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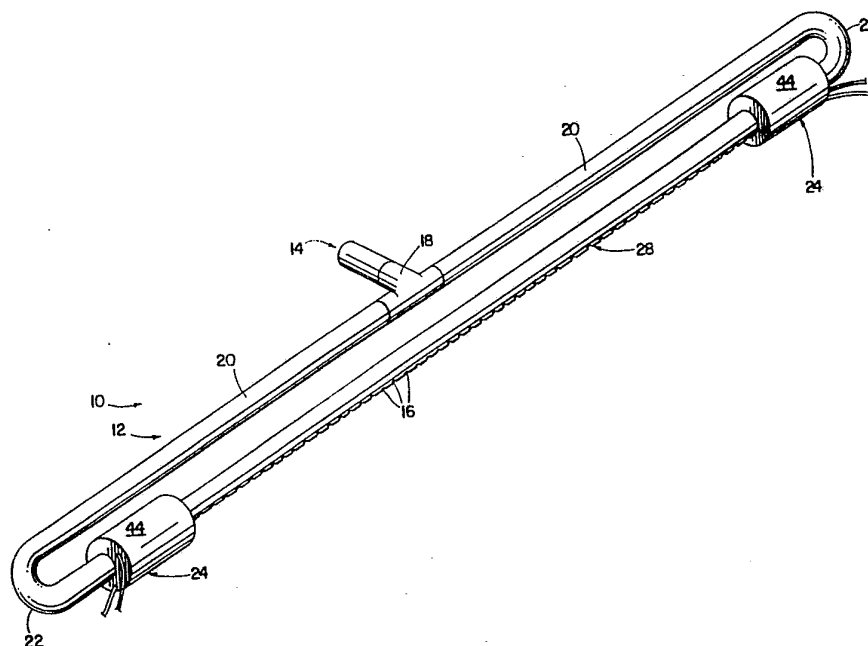
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(54) Title: METHOD AND APPARATUS FOR PROVIDING TEMPERATURE-CONTROLLED FLUID FLOW



(57) Abstract

A method and apparatus for providing temperature controlled fluid flow through the use of a plurality of positive temperature coefficient thermistors (26) disposed in physical series in heat exchange relation with the fluid. The method and apparatus can be used to maintain output air temperature substantially constant over a range of airflow rates, or alternatively can be used to vary output temperature while the airflow rate is held constant. The thermistors (26) are preferably disposed within a conduit structure (10), with fluid flowing longitudinally through the conduit structure (10). In the illustrated embodiment, the method and apparatus are employed for acceleration of setting and drying of liquid media on stock in a printing operation.

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**METHOD AND APPARATUS FOR PROVIDING
TEMPERATURE-CONTROLLED FLUID FLOW**

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Background of the Invention

Field of the Invention

The invention relates to a method and apparatus for heating a fluid to provide temperature-controlled fluid flow.

10

Description of Related Art

Various processes involve the provision of a stream of air or other fluid at a controlled temperature above ambient temperature. One example is the setting and drying of inks, varnishes or coatings on stock in a printing operation, as described in co-pending application Serial No. 585,784, filed September 20, 1990. As described in the above-referenced application, it has been found that the apparatus described therein which employs PTC thermistors to provide temperature-controlled airflow to accelerate setting and drying of liquid media on stock in a printing operation can provide significant advantages over prior methods. In that apparatus, a pair of substantially planar thermistor assemblies are disposed side-by-side, with a fan associated with each assembly.

20

Where a stream of air is heated by a conventional heating coil having a uniform, constant voltage, applied thereacross, increased airflow may result in significantly lower output air temperatures, with thermal power output remaining substantially unchanged. The apparatus described in the above-referenced co-pending application responds to increased airflow by increasing thermal power output, but output air temperature still generally decreases as a function of increased airflow (although to a lesser extent than where conventional heating elements are used).

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It is a general object of the present invention to provide a method and apparatus for effecting temperature controlled fluid flow in which the output fluid temperature

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is substantially independent of fluid flow rate. Further objects of the invention are disclosed below.

Summary of the Invention

The invention provides a method and apparatus for providing temperature-controlled fluid flow at variable flow rates through the use of a plurality of positive temperature coefficient thermistors disposed in physical series within a conduit, in heat exchange relation with fluid flowing through the conduit. The method and apparatus can be used to maintain output air temperature substantially constant over a range of airflow rates, or alternatively can be used to vary output air temperature while the airflow rate is held constant. In one embodiment, the apparatus is employed for accelerating setting and drying of liquid medium on stock in a printing operation. The apparatus in this embodiment comprises a conduit structure in the form of an elongated loop having an elongated, substantially linear outlet plenum with a plurality of nozzles disposed at longitudinal intervals therealong, disposed across the width of a press transfer bed. Assemblies of thermistors in series are disposed at opposite ends of the outlet plenum, and airflow into the conduit is divided between the two assemblies so as to flow into the outlet plenum at both ends.

In accordance with a further aspect of the invention, each of the thermistor assemblies may comprise a plurality of insulated receptacles disposed within a portion of the conduit, with each of the thermistors being nested within a respective one of the receptacles, such that the receptacles provide spacing and electrical insulation between adjacent thermistors. This enables the thermistors to be conveniently connected electrically in parallel with one another by a pair of elongated electrically-conductive rods extending through openings in the receptacles.

In accordance with an alternate embodiment of the invention, the thermistors may be connected electrically in

series by stacking the thermistors together so that their conductive faces are in physical contact with one another, or by separating them with conductive brass bushings having interior surfaces corresponding to the shapes of the thermistors to enable heat transfer from the thermistor faces to air disposed between the thermistors.

