 4. Roller rails 54 are also provided so as to assist in transferring the workpiece into furnace chamber 4 with cast rollers 56 being mounted on roller rails 54. Floor assembly 40 is provided with a rail support 60 upon which roller rails 54 are mounted.

Reference number 46 designates a first source of purging gas (i.e., nitrogen is commonly used but other types of inert gases are acceptable) which may be supplied to furnace chamber 4. Reference number 48 denotes a second source of purging gas which can be supplied to space 7 formed between panel 2 and furnace shell 6.

The furnace assembly 1 thus serves to provide a furnace chamber 4 which, during purging operation, is heated by heating device 5 to a temperature between 500 and 2000°F such that purging gas is introduced from the first source 46 which may include any inert gas. The purging gas forms an enriched endothermic atmosphere within the furnace chamber and is circulated about the furnace by operation of a gas circulating fan (not shown). The protective atmosphere within furnace chamber 4 is also subjected to a pressure which is approximately 0.2 ounces above atmospheric pressure. A corresponding auxiliary gas purge can also be accomplished by the introduction of nitrogen or a similar type gas under pressure approximately 0.2 ounces or more above atmospheric pressure within space 7 via secondary gas source 48. Due to the fibrous composition of the panels (2,3), the nitrogen gas under pressure serves to assist purging of the furnace itself by keeping the exterior surface of exterior panel 2 at a higher temperature than is possible in a conventional furnace and purges water vapor and air by forcing the same towards the furnace chamber 4 by application of heat.

The unique heating device of the present invention is depicted in a first embodiment as having a pair of current path elements, as seen in Figs. 2-8. Therein, a low voltage electric heating device 5 comprises a cylindrical outer housing or sleeve 70 replaceably disposed within furnace assembly 1 and electrically connected to a three phase system by way of a first electric connector 71. A first low resistance current path element 72 and a second current path element 74 are disposed within outer housing or sleeve 70. The current path elements (72,74) are independently electrically connected to the system by way of a dual electric connector 75, being electrically insulated from each other and outer housing 70.

First current path element 72 preferably traverses, or is coextensive with, the entire length of outer housing 70, Fig. 4, whereas second current path element 74 traverses only a portion thereof. Cylindrical outer housing 70 is provided at its lower end with a disk-like portion 85 having an opening 86 such that first current path element 72 may, while making electrical contact with disk 85, conveniently extend beyond the confines of outer housing 70. Cylindrical outer housing 70 may also include a slot 76 about its sidewall such that a lower end of second current path element 74 is exposed to the carbonaceous atmosphere which surrounds outer housing 70.

As depicted in Fig. 3, first current path element 72 is preferably rectangular in cross-section throughout, whereas second current path element 74 is substantially semicircular in cross-section for most of its length. As will be appreciated, the reason for this configuration is so that element 74 will fit within the circumference of tube or sleeve 70.

Outer sleeve 70 may also include a guide bracket 78 capable of preventing shorting and also capable of insulating first current path element 72 from second current path element 74. Guide bracket 78 is preferably formed from a ceramic material.

Fig. 4 is a cross-sectional view of heating device 5. The low resistance current path elements (72,74) are insulated from each other and outer housing 70 by insulation 80. Insulation 80 is typically a loose fiber. When multiple current path bars or elements are used, they typically have a gap therebetween of approximately 1/4".

Cylindrical outer sleeve or tube 70 preferably comprises a first tubular member 82 having a flanged end, and a second tubular member 84 connected to first tubular member 82 by any conventional means. These tubular members are provided with a slot 76 which permits a lower shoulder portion 76A of second current path element 74 to be in electrical contact with tube 70 so that a complete series circuit path is established from 74, then by way of the lower part of tube 70, and return through metallic disk 85 and element 72. Second tubular member 84 includes an opening 86 at one end thereof such that guide disk 85 may be fitted therein and make electrical contact with element 72.

Heating device 5 functions by having the electric current from the AC source 73 passed through the described circuit, including tube 70, so that the heat required by the furnace is principally radiated from the lower part of tube 70, which has a relatively large resistance R, compared with the smaller resistances r and r' respectively of elements 72 and 74.

