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(54) Water heating apparatus.

(57) Water heating apparatus of the invention comprises an inlet section (10, 140), an outlet section (11, 141) and a body (14, 139) between the two sections, the body (14, 139) containing a heater unit (26, 45, 124, 134, 137, 142, 149, 151, 155, 156, 160, 161, 162) including printed circuit heater means. In a preferred embodiment the heater unit (26) is in the form of a printed circuit heater (27) sandwiched between a pair of metal plates and rolled into a spiral. This gives a large contact area for water flowing around the spiral as well as an increased contact time, thus giving improved heating efficiency. In addition the printed circuit heater can be kept relatively short and compact, so that the water heating apparatus itself does not become bulky or expensive.

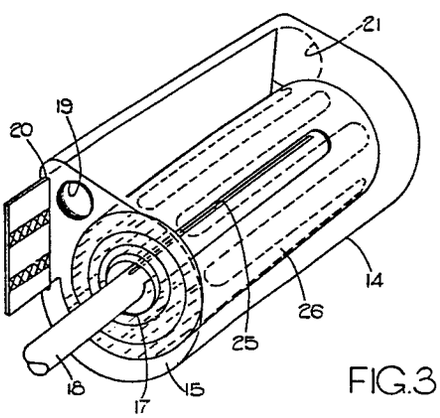

FIG.3.

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WATER HEATING APPARATUS

This invention relates to apparatus for heating water for domestic or commercial purposes and being provided with a supply of water, for example, cold water under pressure from a water main.

Hot water supplies are usually provided from a tank or other storage container, in which there is heating means such as an electrical immersion heater or a coil through which hot water heated by a boiler is circulated. Heat exchange by such methods is relatively slow and inefficient, due to gassification, i.e. water bubbles adhering to the heater element, and also the storage of the hot water is wasteful.

There have therefore been proposed various electrical heating devices which have efficiency sufficient to heat water as it flows through the apparatus. This arrangment eliminates the need for storage of hot water. The electrical heating is by means of electrical resistance heaters which are usually coiled wires disposed in the water passage. This type of apparatus is however only capable of producing a small flow of hot water, for example being sufficient to supply only one tap at a time.

It is the object of the invention to provide water heating apparatus having no necessity for storage of the water which has been heated and which has a high efficiency for the conversion of electrical energy into heat.

According to the invention there is provided water heating apparatus comprising an inlet duct, an outlet duct, and a water heating unit between the inlet and outlet ducts, the heating unit including a printed circuit heater means.

The invention will now be described by way of example with reference to the accompanying drawings in which;

Figure 1 is a schematic perspective view of a water heating apparatus constructed in accordance with one embodiment of the invention,

Figure 2 is a perspective view of a body forming part of the water heating apparatus,

Figure 3 is a further, schematic, perspective view of the body of the water heating apparatus, showing the inside thereof, with an inlet pipe and heater unit therein,

Figure 4 is a perspective view of the inlet pipe and heater unit of Figure 3, removed from the body,

Figure 5 is an end view of the spiral heating unit,

Figure 6 is a schematic perspective view of a first embodiment of water heating means using the body of Figure 3, together with electrical control means,

Figure 7 is a schematic perspective view similar to Figure 6 of a second embodiment,

Figure 8 shows an arrangment of a three stage water heating apparatus, together with control means,

Figure 9 shows a heating unit arrangement where temperature sensors are built in with the heating elements,

Figure 10 is a circuit diagram of the control of the apparatus,

Figure 11 is a cross-sectional view of an inlet section of another embodiment of the invention,

Figure 11a is a perspective view of an alternative heater unit for use with the inlet section of Figure 11,

Figure 11b is a cross-sectional view of an outlet section of the embodiment of Figure 11,

Figure 12 is a perspective view of a further alternative heater unit ,

Figure 13 is a schematic perspective view of a still further alternative heater unit,

Figure 14 is a lay-out of a yet still further form of water heating apparatus,

Figure 15 is a cross-sectional view of a still different form of the apparatus, and

Figure 16 is a diagrammatic lay-out of the apparatus in Figure 15.

Referring to Figure 1 this shows a water heating apparatus for use for example in a domestic situation for providing a supply of hot water and being supplied from a cold water main supply.

The apparatus as shown in Figure 1 includes an inlet section 10 and an outlet section 11 and a body section 12, containing the heating means of the appliance, situated between the inlet and outlet sections. Part of the casing has been removed for clarity and it is to be

understood that the external shape of the apparatus may take any other form instead of the generally rectangular configuration shown. In addition the body section 12 can also be other than rectangular, for example it can be of pear-shaped cross-section, as shown in Figures 2 and 3.

On the inlet section 10 there can be mounted a control 13 by means of which the temperature of the water delivered can be regulated, as will be described.

Figures 2 to 5 show the construction and arrangement of various parts of a first embodiment of water heating apparatus, to fit into a casing in the form of Figure 1 or in any suitable alternative form.

Figures 2 and 3 show a metallic body 14 of generally pear shape in transverse cross-section. The body has end walls 15, 16 respectively and in the end wall 15, which is the inlet end of the body, there is provided a generally central hole 17. The hole 17 is threaded to receive an adaptor plug supporting a cold water inlet pipe 18 which, in use, is arranged to receive pressurised cold or relatively cold water from, for example, the main supply. If required the inlet could incorporate a non-return valve. The wall 15 also contains a further threaded hole 19, which is plugged, in use, and a slot 20.

The end wall 16 has a hole 21, longitudinally aligned with the hole 19, and which is threaded like the hole 17, to receive an adaptor plug 23 (Figures 6 and 7), similar to that fitted in the hole 17, and carrying an outlet pipe 24.

The inlet pipe 18 extends to the interior surface of the end wall 16 where it is closed. However the pipe 18 has an axially extending slot 25 in its surface to allow the cold water to flow therefrom into a spirally arranged heater unit 26 shown in Figure 3.

The heater unit, shown best in Figures 4 and 5, is in the form of an electrical printed circuit heater 27 sandwiched between a pair of metal plates and rolled into a spiral. Connections 28 for supplying power to and for controlling the heater are provided on a longitudinal extension part at one corner 29 of the heater unit which protrudes through the slot 20. A glass or metal laminate, i.e. aluminium can be provided around the outside of the heater unit.

With the heater unit fitted in the water heating body 14 and being closed by the end walls 15, 16, which are, for example, secured to the remainder of the body by welding as shown in Figure 3, it can be appreciated that cold water entering the inlet pipe 18 will flow out of the slot 25 and into the innermost turn of the spiral of the heater unit. The water will then flow around the remaining spirals until it leaves the outermost part of the spiral and flows out of the outlet pipe 24 carried by the plug 23 fitted in the hole 21 in the outlet end wall 16 of the body 14.

The fact that the heater unit is a spiral, in this example of four turns, means that the surface area of the heater unit contacted by the water, as well as the contact time is significantly increased as compared to conventional heater units such as heating coils. This increases the efficiency of the heater, whilst enabling it to be kept relatively short and compact, thus allowing the water heating apparatus itself to be made compactly and less expensively. It has also been found that this construction

of heater substantially reduces gassification, further improving the heating efficiency.

Figure 6 shows a first example of an assembled body 14, inlet and outlet pipes 18, 24 heater unit 26 and associated controls for water heating apparatus of the invention. A casing 30 is shown schematically around the body 14, and this can contain asbestos or the like as heat insulation material. Electrical connection lines 31, 32 are taken from a power supply (to be described in Figure 10) to the connections 28 on the corner extension 29 of the heater unit. An override or cut-out sensor 33 is fitted on the body 14 to monitor the temperature of the water entering the outlet pipe 24 and to operate if a predetermined maximum value is exceeded. For example it could operate to switch off the heater unit and could be manually or automatically reset. Electrical lines 34, 35 connect the sensor to a control circuit, not shown.

Figure 7 shows a similar arrangement to figure 6, but with an increased number of printed circuit heaters, giving six contacts 36 and associated supply lines 37. As well as an override sensor 38, similar to the sensor 33 in Figure 6, there are additional sensors 39, 40 in the inlet and outlet pipes 18, 24 respectively, to provide electrical signals related to the temperature of water flowing therein. Each sensor has a pair of electrical connection lines leading therefrom to the control means of the water heating apparatus, which will be described below.

Typically a small heater unit, such as that shown in Figure 6, will be used in a 5kw water heating apparatus and a multi-circuit arrangement such as in Figure 7 would produce 10kw.

Figure 8 shows the use of three body assemblies of Figure 6 connected in series, so that each one can perform a stage of the water heating operation. The inlet pipe 18 of the first body assembly is fed from the cold water supply and after being heated by passing around the spiral heating unit in the body, the water passes out through the outlet pipe 24 of said first body, which also serves as the inlet pipe to the next body downstream in the series, and so on for the third and any subsequent body assemblies, as the number is not limited to the three shown. This arrangement reduces the wear on each heater unit and thus prolongs the life thereof. Each body assembly is shown as in Figure 6, but with a water temperature sensor 41, and although not shown each body assembly can also be provided with an override sensor. A heater control unit 42 and a temperature control unit 43 are also shown, along with a water outlet distribution system of five outlet branches 44 for the heated water to be taken off. The temperature sensors monitor water temperature along the whole body assembly and can detect hot or cold spots, for example, to cut out the heater in one particular section thereof. Thus with this arrangement each assembly can raise the water temperature by a given amount so that the heating load is spread over three heater units to produce water of the required temperature at the outlet of the end assembly. If required the bodies could be as in Figure 7.