Where uniform, constant voltage is supplied to the thermistors, the thermistors' inherent positive-temperature coefficient enables output air temperature to be maintained within a relatively narrow range regardless of variations in airflow over a relatively wide range. Where it is desired that output temperature be substantially lower than the Curie temperature of the thermistors, an integrating thermocontroller may be provided to selectively switch the thermistors between "on" and "off" states in response to input from a thermocouple or a thermostatic device. This capability enables temperature of output air to be controlled precisely and varied as desired with airflow rate maintained constant.

Further aspects of the invention will become apparent from the detailed description which follows.

Brief Description of Drawings

FIG. 1 is a perspective view illustrating apparatus in accordance with an embodiment of the invention.

FIG. 2 is a fragmentary perspective view of apparatus in accordance with a second embodiment of the invention.

FIG. 3 is an exploded perspective view of a portion of the apparatus of FIG. 1.

FIG. 4 is an exploded perspective view of a portion of the apparatus of FIG. 3 comprising a thermistor in conjunction with an associated spacer.

FIG. 5 is a front elevational view of the spacer of FIG. 4.

FIG. 6 is a rear elevational view of the spacer of FIG. 4.

FIG. 7 is a sectional view taken substantially along line 7-7 of FIG. 6.

FIG. 8 is a schematic perspective view illustrating the apparatus of FIG. 1 installed in a printing press.

FIG. 9 is an electrical schematic diagram illustrating a control system for use in an embodiment of the invention.

Detailed Description of Preferred Embodiments

10 The invention is preferably embodied in a method and apparatus for heating a fluid to provide temperature-controlled fluid flow. The method and apparatus can be used to maintain output air temperature substantially constant over a range of airflow rates, or alternatively
15 can be used to vary output air temperature while the airflow rate is held constant. For purposes of example, the invention will be described in an embodiment which is particularly adapted for use in effecting temperature-controlled airflow to accelerate setting and drying of
20 liquid media on stock in a printing operation.

Referring to FIG. 1, the apparatus in the illustrated embodiment comprises a unit 10 which includes a conduit structure having an elongated loop configuration for transmitting air from an inlet 14 to a plurality of air
25 nozzles 16. Air flowing into the inlet is divided equally at a T-fitting 18 into a pair of oppositely extending, substantially linear sections 20, 22 which extend outward to 180° bends 22 at opposite ends of the unit. Disposed immediately downstream of the bends 22 are a pair of
30 thermistor assemblies 24, comprising a plurality of thermistors 26 disposed in physical series. Between the thermistor assemblies 24 is a substantially linear outlet plenum 28 having a plurality of aligned nozzles 29 therein. Thus, the thermistor assemblies 24 provide balanced airflow
35 into opposite ends of the outlet plenum 28 to provide evenly distributed airflow along the length thereof.

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As illustrated in FIG. 8, one or more of the units 10 may be mounted on a printing press 30 so as to provide evenly distributed airflow at a controlled temperature across the width of the press transfer bed 32.

5 The illustrated press 30 is a high-pile press, employing a conventional gripper mechanism to transfer sheets. The gripper mechanism comprises a plurality of gripper bars 34 thereon which are carried along the lower portion 36 of the chain as they transport sheets along the transfer bed for
10 release into a pile. After releasing the sheets, the gripper bars return along the upper portion 38 of the chain.

To promote efficiency in effecting flow of temperature-controlled air over liquid media such as inks,
15 varnishes, or coatings on the sheets, the units 10 are disposed between the upper and lower portions of the chain, with the outlet plena 28 in close proximity to the sheets, and with the nozzles 16 pointing downward so that air will impinge on the sheets as it is blown outward through the
20 nozzles.

As illustrated in FIG. 8, three units 10 may be disposed in a series over the press transfer bed 32. Air is supplied to the units 10 by a manifold 40 which receives air from a shop air line 42 charged by a compressor. A
25 valve 43 or other means may be employed to enable variation of flow rate.

As illustrated in FIG. 3, each of the thermistor assemblies 24 is enclosed in a cylindrical portion 44 of the conduit structure 12 which, in the illustrated
30 embodiments, is enlarged as compared with the remainder of the conduit structure. For purposes of example, the conduit structure may comprise primarily 1-1/2 in. pipe with the enlarged portions 44 comprising segments of 3 in. diameter copper pipe. Annular aluminum end members 45 are
35 provided at opposite ends of the enlarged segments to connect the enlarged sections 44 to the 1-1/2 in. diameter portions contiguous therewith. Each of the thermistor

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assemblies 24 in the illustrated embodiment comprises six thermistors arranged in physical series within the enlarged segment 44, connected electrically in parallel.

Each of the six PTC thermistors 26 is nested in a separate non-electrically conductive ceramic receptacle 46 having a substantially cylindrical outer peripheral surface 47 for fitting closely within the associated pipe segment 44. A substantially triangular opening 48 extends longitudinally therethrough, with an internal shoulder 49 to support the associated thermistor 26 stably therein. Three threaded brass rods 50a, 50b and 50c extend through longitudinal bores 52 in the ceramic receptacles to provide mechanical integrity for the assembly. Two of the three threaded rods 50a and 50b also perform an electrical function, providing parallel electrical connection for the six thermistors 26.

PTC thermistors are characterized by a sharp increase in electrical resistance as a function of temperature. Known PTC thermistors are made of an oxide semiconductor ceramic comprising barium titanate doped with trivalent ions such as yttrium or pentavalent ions such as niobium.