Fig. 5 is a top plan view along line 5-5 of Fig. 4, in which first current path element 72 is disposed in the center of outer housing 70 and second current path element 74 is disposed nearer to one side of tube 70.

Fig. 6 is a cross-sectional view along line 6-6 of Fig. 4 and depicts the semicircular and rectangular shapes of element 74 and 72, respectively.

Fig. 7 is a cross-sectional view along line 7-7 of Fig. 4 and depicts the positioning of element 74 within slot 76.

Fig. 8 is a cross-sectional view along line 8-8 of Fig. 4, wherein element 72 is contained within tubular member 84.

Referring now to Fig. 9, there will be seen an alternate preferred embodiment of the heating device in accordance with the present invention. Similar numerals in the form of prime numerals have been applied to this figure.

Instead of two low resistance current path elements as was the case with the previous preferred embodiment, only one very low resistance element 72' is utilized, such element being located on the axis of the device 5'. In this embodiment, the outer housing or sleeve 70' comprises two tubular members 82' and 84' suitably connected at adjacent ends, as was the case before. However, herein a much lower resistance R1 is chosen for the higher tubular member 82'; and a much higher resistance R2 for the lower tubular member 84'. Consequently, when a source of power is connected to the upper end of element 72' and to the upper end of sleeve 70', current flows through the series circuit comprising such element 72' and sleeve 70', the lower end of 70' providing a metallic connection 85' to the element 72'. Accordingly, the lower tubular member 84' with its much higher resistance will produce the significantly radiated heat from the heating device. A cylindrical ceramic insulator 90' is located at the upper part of device 5', disposed between element 72' and tubular member 82'.

While I have shown and described several embodiments in accordance with my invention, it is to be clearly understood that the same are susceptible to numerous changes apparent to one skilled in the art. Therefore, I do not wish to be limited to the details shown and described but intend to show all changes and modifications which come within the scope of the appended claims.

## Claims

**1.** A low voltage electric heating device for application in a furnace which comprises:

an outer housing for replaceable disposition within said furnace;

at least one current path element positioned within said outer housing, said current path element being electrically connectable to a source of power and electrically insulated from a substantial part of said outer housing;

means for concentrating the heat radiated from said device at the lower part of said device, said means including a current path having in series at least said one current path element and at least a part of said outer housing.

**2.** The heating device according to claim 1, in which said current path element extends the entire length of said outer housing.

**3.** The heating device according to claim 1, in which said outer housing is open at one end such that said current path element extends beyond said outer housing to enable connection of said current path element to a source of power.

**4.** The heating device according to claim 1, in which said current path element has a rectangular cross-section.

**5.** The heating device according to claim 1, in which said outer housing includes a guide bracket capable of guiding said current path element and insulating said current path element from said outer housing.

**6.** The heating device according to claim 5, in which said guide bracket is formed from a ceramic material.

**7.** The heating device according to claim 1, further including a second current path element, said second element being in electrical contact with said outer housing to define a series circuit with a part of said outer housing.

**8.** The heating device according to claim 1, in which said current path element is insulated from said outer housing by insulation in the form of a loose fiber.

**9.** The heating device according to claim 1, in which said outer housing comprises a first tubular member having a flanged end and a second tubular member connected to said first tubular member, said second tubular member having a higher resistance than said first tubular member.

**10.** A low voltage electric heating device for application in a furnace which comprises:

a cylindrical outer housing for replaceable disposition within said furnace; and

a first current path element and a second current path element disposed within said outer housing, said current path elements being electrically connectable to respective first and second terminals of a source of power;

said elements being electrically insulated from each other and, in part, from said outer housing.

**11.** The heating device according to claim 10, in which said first current path element extends axially for the entire length of said outer housing, and said second current path element extends axially for only a portion of the length of said outer housing, making electrical contact with said outer housing to define a series circuit for generating heat.

**12.** The heating device according to claim 10, in which said cylindrical outer housing is open at one end such that said first current path element extends beyond said outer housing to enable connection with said source of power.