Figure 9 shows an arrangement where the temperature sensor 44 is produced together with the heating elements 45 in the printed circuit board of the heater unit. This is a particularly compact arrangement allowing connections 46 to be made to the heater control unit 47 and connections 48 to the temperature control unit 49 at the board edge, thereby dispensing with an external, separate temperature sensor, like the sensor 41 in Figure 8. However like the sensor 41, the sensor 44 monitors water temperature along

the whole of the heater unit and can cut out a heating section if a hot spot is detected.

Figure 10 shows an dectrical control circuit suitable for all the water heating arrangements shown in Figures 1 to 9, where the heating apparatus has associated temperature sensing.

A spiral heater unit is denoted by the numeral 50 and sensors for monitoring inlet and outlet water temperature are denoted by the numerals 39 and 40, as for Figure 7, in the inlet and outlet sections 10 and 11. The heater unit is controlled through a solid state switch or relay 51. This is provided with a mains electrical supply at 52. If a relay is used, it can be of any suitable type, for example incorporating a triac value.

The sensors 39, 40 are connected in a bridge circuit 53 which is variable at 54 to regulate the heater unit output. This variation is carried out by way of the control knob 13 of Figure 1. A 24 volt power supply is connected between lines 55 and 56 with the voltage being supplied to the switch or relay 51. The line 55 is continued to the variable adjustment means 54 of the bridge circuit 53, whilst the line 56 is connected to the opposite point of the circuit 53. A line 57 extends from a further junction of the bridge circuit between the connection of the sensor 39 and a resistor to one input of an operational amplifier 58. This is a (temperature) difference amplifier. A line 59 extends from the remaining junction of the circuit 53 to another input of the amplifier 58. An output line 60 from the amplifier is connected to the line 56 of zero voltage, through resistors 61 and 62. Connected between the lines 59 and 60 is a coil 63.

A line 63 extends from the switch or relay 51 to join the line 60 between the resistors 61, 62. It has a diode 64 connected in it between collector and base and a line 65 from the emitter of the diode 64 extends to the base of another diode 66, whose collector and emitter are in a line 67 between lines 56 and 63. A further resistor 68 is connected between the lines 56 and 65 to complete the circuit.

The arrangement is such that the inlet and outlet temperatures are sensed by senors 39, 40 and according to the setting of the control knob 13 at variable adjustment 54, the heater current is regulated to maintain the chosen output temperature despite changes in input temperature.

Referring to Figures 11, 11a and 11b, these show inlet and outlet sections and an alternative form of heater unit for use in water heating apparatus in the form shown in Figure 1. The inlet section 10 shown in Figure 11 includes a central water duct 114. In the entrance of this is an adaptor 115 for attachment to associated pipework and this also incorporates a non-return valve indicated generally at 116. The non-return valve may take any conventional form. Extending into the duct 114 in the inlet section is an electrical temperature sensor device 117 which is capable of providing an electrical signal related to the temperature of the water flowing through the inlet duct.

Surrounding the duct 114 are casings containing the electrical supply and control equipment can be of the forms already described. The provision of these around the inlet duct provides for the cold water flowing therethrough cooling for the electrical and electronic equipment.

At the top of the section 10 there is a screw adaptor 118.

The outlet section 11 also has a central duct 119 through which the heated water flows. At the outlet end is an adaptor 120 for connection to associated pipework and there is also an electrical temperature sensor 121 which extends into the duct 119. There is also a screwed adaptor 122 at the inlet end of the duct 119.

Situated close to the duct 119 is a temperature responsive switch 123. Like the sensors 33 and 38 already described, this is arranged to operate in the event that the temperature in the outlet duct 119 exceeds a predetermined maximum value. It is arranged to be manually reset when it has been actuated in the event of excess temperature conditions.

As shown in Figure 1, the body section 12 can be in the form of a rectangular cowling, and within this is a cylindrical heating unit 124 shown in Figure 11a. This has screw threaded ends to engage in the adaptors 118 and 122 in the inlet and outlet sections 10 and 11. Within this is a matrix indicated at 125 made up from a number of printed circuit boards each with printed electrical heater circuits on their respective surfaces. The matrix is made up from a number of boards arranged perpendicularly to one another so as to define a number of square or rectangular through flow passages for water each passage being bordered by the heating elements printed on the circuit boards.

Conveniently the matrix is made up from a number of flat boards with slits which enable inter-engagement between the boards in a rigid manner. Electrical connections between them are either at the ends or at any convenient place within the matrix..

External connections of which there are four shown at 126 provide electrical supply to the printed circuit boards.

The apparatus therefore operates with water flowing through the inlet duct 114 of the inlet section 10 and through the matrix 125 to be heated as it passes through this unit. The water having been heated then flows out through the outlet duct 119. Heating of the water occurs only when there is a demand and there is therefore no necessity for storage of heated water.

Although this matrix type of heater unit is quite satisfactory in use, it is more expensive than the spiral type of heater unit and provides a shorter travel than with the sprial type.

Figure 12 shows a further alternative heater unit having a number of parallel printed circuit board plates 134. Each is rectangular and they are mounted apart by support columns 135. Such a unit would be enclosed within a surrounding cowling and electrical connections can be made at the edges of the plates.

Figure 13 shows an alternative matrix form of heater unit at 137 of generally rectangular configuration instead of the cylindrical form shown in Figure 11a. It is however constructed in similar manner. Part is broken away for clarity to show the heating elements.

Figure 14 shows an alternative heating apparatus which includes a casing 138 containing a hollow body 139. An inlet pipe 140 and an outlet pipe 141 are connected to opposite ends of the body 139 and within it are a pair of printed circuit board heater plates 142 having provision for electrical connection of their opposite ends outside the body 139. These may be arranged to

provide disturbance to the flow of water through the body so that maximum heat exchange takes place from the heaters to the water. The inlet and outlet pipes 140, 141 include respective temperature sensors 143, 144 connected in control circuits in the manner already described.

The inlet pipe 140 is connected to pipework 145 which includes a mannual valve 146 for interrupting the supply and a solenoid operated valve 147 upstream of the manual valve. The solenoid valve is connected in the control circuit to regulate the supply according to the load and output temperature requirements.

Figures 15 and 16 shows a further form of water heating apparatus which might be used in a commercial environment. A number of alternative sections are shown of which two or more may be used in combination, or each can be used individually as required. Inlet and outlet sections are omitted and there is shown only the heating unit which, in this example, has four sections. The first section 148 has a tubular printed circuit board heater 149 being flared towards the inlet end. Figure 16 shows the circular section of this. The printed heater elements are shown as a coil on the printed circuit board and electrical connections to opposite ends of this are indicated at 150.

A similar but cylindrical form of heater unit 151 is shown in the section 152 at the opposite end of the appliance. Electrical connections to this are indicated at 153.

The section 154 has two parallel cylindrical units each formed as a printed circuit board 155, 156. Respective electrical connections are indicated at 157, 158.

The further form shown in the section 159 has three parallel cylindrical units 160, 161, 162 with respective electrical connections 163, 164, 165.

Other forms of heater can be used each incorporating printed circuit boards. These may be insulated or exposed directly to the water in which case adequate earthing is necessary.

As stated, however, the spiral arrangement is most advantageous, since in addition to its efficiency advantages and lower cost, it simplies electrical connections thereto because they can be made at any convenient place.

With some constructions of water heating apparatus using this invention, it is envisaged that it will be possible to reduce costs to a degree where the apparatus can be considered disposable.

CLAIMS

1. Water heating apparatus comprising an inlet duct, an outlet duct and a water heating unit between the inlet and outlet ducts, the heating unit including printed circuit heater means.

2. Apparatus as claimed in claim 1, including sensor means for providing information relating to the temperature of water in the apparatus.

3. Apparatus as claimed in claim 2, wherein said sensor provides an electrical signal related to the temperature of water along the length of the heating unit, and control means for regulating the electrical supply to the heating unit in response to said signal.

4. Apparatus as claimed in claim 2, including respective electrical sensors for providing electrical signals related to the temperature of water passing through the inlet and outlet ducts, and a control for regulating the electrical supply to the heating unit in response to signals received from said temperature sensors in the inlet and outlet ducts.

5. Apparatus as claimed in any one of claims 1 to 4, including override sensor means operable to cut-off electrical supply to the heater unit if the water temperature exceeds a predetermined temperature.

6. Apparatus as claimed in any one of the preceding claims, wherein the heating unit is in the form of a spiral.

7. Apparatus as claimed in claim 6, wherein an inlet pipe supplies water, in use, to said spiral heating unit and said water circulates around the coils of the spiral before leaving through an outlet pipe.

8. Apparatus as claimed in claim 6 or claim 7, wherein the spiral heating unit is fitted between opposite ends of a body which closes the ends of the spiral respectively, and an extension of the spiral heating unit protrudes through a slot in said body to provide electrical connection thereto.