A significant characteristic of the thermistor is its Curie temperature, which is a temperature at which rapid increase in resistance as a function of temperature occurs, at which the thermistor has a resistance of twice the minimum resistance value, with resistance being measured using a terminal voltage of 1.5 volts DC or less. The preferred PTC thermistors 26 are commercially available Curie thermistors which have a Curie temperature of about 260°C. Each has conductive coatings on its opposite major faces 54 and 56, with a respective electrical lead 58 welded to each face. This arrangement provides current flow across the semiconductive element over substantially the entire area thereof.

The thermistors in the illustrated embodiment have a plurality of small transverse openings 60 formed

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therethrough for airflow. The openings 60 may have a diameter of, e.g., about 1 mm, with each perforation equally spaced from adjacent perforations disposed at 60° intervals at center-to-center distance of about 2 mm. Each thermistor is generally triangular, and, more specifically, is shaped as an equilateral triangle.

Each of the leads 58 extends to a lug or connector 62 at its end. Each of the connectors 62 has a circular opening 64 therein for engaging the associated threaded rod. An arcuate recess 66 is provided on one face of the receptacle 46 to accommodate the leads 58. Each of the bores 52 accommodating one of the electrical conducting threaded rods has a counterbore 67 for receiving the connector and a nut which provides a good electrical connection between the thermistor and the associated rods 50a and 50b.

The ceramic receptacles may be cast from dental clay. As an alternative to the illustrated ceramic receptacles, receptacles of similar configuration may be injection molded from a high temperature plastic for volume production.

It should be appreciated that various alternatives to the specific thermistor configuration illustrated may be provided. For example, thermistors of various shapes might be employed as alternatives to the triangular thermistors illustrated herein which are commercially available items. The triangular thermistors have an advantage of allowing space to install conductor rods, as in the illustrated configuration. However, circular disc-shaped thermistors might alternatively be employed, stacked without the use of receptacles, or with conductive receptacles such as brass bushings having openings therein corresponding to the shapes of the thermistors, with the thermistors electrically connected in series. Alternatively, a conduit of square cross-section might be employed in combination with "barn"-shaped thermistors, i.e., thermistors having the shape of a square

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with two adjacent corners cut off to accommodate electrical connecting rods to connect the thermistors.

Also, the number of thermistors in the assemblies may be varied in accordance with the demands of a particular usage context. As the number of thermistors in the series is increased, flow resistance increases, resulting in a fluid pressure drop across the assembly. However, increasing the number of thermistors has the advantage of increasing the uniformity of output air temperature that can be achieved without external controls.

In balancing the foregoing considerations, and also taking into consideration the current loads of the thermistors, the number of thermistors in each assembly has been selected to provide optimal performance in the context of the illustrated use in a high-pile press. In other contexts, other numbers of thermistors might be preferable.

A 220-volt power system is preferably employed. The thermistors draw about 3300 watts when a compressor producing 90 cfm at 52 in. H₂O is used to provide ambient air. Peak power consumption would be approximately 6600 watts, over a start-up period of several seconds. The thermistors in the illustrated embodiment preferably have a surface temperature of about 260° C. At airflow rates of 100 cfm, the apparatus described above provides an output air temperature of about 240° C.

As illustrated in FIG. 2, a temperature sensing device 86 which may comprise a thermocouple or thermostat, may be employed to detect output air temperature. If output air temperature substantially below the 260° C. range is desired, an integrating thermocontroller 80 may be employed to switch the thermistor assemblies 24 on and off in order to provide the desired output air temperature.

The thermocontroller 80 includes a thermostat which compares the actual air temperature downstream from one of the thermistor assemblies with a preset reference temperature. The controller selectively switches the thermistors 26 between "on" and "off" positions as

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necessary to adjust the output temperature toward the reference temperature. When the actual temperature is approaching the reference temperature, the controller effects switching before the reference temperature is reached.

The controller 80 effects switching of the thermistors 26 through the use of a relay 88. The controller selectively 80 applies a 24 volt current to the relay 88 to effect switching of 220 volt current to the thermistors. Power for the thermistors as well as the controller is supplied by a 220 volt power supply 82. A transformer 84 steps the voltage down to 24 volts for the relay.

A manual switch 90 may be provided to enable the operator to override the controller and maintain the thermistors constantly in the "on" state for a desired period of time. This may be useful during start-up, or during other circumstances when it is desirable to maximize heat output. A main power switch is shown at 92.

The use of the controller 80 enables setting and/or drying of ink to be accelerated to a desired degree while also enabling heat output to be limited approximately to a minimum, so as to avoid excessive heating of environmental air, and excessive energy usage. While the preferred thermistors 26 have Curie temperatures of about 260° C., the thermocontroller 80 as described above enables air output temperature to be maintained at any desired temperature, from ambient temperature up to about 240° C., with relatively little variation in air temperature resulting from variation in airflow rates.

From the foregoing, it should be appreciated that the invention provides a novel method and apparatus for providing temperature-controlled fluid flow at variable flow rates. The invention is not limited to the embodiments described herein, and may be embodied in, e.g., apparatus for effecting heat-shrinking of polymeric film material in packaging operations; apparatus for heat

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sealing of various polymeric materials; curing of inks or dyes in operations for silk-screening articles of clothing; or various other contexts where it is desirable to provide fluid flow at a controlled temperature which is capable of
5 being maintained within a relatively narrow range regardless of variations in flow rate over a relatively wide range.

The invention is particularly pointed out by the following claims.