**13.** In a furnace for the heat treatment of metals or the like, a low voltage electric heating device that permits operation directly in a carbonaceous atmosphere, said electric heating device comprising:

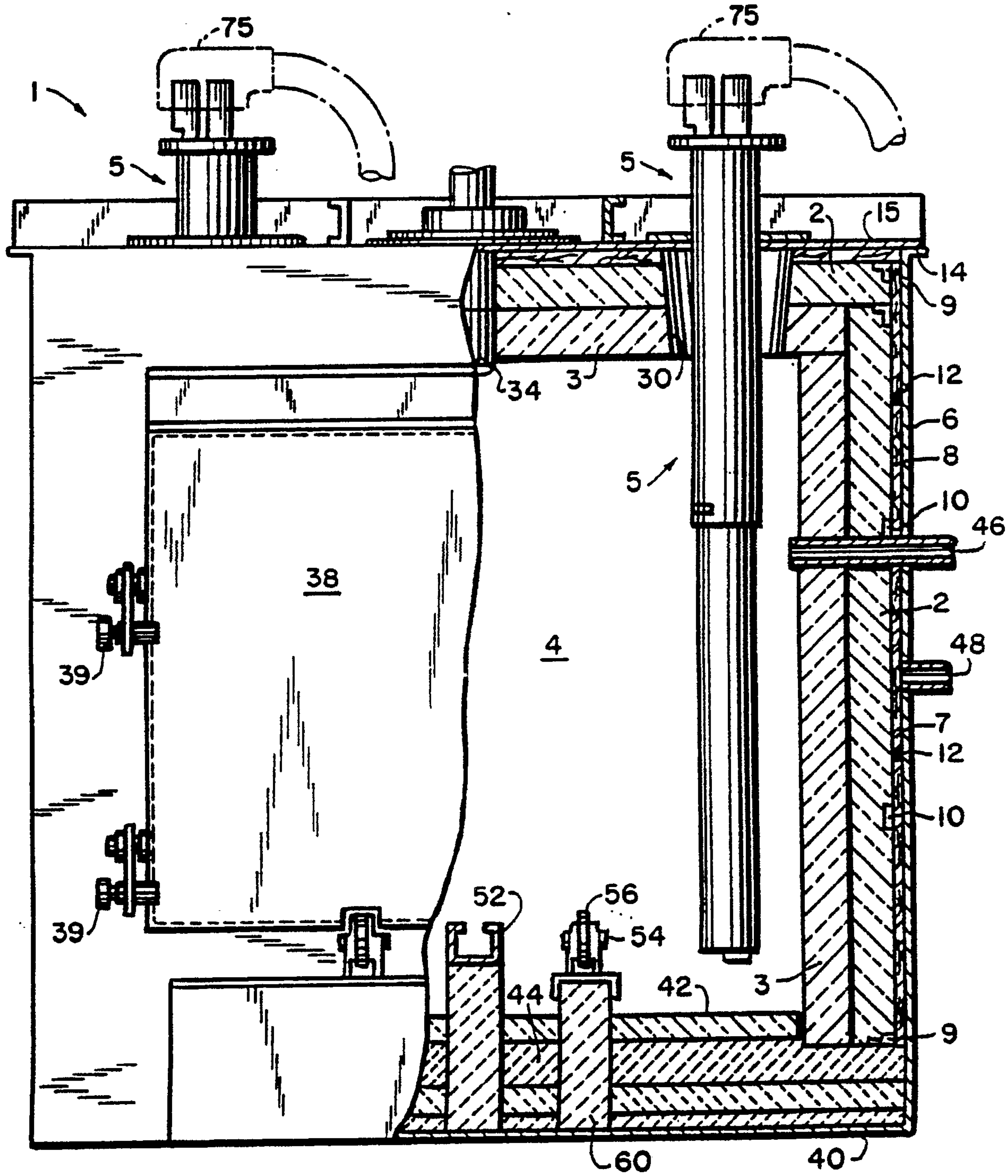
a source of power;

a cylindrical outer housing replaceably disposed within said furnace; and

a current path element disposed within said outer housing, said current path element being electrically connected to a first terminal of said source of power and electrically insulated from a substantial part of said outer housing.

**14.** In a furnace as defined in claim 10, further comprising an electrical connection from said outer housing to a second terminal of said source of power.