9. Apparatus as claimed in any one of claims 6 to 8, wherein a single printed circuit heater is provided in said heater unit.

10. Apparatus as claimed in any one of claims 6 to 8, wherein a plurality of printed circuit heaters are provided in said heater unit.

11. Apparatus as claimed in any one claims 1 to 10, wherein the heating unit comprises at least one printed circuit heater sanwiched between a pair of plates.

12. Apparatus as claimed in claim 11 wherein said plates are metallic.

13. Apparatus as claimed in any one of claims 1 to 5, wherein the heating unit comprises a matrix of printed circuit boards with printed electrical heater circuits thereon.

14. Apparatus as claimed in claim 13, wherein the heating unit matrix is made up of a number of boards arranged perpendicularly to one another to define a plurality of square or rectangular flow passages therethrough.

15. Apparatus as claimed in claim 14, wherein said matrix is square or rectangular.

16. Apparatus as claimed in claim 14, wherein said matrix is cylindrical.

17. Apparatus as claimed in claim 13, wherein said matrix comprises a number of parallel printed circuit board plares spaced one above the other on support columns.

18. Apparatus as claimed in calim 17, wherein said plates are rectangular.

19. Apparatus as claimed in any one of claims 1 to 18, wherein separated heating stages are provided in series, with each stage including a heating up, so that, in use, the temperature of water can be raised in each stage upto the required value.

20. Apparatus as claimed in claim 19, wherein three stages are provided.

21. Apparatus as claimed in any one of claims 1 to 5, wherein a body through which the water passes, in use, contains one or more printed circuit board heater plates, having means for disturbing the flow in the body for increased heat exchange.

22. Apparatus as claimed in claim 21, in which said plates are parallel and arranged facing the flow direction.

23. Apparatus as claimed in any one of claims 1 to 5, in which the heating unit comprises a tubular printed circuit board heater flared towards one of its ends, with the printed heater elements arranged as a coil on the printed circuit board.

24. Apparatus as claimed in any one of claims 1 to 5, in which the heating unit comprises a cylindrical printed circuit board with the printed heater elements arranged as a coil thereon.

25. Apparatus as claimed in claim 24, wherein a plurality of said cylindrical printed circuit boards are arranged in parallel to form the heating unit.

26. Apparatus as claimed in claims 23, 24 and 25, wherein two or more of the different heater units are combined in series to provide as a multi-section heater.

27. Apparatus as claimed in any one of claims 2 to 4, wherein said printed circuit heating means has said sensor or sensors built in with it.

28. Apparatus as claimed in claim 27, wherein connections to said heating means and said sensor or sensors are provided at an edge of a board carrying said printed circuit heater means.

29. Apparatus as claimed in any one of claims 2 to 28, including a control circuit for increasing or decreasing the output of the heating unit, in use, in response to said temperature sensor or sensors, to maintain a chosen water output temperature.

30. Apparatus as claimed in claim 29, wherein said control circuit comprises a resistance bridge circuit to which said sensor or sensors are connected and which has a variable resistance settable to correspond to a chosen water output temperature, the arrangement being such that with said resistance set to give a chosen water output remperature, a deviation from said temperature at the output of the apparatus causes adjustment of the current supply to the heating unit by means of a mains powered solid state switch or relay controlled by an electrical signal from said bridge circuit passed through an operational amplifier in said control circuit.

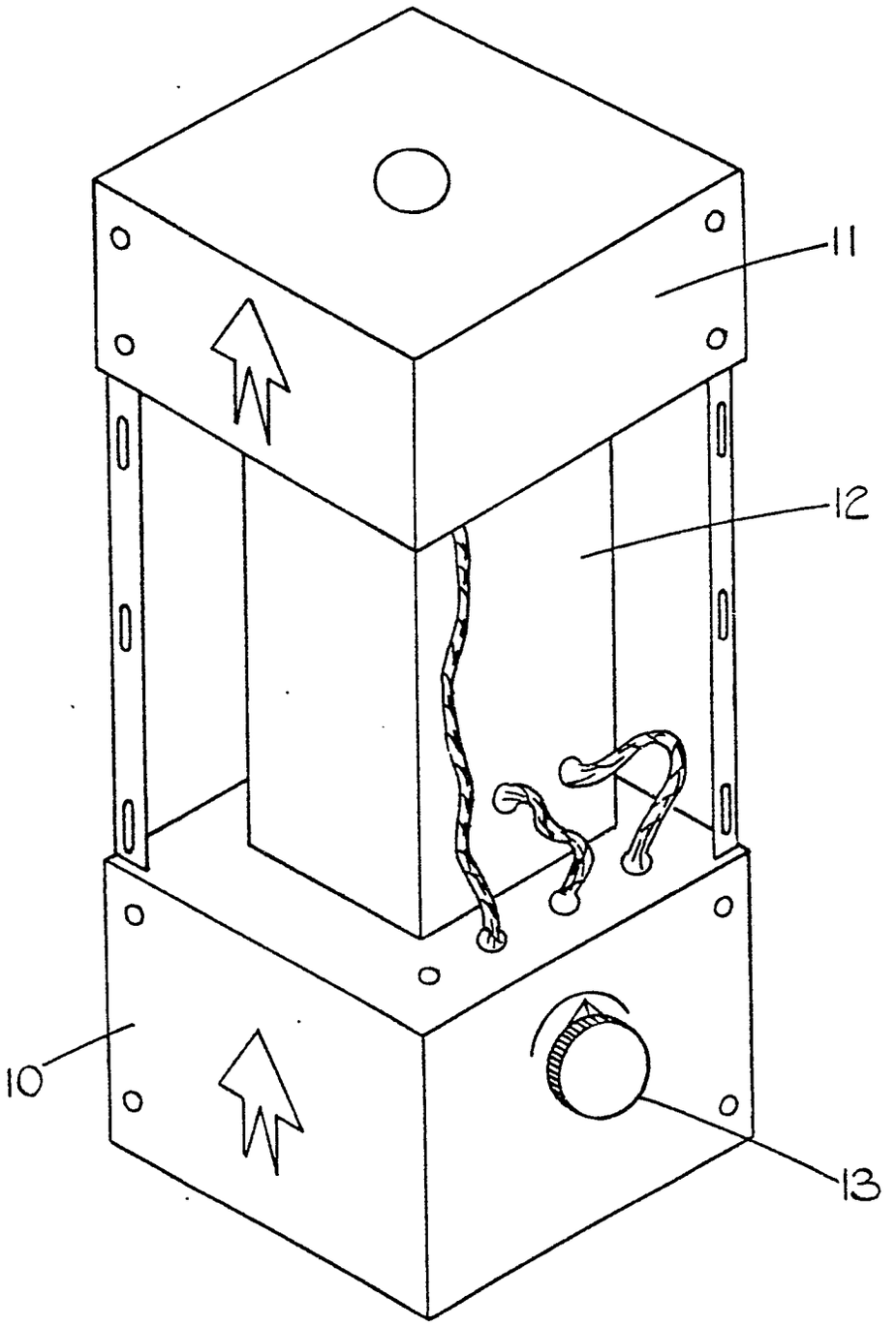

FIG.1.

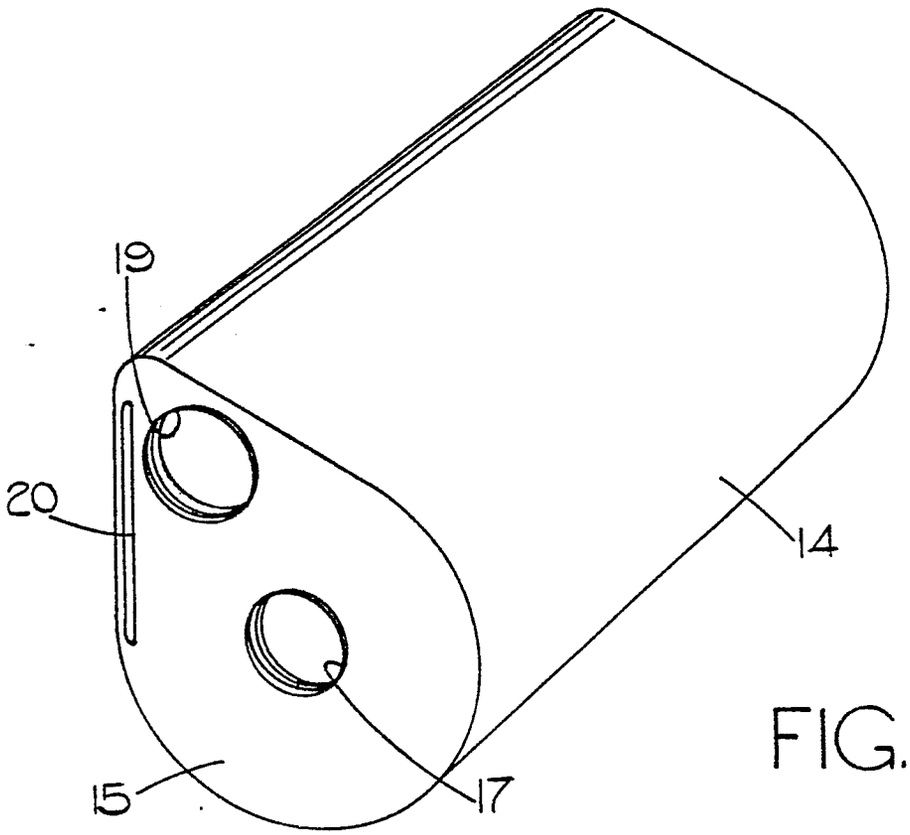

FIG.2.