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What Is Claimed Is:

1. Apparatus for providing temperature-controlled fluid flow, comprising:
 - a conduit structure having an inlet and at least
5 one outlet;
means for effecting flow of fluid through said conduit structure from said inlet to said at least one outlet at a flow rate within a predetermined range;
at least one assembly of positive temperature
10 coefficient thermistors, each assembly comprising a plurality of positive temperature coefficient thermistors disposed in physical series within said conduit structure between said inlet and said at least one outlet for heat exchange with said fluid flowing through said conduit
15 structure; and
means for supplying current to said thermistors.
 2. Apparatus in accordance with Claim 1 wherein said at least one assembly of positive-temperature-coefficient thermistors comprises a pair of thermistor
20 assemblies.
 3. Apparatus in accordance with Claim 2 wherein said conduit structure provides two separate flow paths to said at least one outlet, said conduit structure comprising a divider adjacent said inlet and downstream therefrom for
25 dividing fluid flow;
a pair of substantially linear sections extending in opposite directions downstream from said divider;
a pair of 180° bend sections, with a respective one of said bend sections extending downstream from each of
30 said substantially linear sections;
a pair of containment sections containing said assemblies of PTC thermistors, disposed between said 180° bend sections and downstream therefrom; and
a substantially linear outlet section disposed
35 between said containment sections and downstream therefrom;

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said at least one outlet comprising a plurality of outlet nozzles disposed at longitudinally spaced locations along said outlet section.

4. Apparatus in accordance with Claim 1 wherein
5 each of said assemblies further comprises a plurality of insulative receptacles disposed longitudinally within a portion of said conduit, each of said thermistors being nested within a respective one of said receptacles, said receptacles providing spacing between adjacent thermistors.

10 5. Apparatus in accordance with Claim 4 wherein said assembly further comprises a pair of elongated electrically-conductive rods for connecting said thermistors electrically in parallel, said receptacles having bores formed therein to accommodate said rods.

15 6. Apparatus in accordance with Claim 1 wherein said thermistors are connected electrically in parallel.

7. Apparatus in accordance with Claim 1 further comprising means to supply a substantially uniform, constant voltage to said thermistors.

20 8. Apparatus in accordance with Claim 1 further comprising an integrating thermocontroller for selectively switching said thermistors between an "on" state and an "off" state to adjust air output temperature toward a preset reference temperature.

25 9. A method of providing temperature-controlled fluid flow, comprising:

providing a conduit structure having an inlet and at least one outlet;

30 effecting flow of fluid through said conduit structure from said inlet to said at least one outlet;

providing at least one thermistor assembly, each comprising a plurality of positive-temperature-coefficient thermistors disposed in physical series within said conduit structure between said inlet and said at least one outlet
35 for heat exchange with said fluid flowing through said conduit structure, each of said thermistors having a Curie

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temperature, said fluid being at a temperature below said Curie temperature at said inlet; and

supplying electric current to said thermistors

10 10. A method in accordance with Claim 9 wherein
said thermistors in each assembly are connected
electrically in parallel.

11. A method in accordance with Claim 9 wherein
said thermistors in each assembly are connected
electrically in series.

10 12. A method in accordance with Claim 9 wherein
the Curie temperatures of said thermistors are
substantially equal to one another, said Curie temperatures
being about 260° C.

15 13. A method of effecting temperature-controlled
airflow to accelerate drying of liquid media on stock as
said stock travels from a first location to a second
location in a printing press, comprising:

providing a conduit structure having an inlet and
at least one outlet;

20 effecting flow of air through said conduit
structure from said inlet to said at least one outlet;

providing a plurality of positive-temperature-
coefficient thermistors disposed in physical series within
said conduit structure between said inlet and said at least
25 one outlet for heat exchange with said air flowing through
said conduit structure, each of said thermistors having a
Curie temperature, said air being at a temperature below
said Curie temperatures at said inlet;

supplying current to said thermistors; and

30 directing said air from said outlet to said
stock.

14. Apparatus for providing temperature-
controlled airflow to accelerate drying of liquid media on
stock as said stock travels from a first location to a
35 second location in a printing press, comprising:

a conduit structure adapted to be supported on
the printing press, having an inlet and at least one outlet;

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means for effecting flow of air through said conduit structure from said inlet to said at least one outlet;

5 at least one thermistor assembly comprising a plurality of positive-temperature-coefficient thermistors disposed in physical series within said conduit structure between said inlet and said at least one outlet for heat exchange with said air flowing through said conduit structure, each of said thermistors having a Curie
10 temperature; and

means for supplying electric current to said thermistors.

15 15. Apparatus in accordance with Claim 14 wherein each of said thermistor assemblies comprises six thermistors connected electrically in parallel.

16. Apparatus in accordance with Claim 14 further comprising thermostatic control means for operating said thermistors at temperatures substantially below their Curie temperatures.