FIG.1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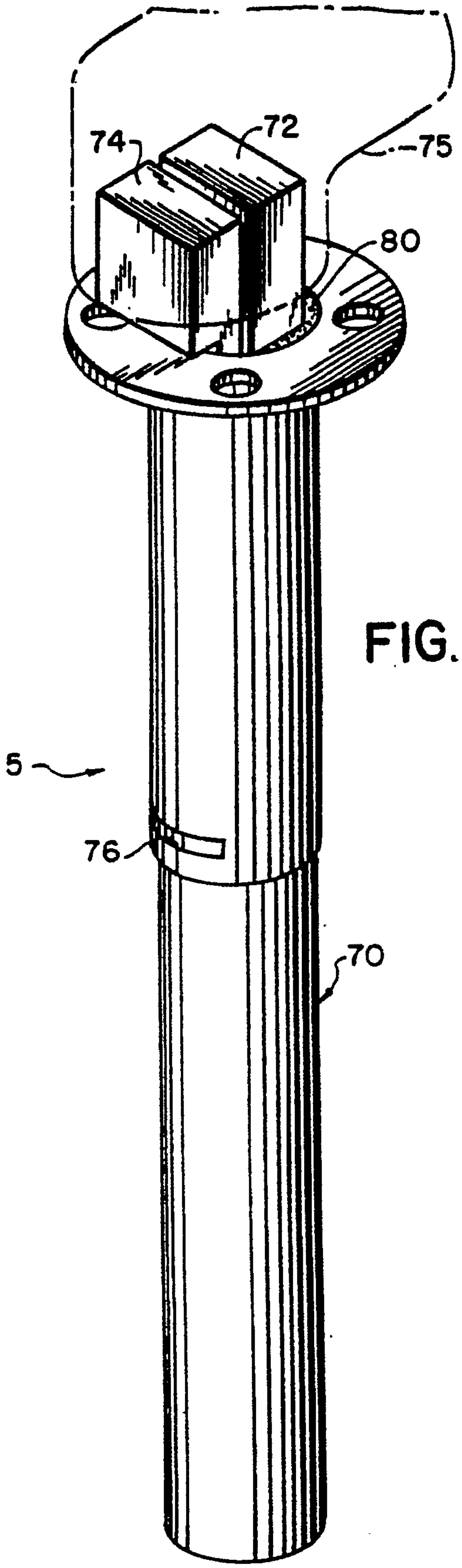