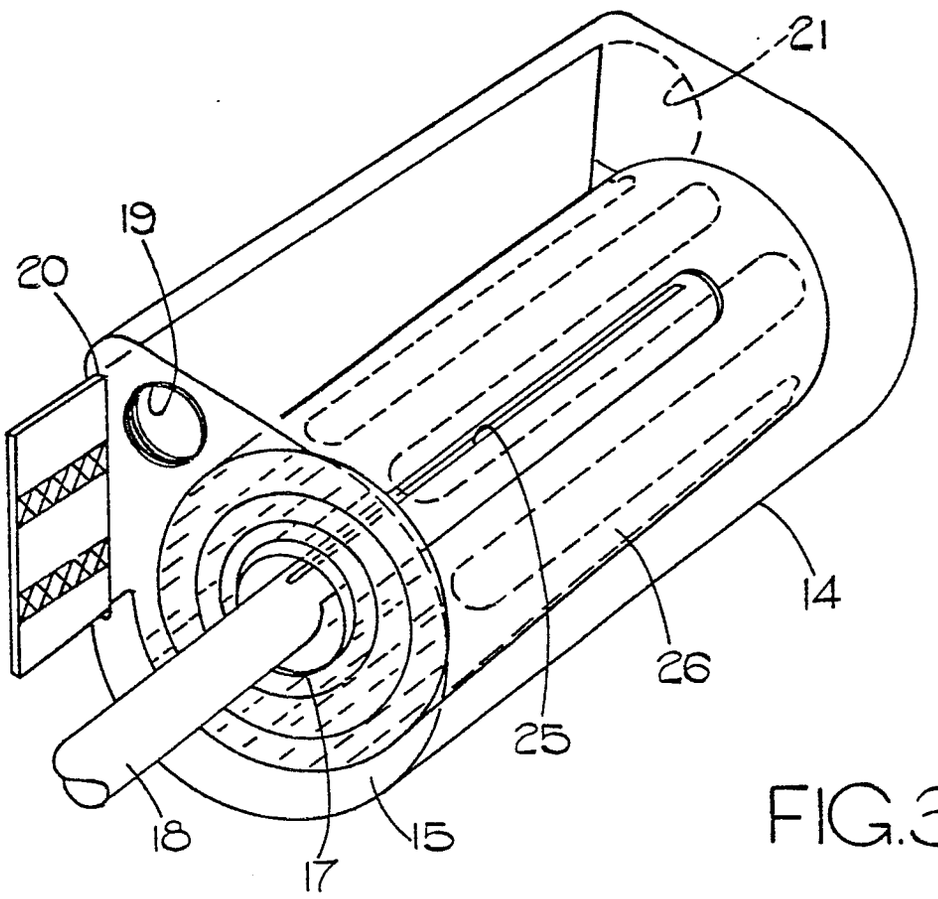

FIG.3.

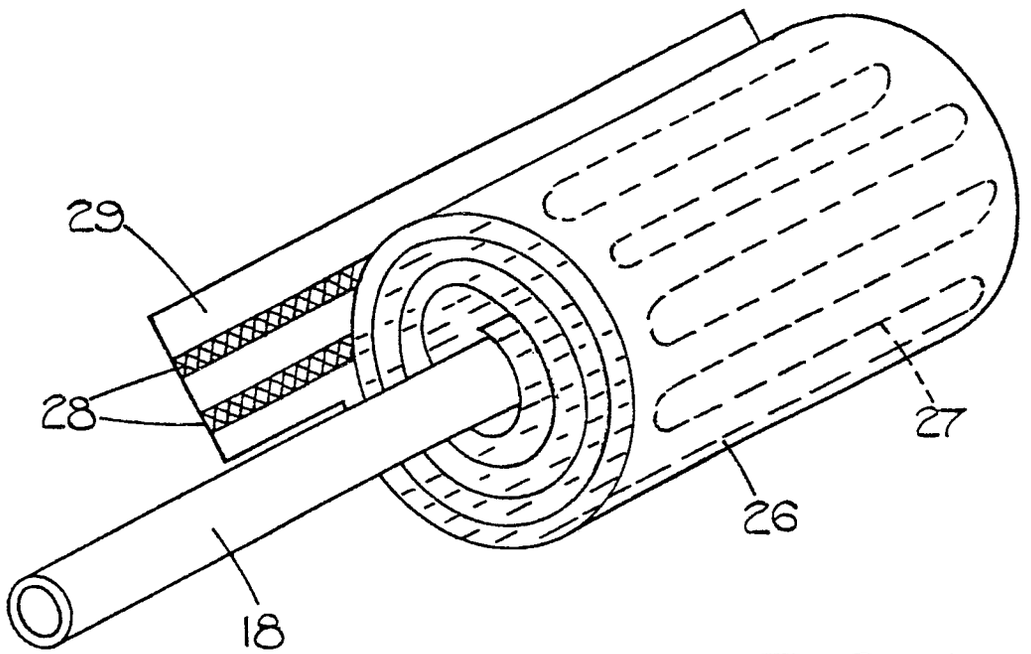

FIG. 4.

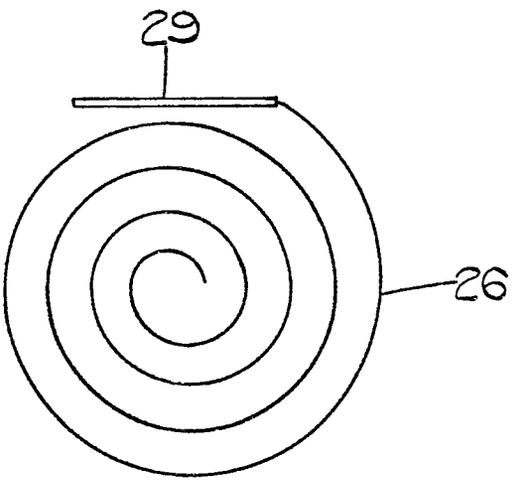

FIG.5

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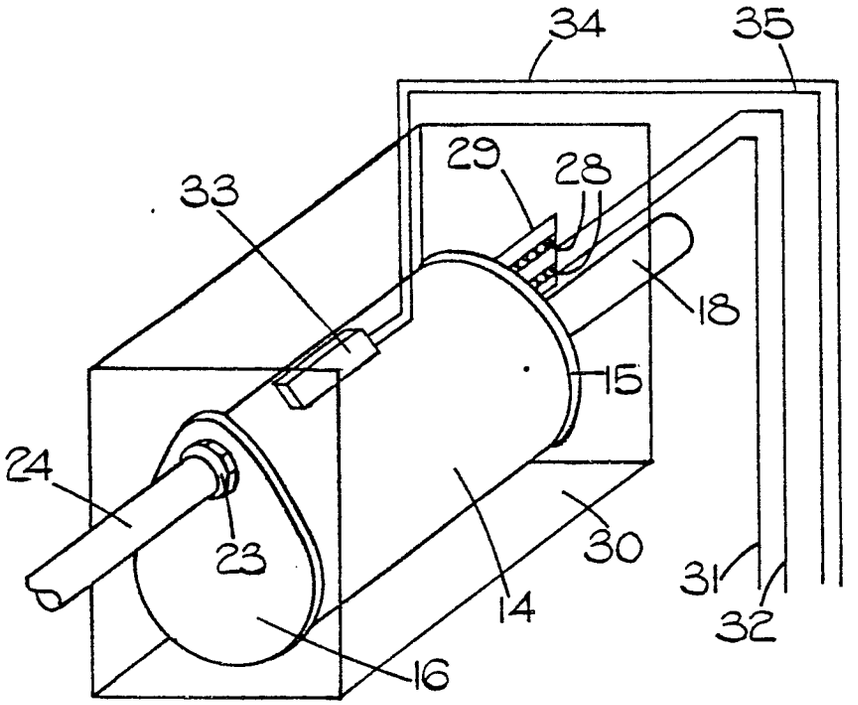

FIG.6.