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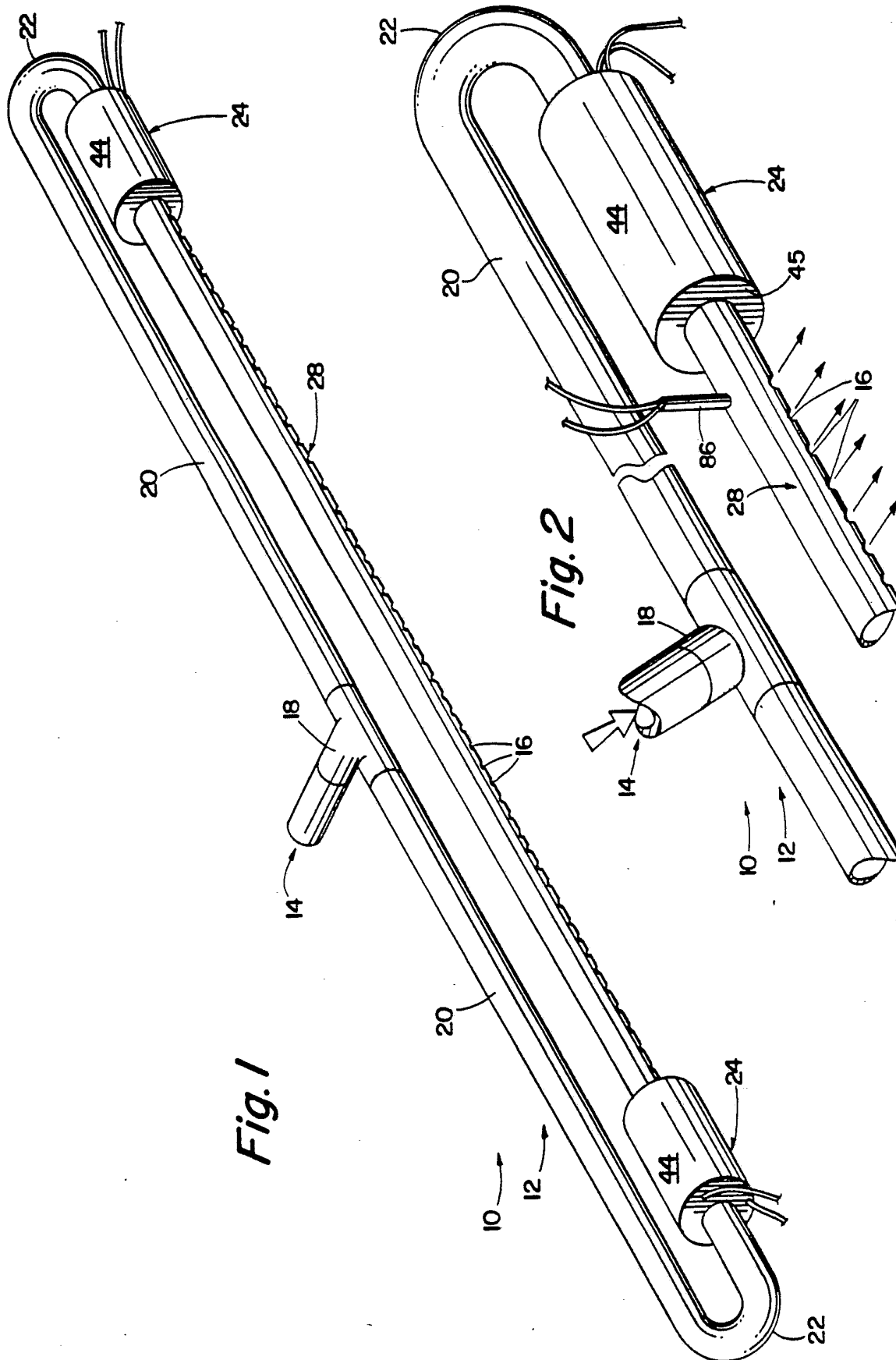
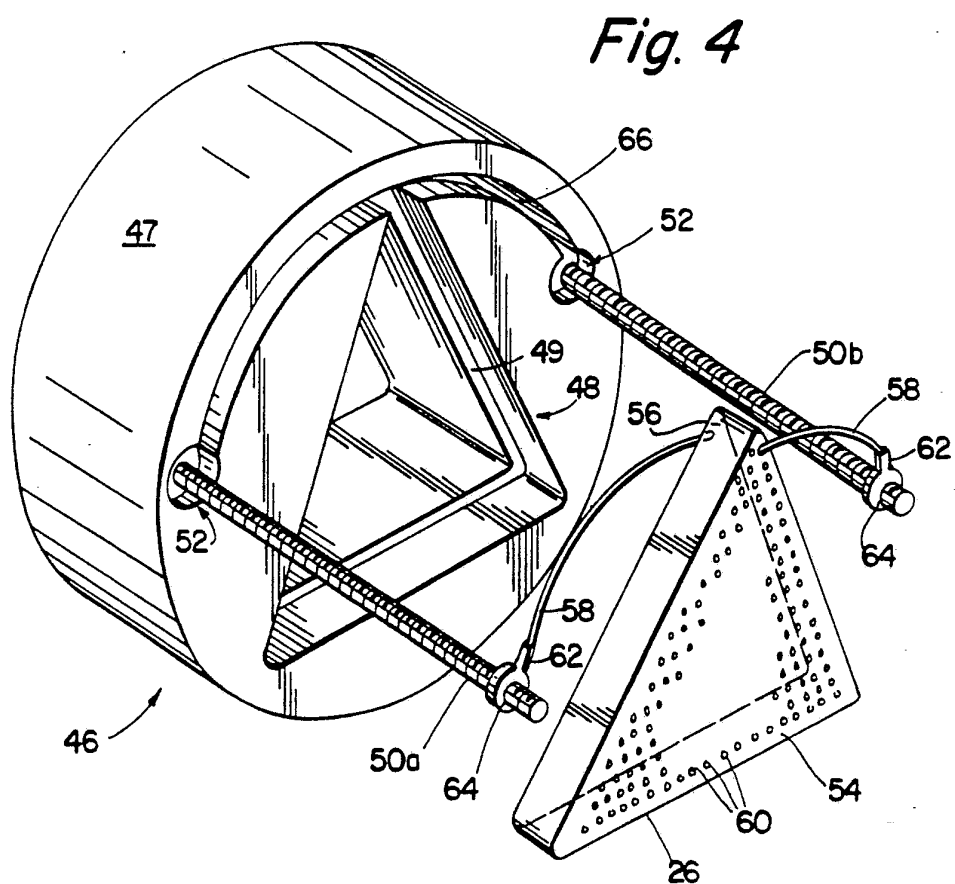
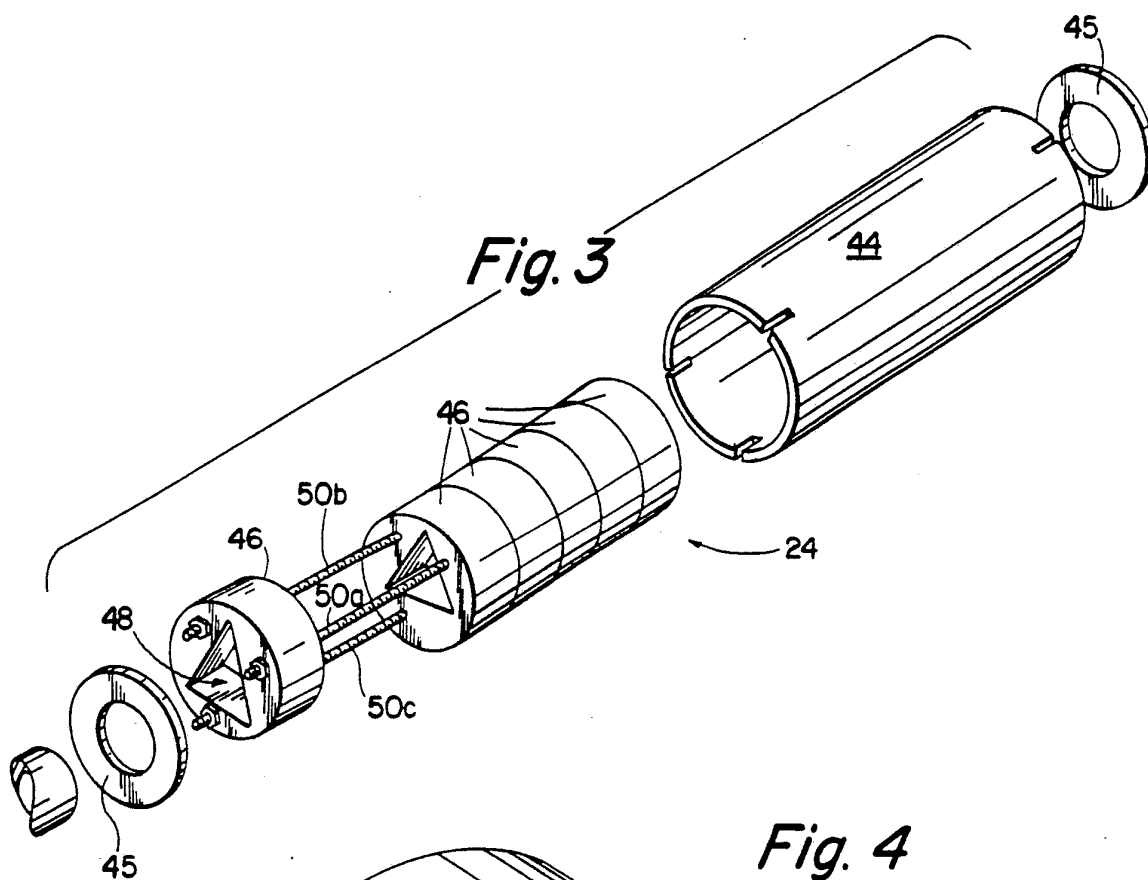