FIG.2

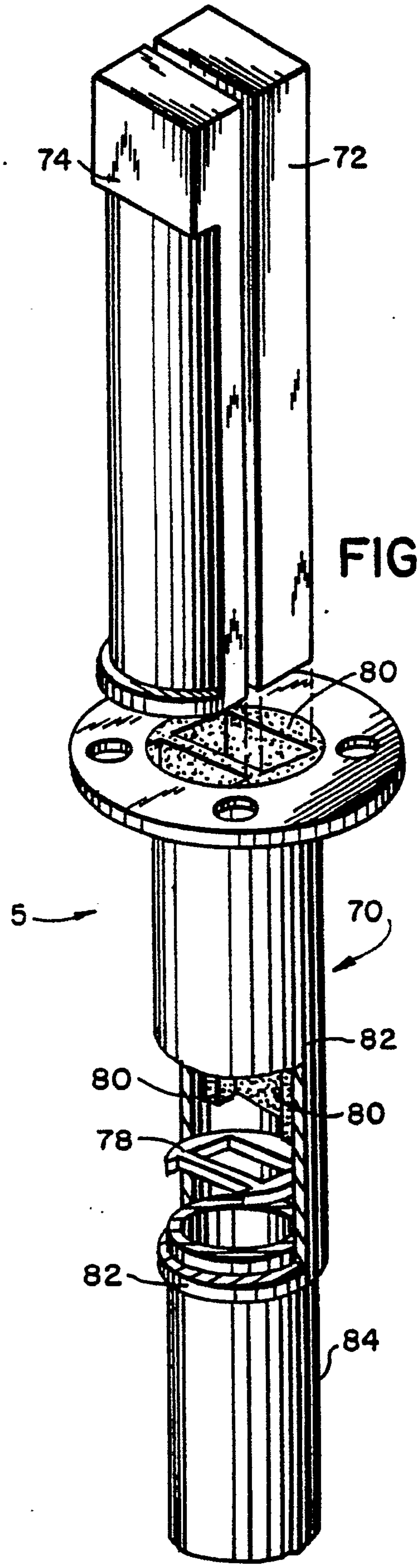


FIG.3

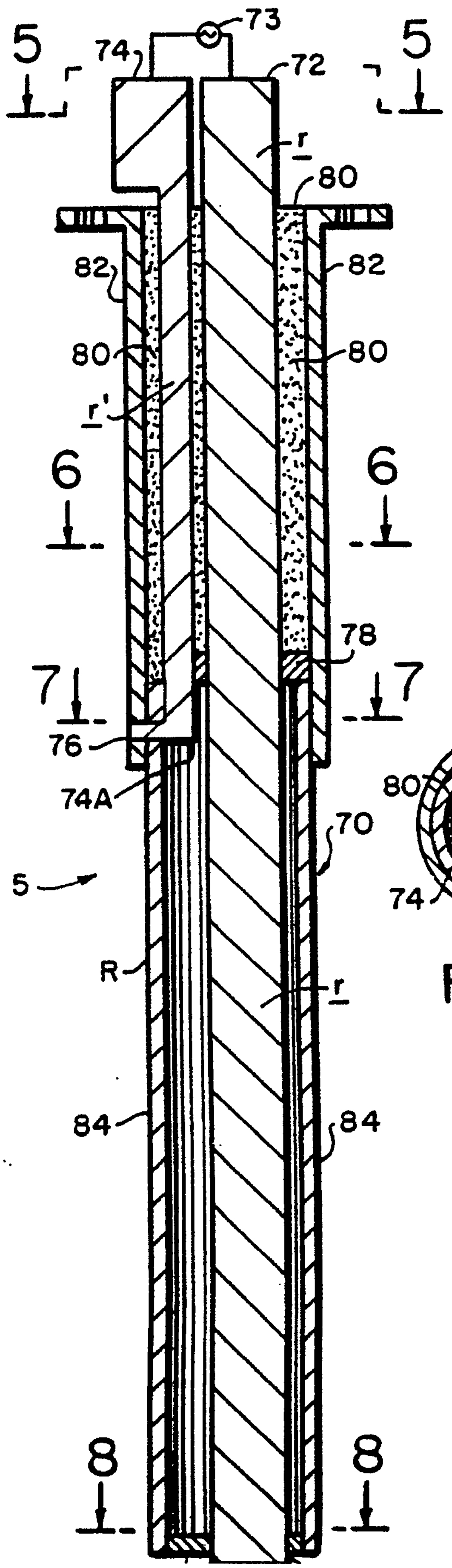


FIG.4

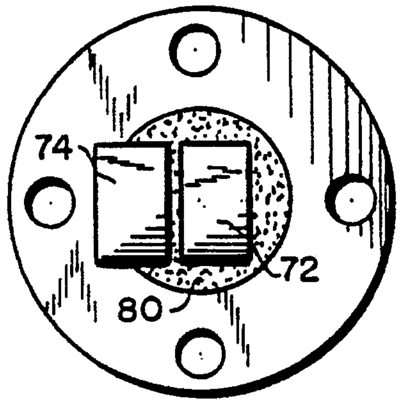


FIG.5

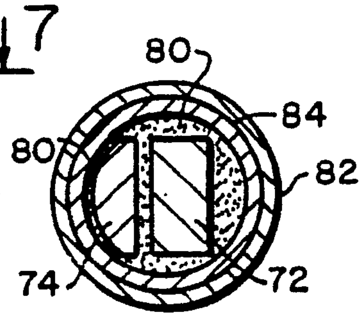


FIG.6

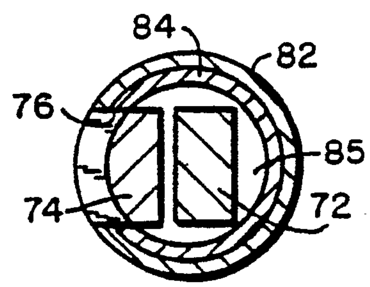


FIG.7

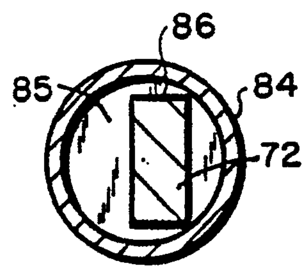


FIG.8

FIG.9