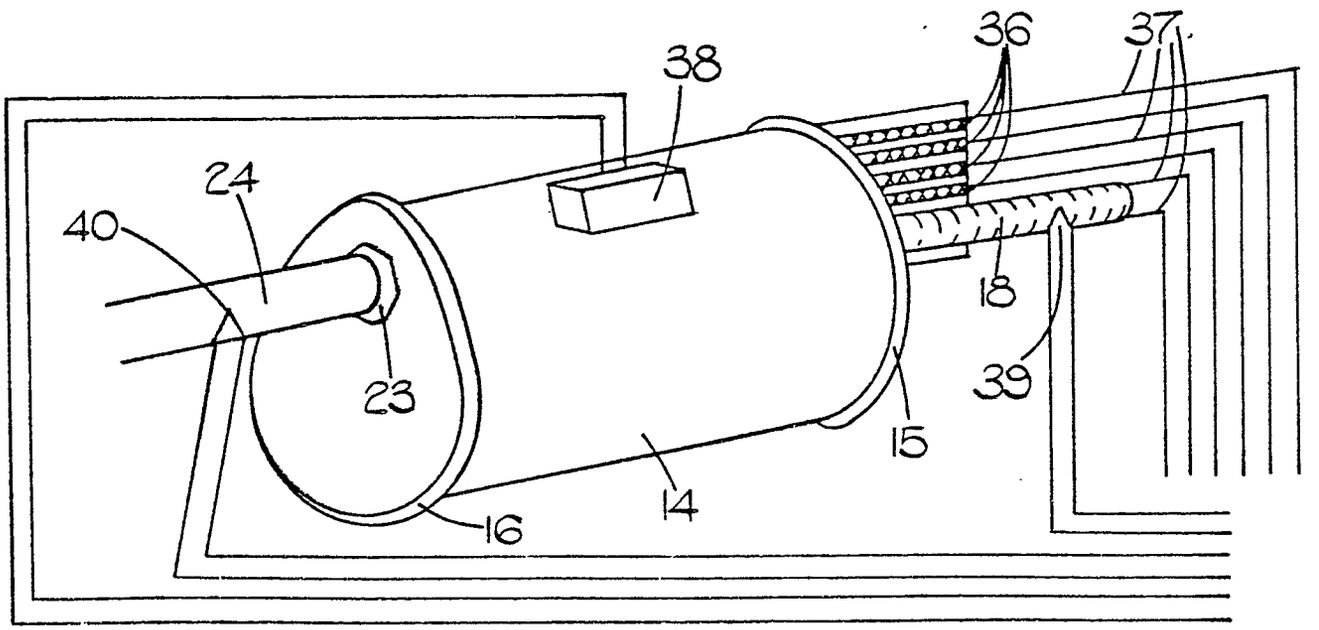

FIG.7.

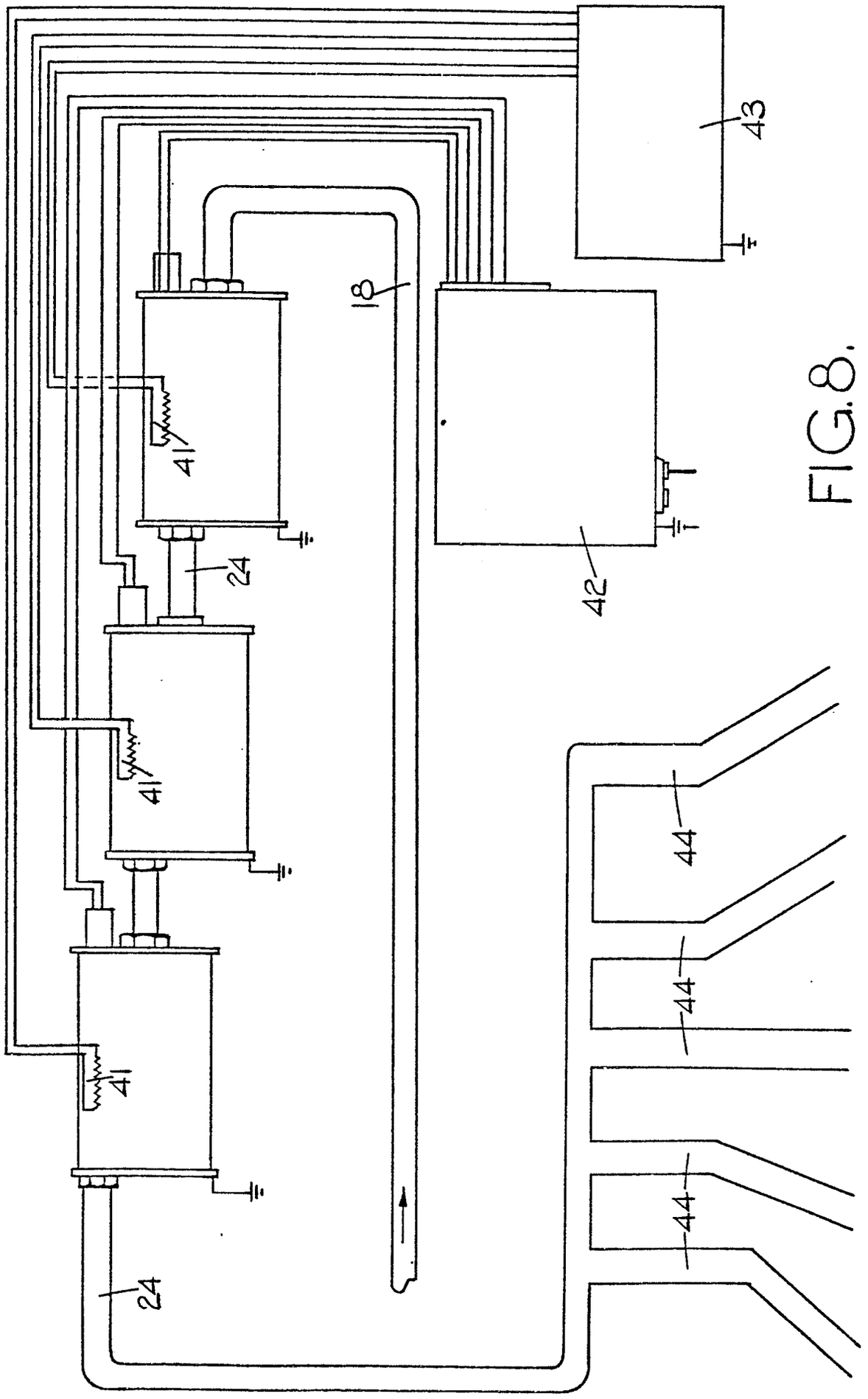

FIG.8.

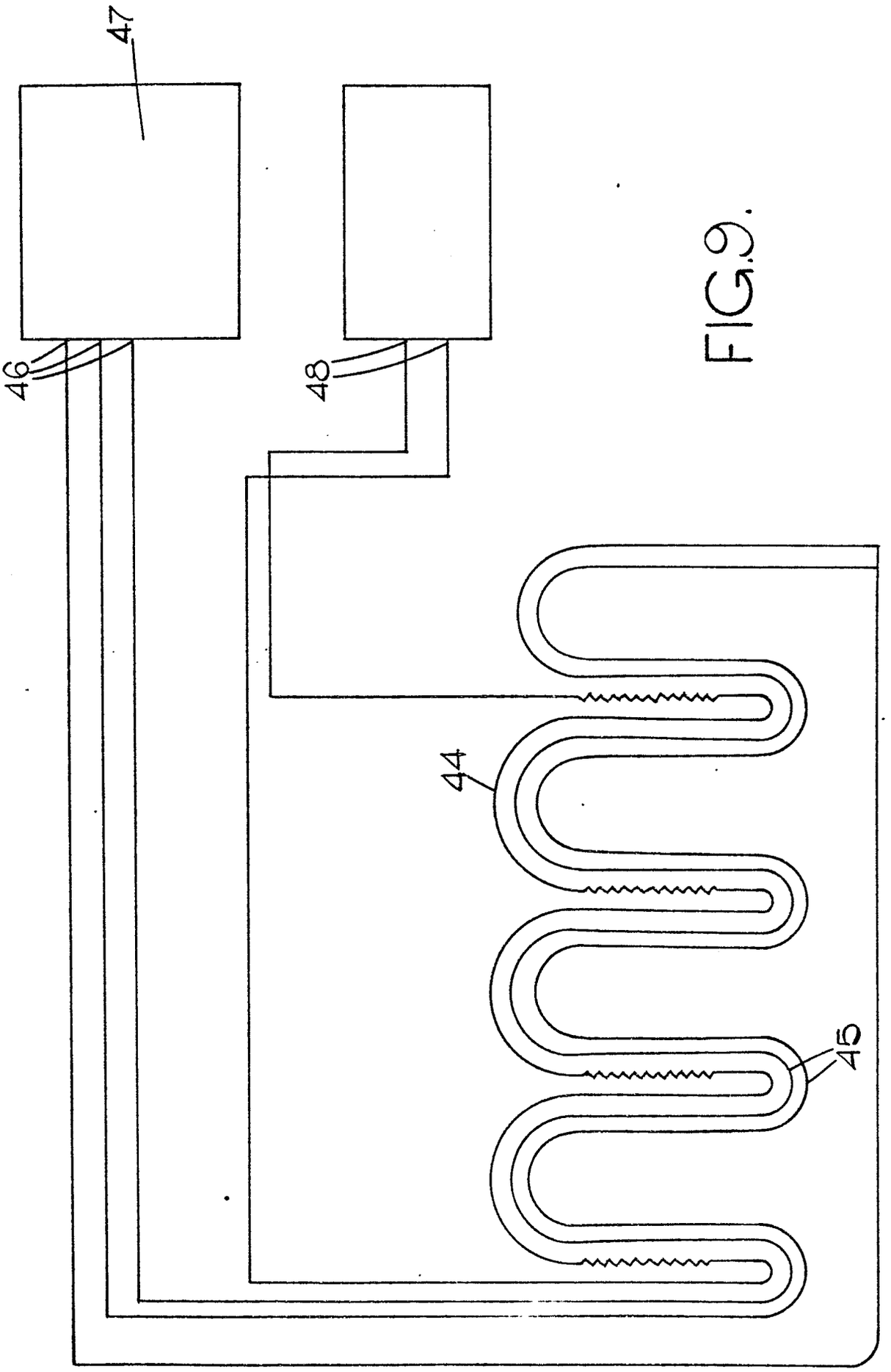

FIG.9.