Fig. 1

Fig. 2

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SUBSTITUTE SHEET

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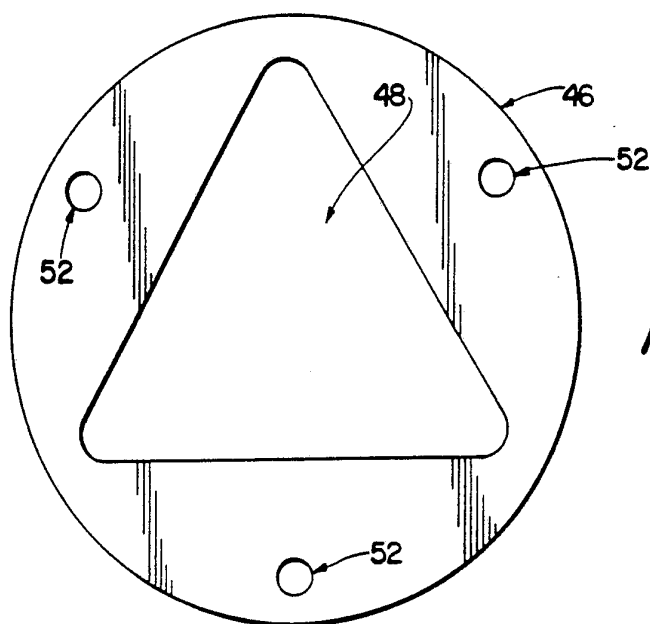


Fig. 5

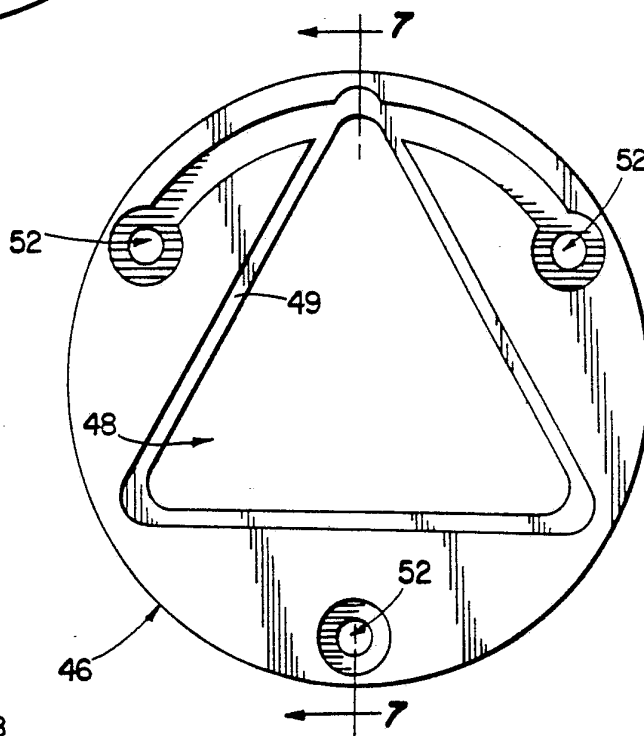


Fig. 6

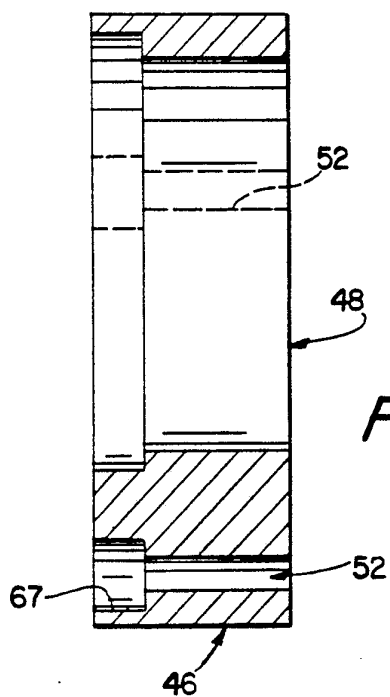


Fig. 7

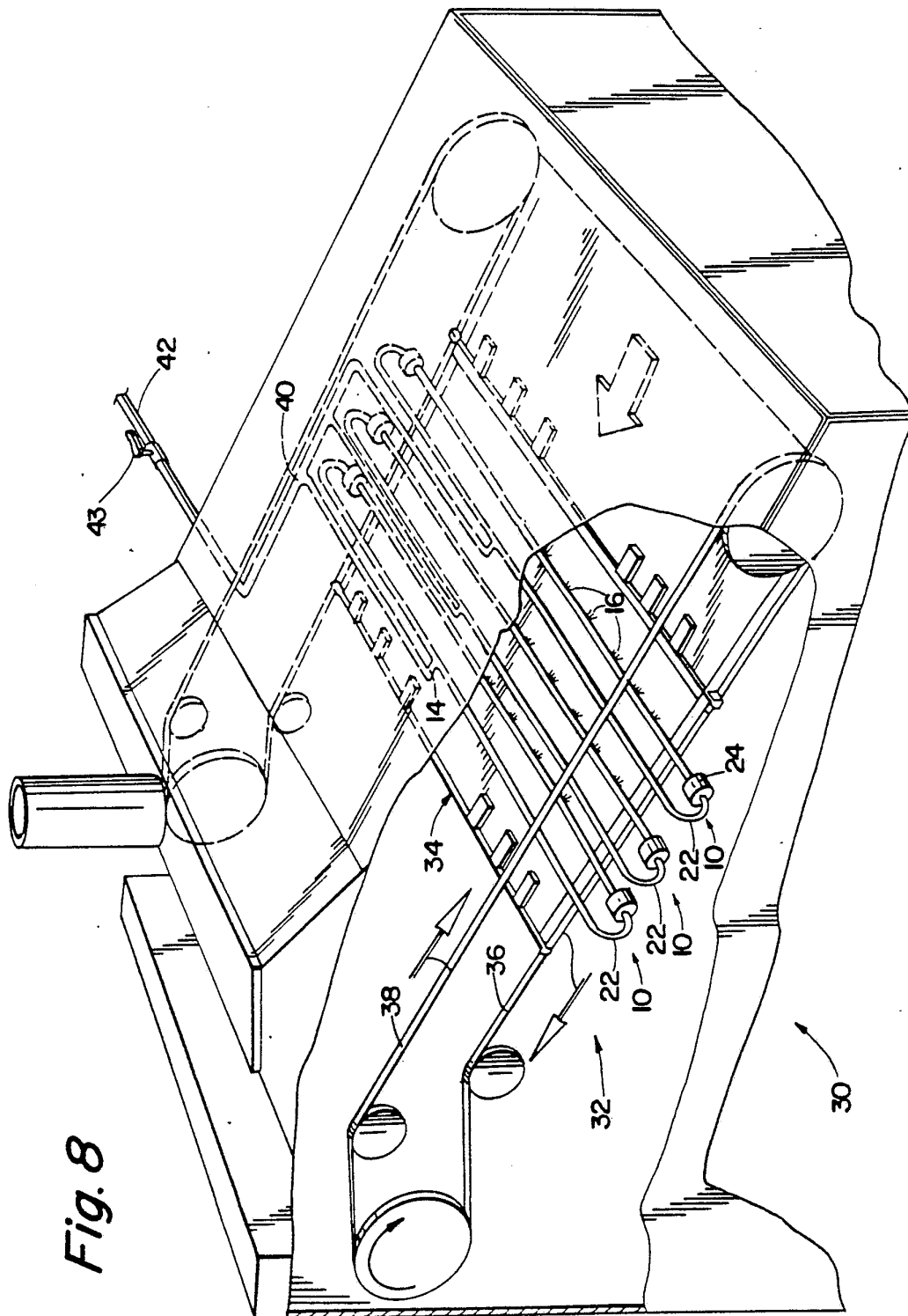
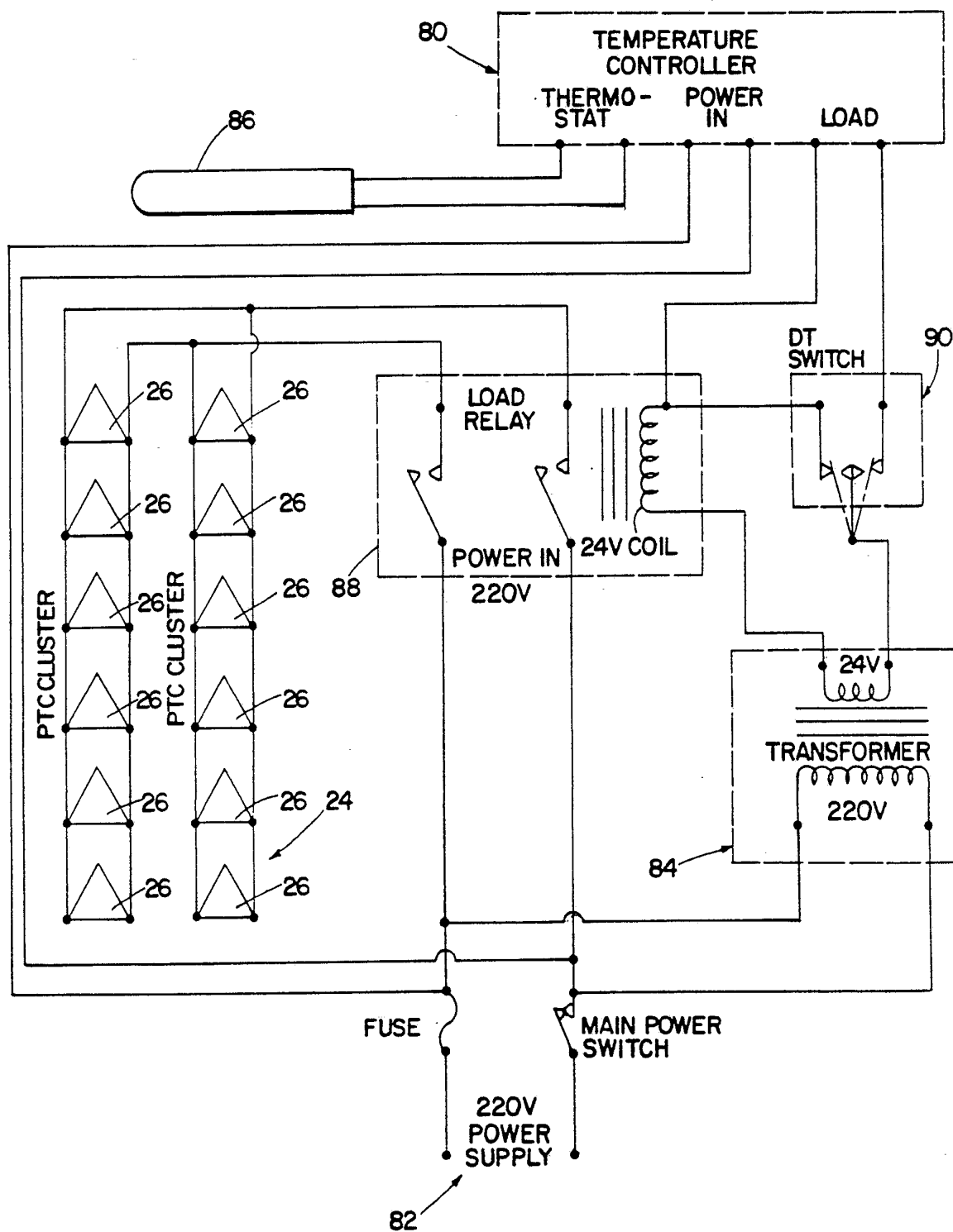