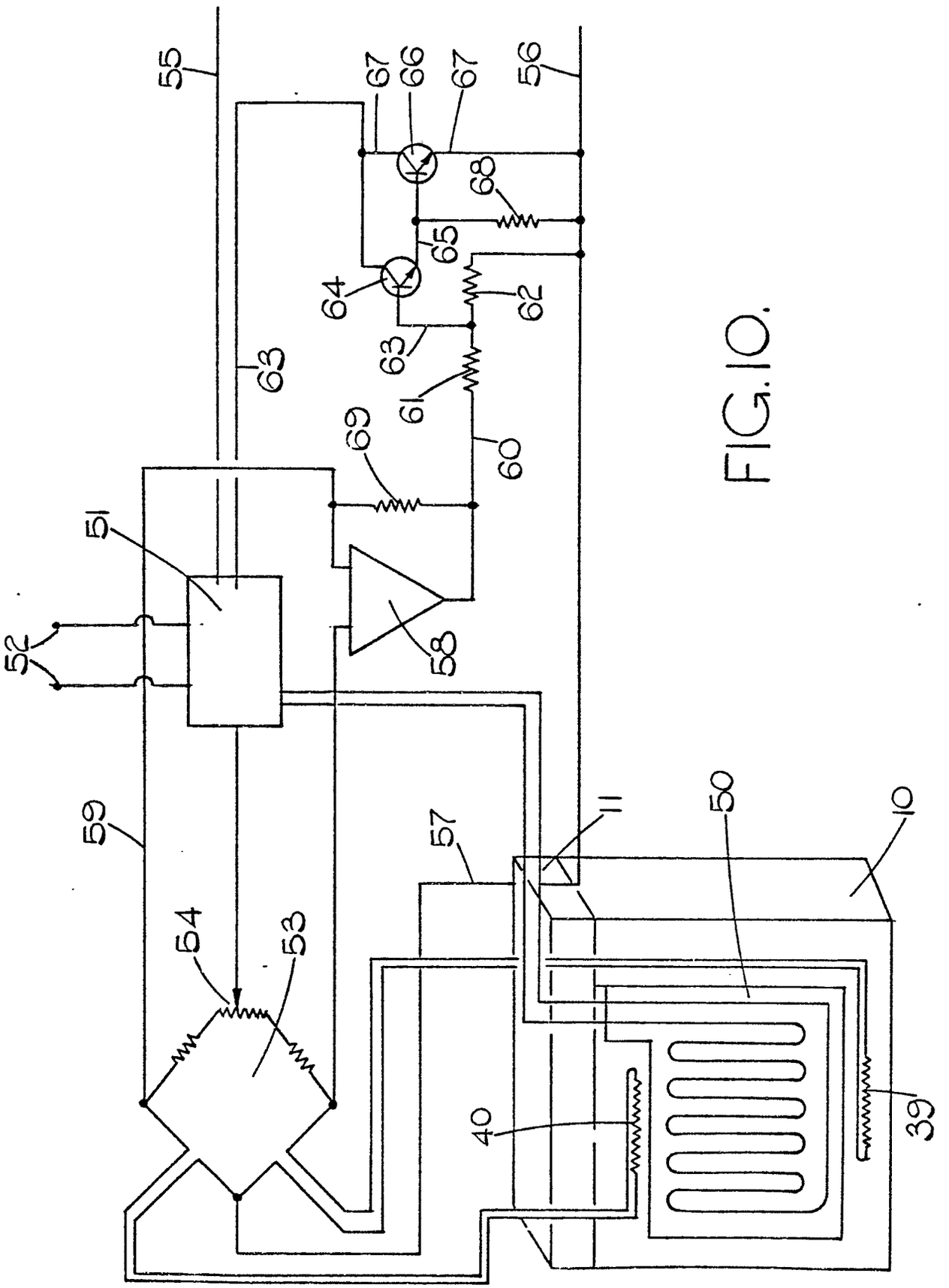
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FIG. 10.

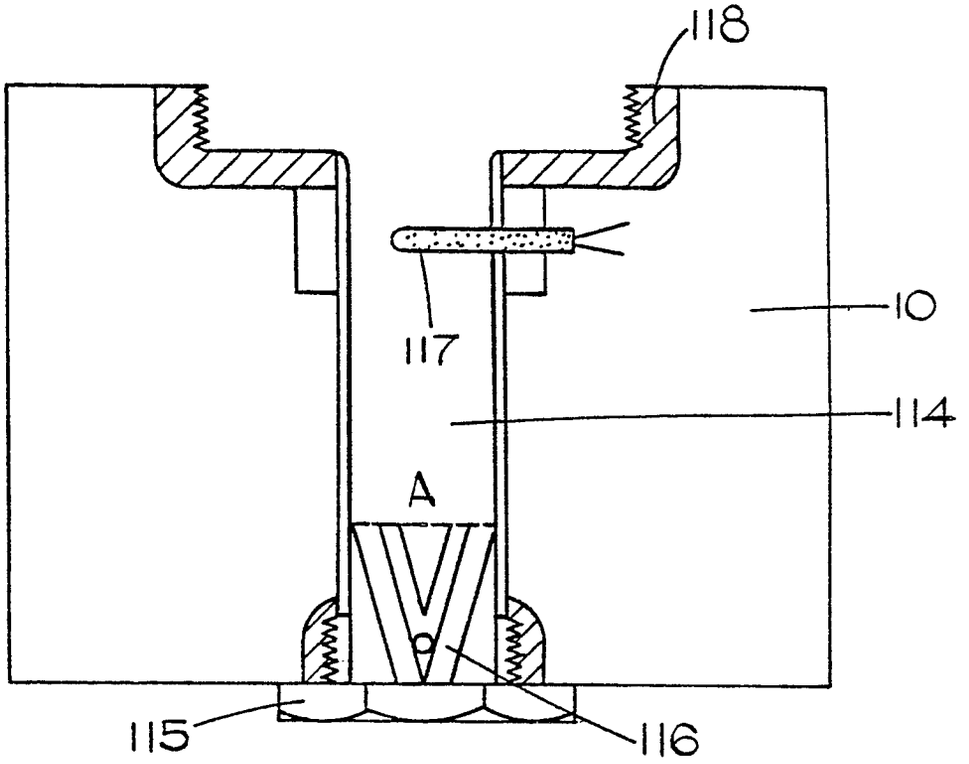

FIG.11.

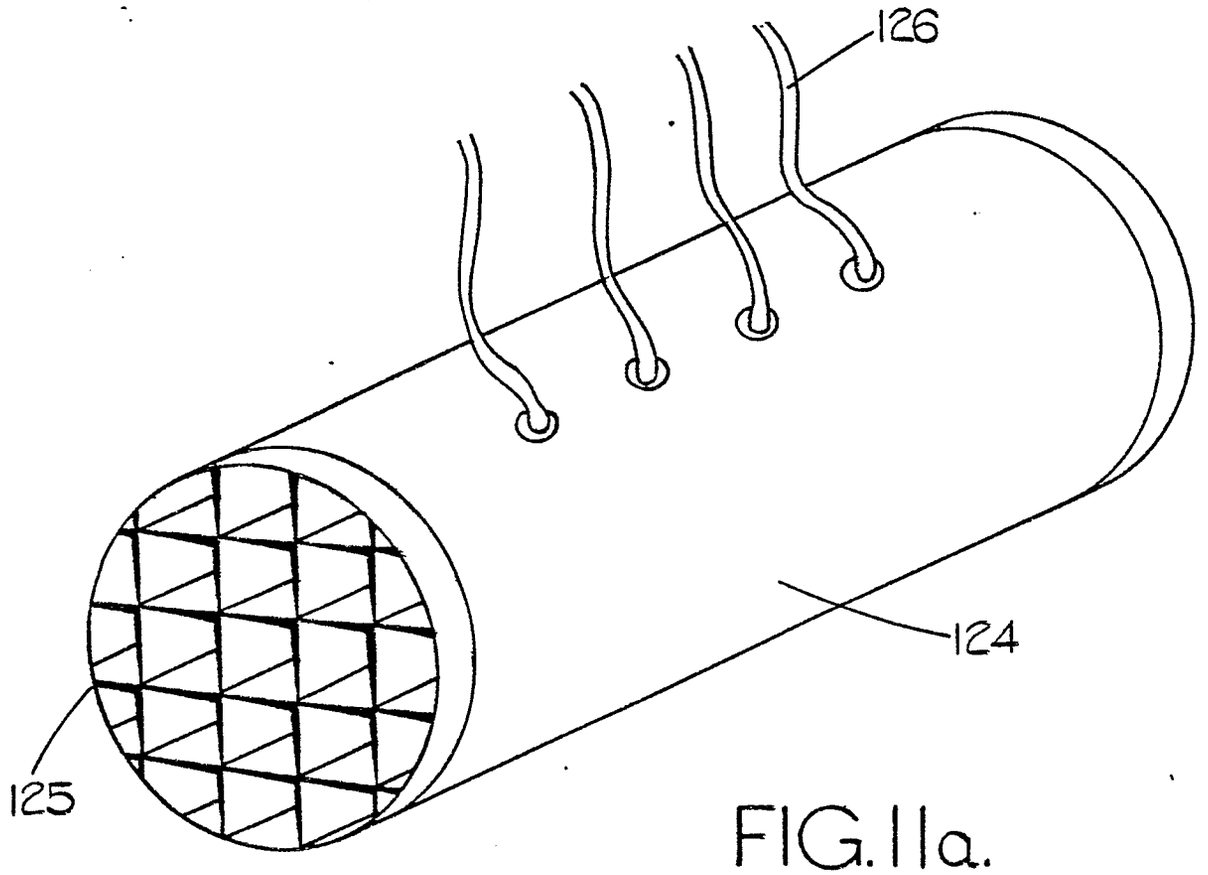

FIG.11a.