Fig. 8

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*Fig. 9*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/07402

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) : F26B 3/04, H01H 37/12; H05B 1/00

US CL : 34/33,54; 219/216; 392/379

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 34/55,48,46,26,28;392/382/504,505

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

1) S 392/379/ CCLS and PTC

2) S 392/CLAS and PTC and Fluid

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 3,526,752 (BELL), 01 SEPTEMBER 1970, See entire document.	1,2 and 9
Y	US,A, 4,717,813 (BERG ET AL), 05 JANUARY 1988, See entire document.	1,2,6,7 and 9-12
Y	US,A, 5,028,763 (CHUNG-TAI), 02 JULY 1991, See col 2, lines 12-66.	4,6 and 7
A	US,A, 4,195,415 (LIVINGS ET AL), 01 APRIL 1980, See entire document.	13
A	US,A, 3,975,832 (MORI ET AL), See col 5, lines 42-61.	13

☐

Further documents are listed in the continuation of Box C.

☐

See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

06 NOVEMBER 1992

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/07402

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

Restriction to one of the following inventions is required:

I. Claims 13-16, drawn to electrical heating means for controlling airflow temperature to accelerate drying of a liquid media in a drier apparatus, classified in Class 34, subclass 60.

II. Claims 1-12, drawn to electrical heating means for controlling airflow temperature, classified in class 392/379.

Invention of Group I pertaining to the electrical heating means of controlling airflow temperature to accelerate drying of a liquid media in a drier apparatus and Group II pertaining to electrical heating means of controlling airflow temperature are related as combination and subcombination. Inventions in this relationship are distinct if it can be shown that (1) the combination as claimed does not require the particulars of the subcombination as claimed for patentability, and (2) that the subcombination has utility by itself or in other combinations. (M.P.E.P. § 806.05(c)). In the instant case, the combination as claimed does not require the particulars of the subcombination as claimed because the airflow temperature through the printer press drier apparatus could be controlled by separate means such as a heat exchanger or a radiant heat pipe connected to a thermostat. The subcombination has separate utility such as providing temperature heating for hair curlers or an electronic mosquito zapper.