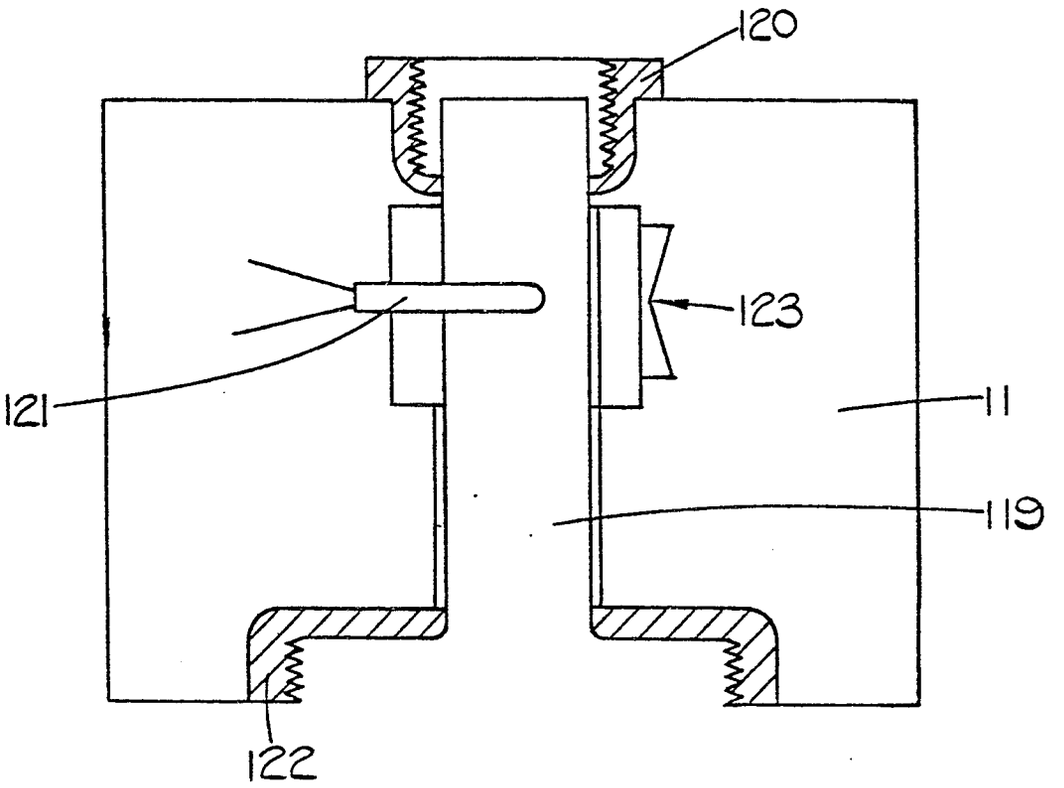

FIG.11b.

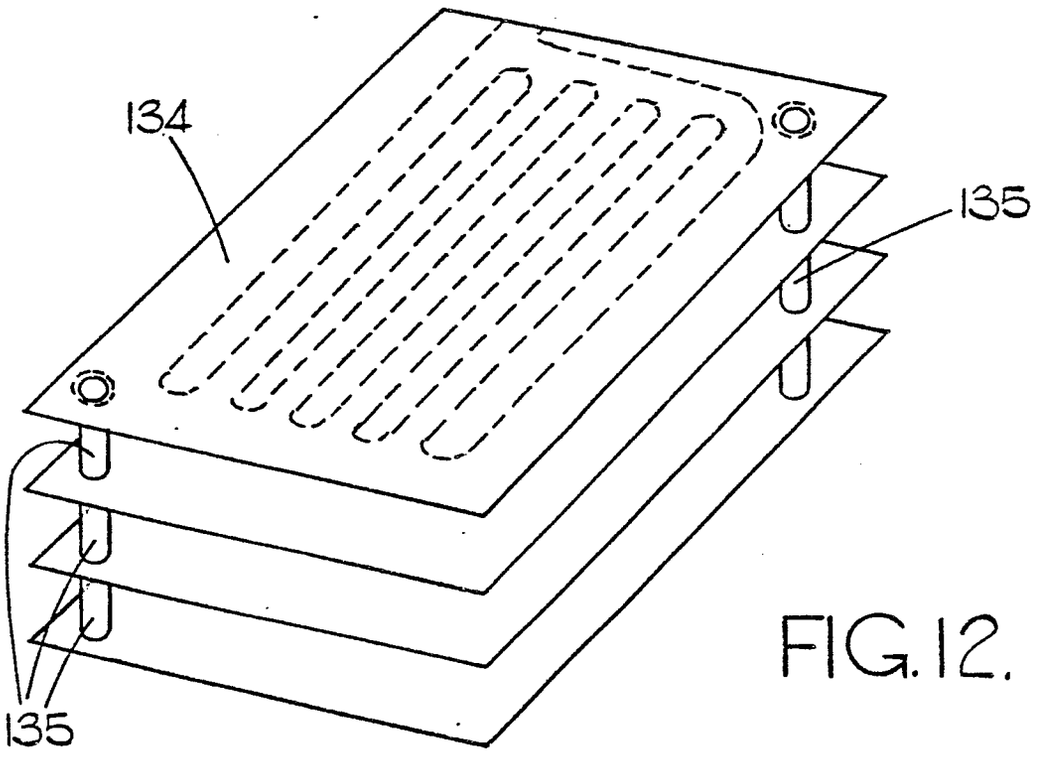

FIG.12.

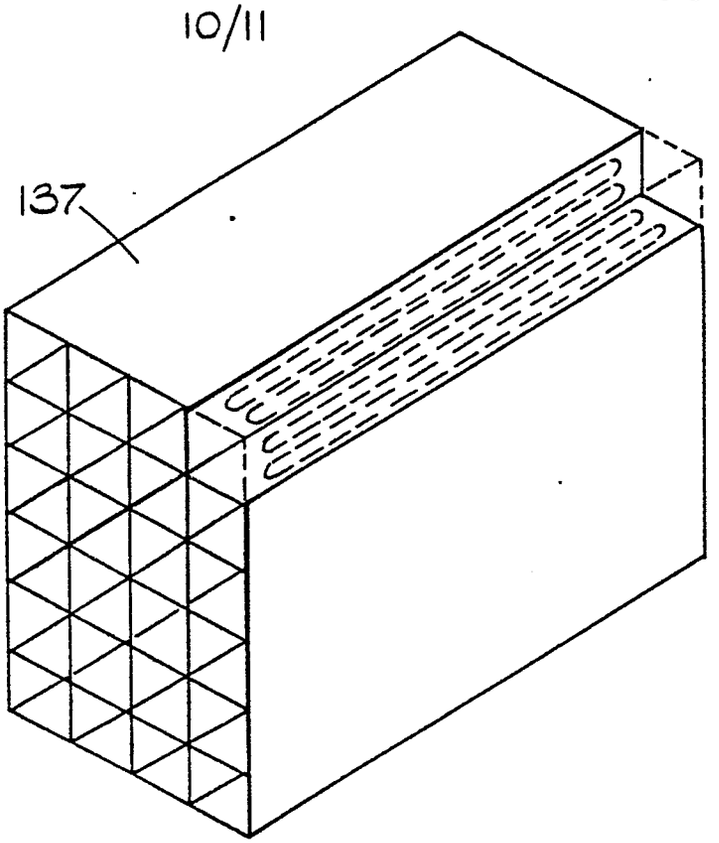

FIG.13.

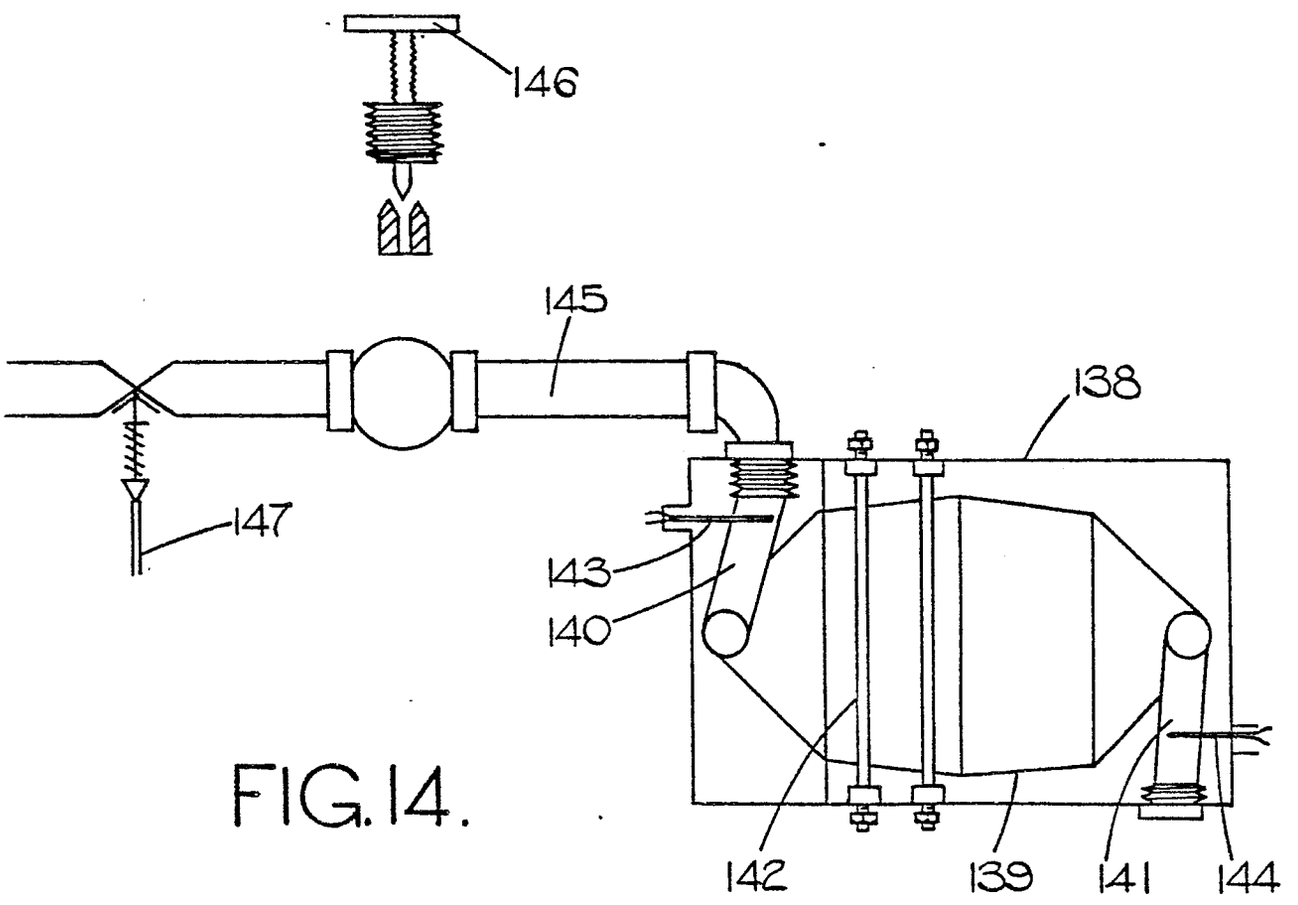

FIG.14.

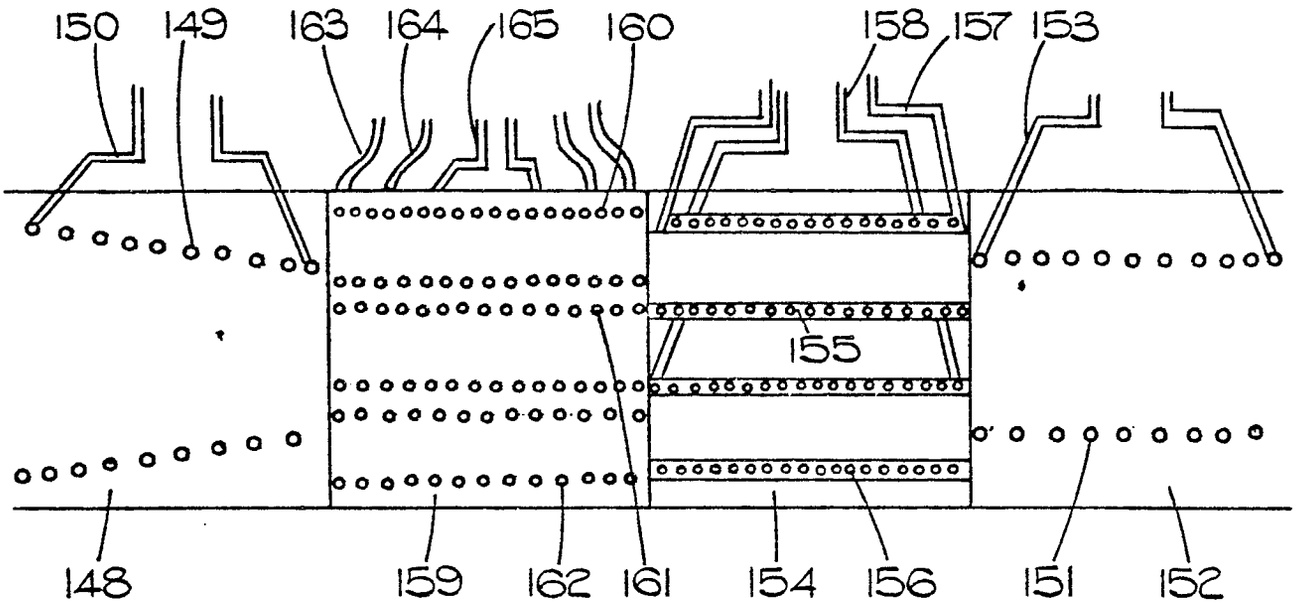
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FIG.15.

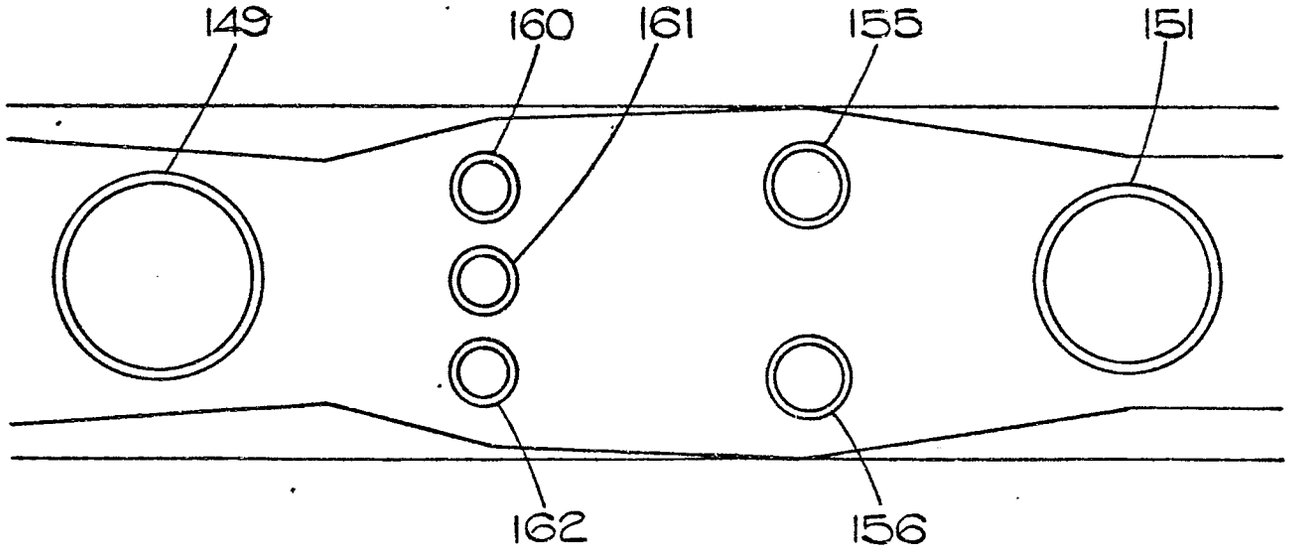
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FIG.16.

European Patent Office

EUROPEAN SEARCH REPORT

0074801
Application number

EP 82 30 4736.0

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y	DE - A - 2 240 186 (STIEBEL ELTRON) * claims 1, 2 * --	1	F 24 H 1/10 F 24 H 9/18 F 24 H 9/20
Y	DE - B2 - 2 327 941 (LICENTIA) * fig. 1 * --	1	H 05 B 3/26
A	US - A - 3 885 125 (PALM et al.) * fig. 2 * --	1	
A	US - A - 4 185 187 (ROGERS) * fig. 2 * --	1	TECHNICAL FIELDS SEARCHED (Int.Cl. ³)
A	US - A - 4 093 847 (WALKER et al.) * fig. 5 * ----	2	F 24 H 1/00 F 24 H 9/00 H 05 B 3/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	02-12-1982	PIEPER

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