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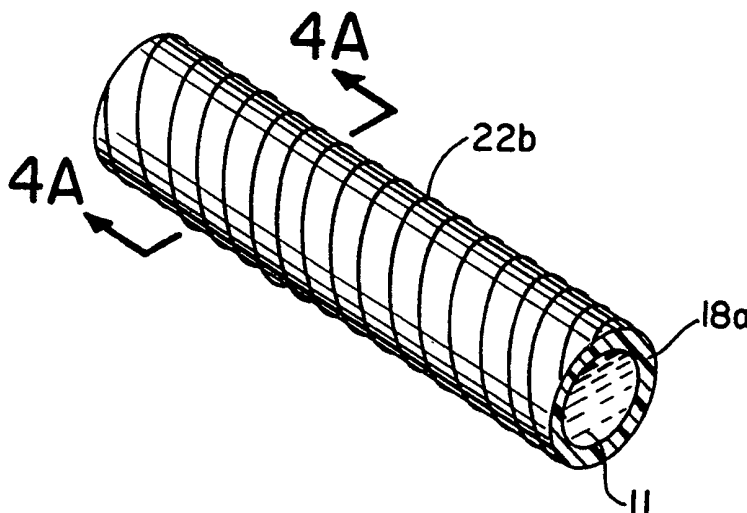
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(54) Title: SYSTEM AND APPARATUS FOR WARMING PATIENT INFUSION MEDIUM



(57) Abstract: A system for infusing a medium into a patient is disclosed which includes a tube (18), around or through which the patient infusion medium (11) flows from an input end (16) which receives from the reservoir (14) to a discharge end (20) which flows to the patient (12), an electrical conductor (22) in contact with a portion of the tube (18) or the infusion medium (11) and an electric circuit (24) which heats the electrical conductor (22) when activated. The electric circuit (24) includes a power source which heats the electrical conductor in a controlled manner. The electric circuit senses the temperature of the patient infusion medium at the discharge end of the tube (20) and also senses the temperature at the electrical conductor and shuts down the power

source if either temperature reaches a temperature which can be dangerous.

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"SYSTEM AND APPARATUS FOR WARMING PATIENT INFUSION MEDIUM"

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15 CROSS-REFERENCE TO RELATED APPLICATIONS

Priority of US Patent Application Serial No. 09/357,787, filed 21 July 1999, incorporated herein by reference, is hereby claimed.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

20 REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

25 The present invention relates generally to methods and apparatus for heating a fluid as it flows through a tube, and in particular, to methods and apparatus for heating patient infusion medium as it is infused into a patient.

Even more particularly, the present invention relates to an improved method and apparatus for warming a patient (human or animal) that provides a tube (or tape for remainder).

2. General Background of the Invention

30 Hypothermia and its disastrous side effects have been tolerated by the medical community for many years. Medical experts know that warm fluids are needed to treat patients

and victims who may suffer from the pain and complications of hypothermia, but there has been no medical device that could produce warmed blood and other intravenous fluids in both pre-hospital emergencies and in all hospital settings.

The overall goal of fluid warming is to prevent and treat hypothermia. Hypothermia
5 occurs when the patient core temperature drops below 95 degrees F or 35 degrees C. Intravenous fluid warming increases the core temperature of the body. It enhances CPR and other emergency measures, which are often ineffective with core temperatures below 95 degrees F or 35 degrees C. In the hospital, intravenous fluid warming helps prevent other costly complications.

Preventing and treating hypothermia is a critical issue in patient care quality and cost.
10 Recent studies have tracked the costs of complications caused by hypothermia, including (a) impaired wound healing, (b) more frequent infections, (c) morbid cardiac events, (d) respiratory failure, (e) increased bleeding, (f) prolonged length of hospitalization, and (g) death.

Prior systems exist which heat patient infusion media for infusion into a patient by heating the infusion tube indirectly, using excessive power for emergency or field use. Such
15 systems have used coiled tube to save space and minimize the area necessary for contact by the indirect heating element. Some such systems have attempted to monitor the temperature of the fluid at some point in the tube.

Current methods of warming fluids include use of microwave or stationary heating of the intravenous bags, which cool quickly when hung on the intravenous pole. There is a need for a
20 portable, disposable, low cost unit that can prevent and treat hypothermia with emergency patients in the field and in the hospital.

BRIEF SUMMARY OF THE INVENTION

A system for infusing a medium into a patient from a medium reservoir includes a tube,
25 around or through which the patient infusion medium flows from an input end which receives from the reservoir to a discharge end which flows to the patient, an electrical conductor in contact with a portion of the tube and an electric circuit which heats the electrical conductor when activated. The electric circuit includes a power source which heats the electrical conductor in a controlled manner. The electric circuit senses the temperature of the patient infusion medium
30 at the discharge end of the tube and also senses the temperature at the electrical conductor and shuts down the power source if either the temperature of the electrical conductor reaches a

temperature which might damage the tube or the temperature of the patient infusion medium at the discharge end of the tube reaches a temperature which might endanger the patient.

In one arrangement, the electrical conductor is, at least in part, a metal deposited on the portion of the tube by metal ionization, electroplating or other depositing process. One suitable
5 such metal is aluminum, but a conductive metal alloy can be tailored to the conductance required by a particular application. In other arrangements, the electrical conductor includes woven carbon fiber substantially surrounding the tube or is some conductor woven into the tube. In one arrangement, the tube is made up of a plurality of layers and the electrical conductor is co-extruded between two layers of the tube. In a number of arrangements, the electrical conductor
10 comprises one or more metal wires: a metal wire forming a spiral around the tube, one or more metal wires woven around the tube. In one arrangement, the tube includes multi-lumen tubing, and the electrical conductor occupies at least one of the lumens.

In another arrangement, the electrical conductor is in direct contact with the patient infusion medium. In one version of this arrangement, the electrical conductor is, in part, a wire
15 running inside a portion of the tube.

One arrangement of a system according to the present invention further includes a tube holder, and the portion of the tube in contact with the electrical conductor is coiled around the tube holder, substantially conforming to the shape of the tube holder. The tube holder includes two surfaces wherein sections of the tube are substantially linear along each surface. The two
20 surfaces are connected to each other at each end by one or two surfaces wherein sections of the tube are substantially curved, so that the coiled tube forms a substantially flat package.

These are other objects, advantages and features of this invention will be apparent from the following description taken with reference to the accompanying drawings, wherein is shown a preferred embodiment of the invention and wherein like reference numerals denote like
25 elements.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a system for infusing a medium into a patient according to the present invention;

Figure 2 is a cross-sectional view of a tube and electrical conductor according to the
30 present invention;

Figure 3 is a schematic representation of an electric circuit to heat the electrical

conductor;

Figure 4 is a perspective view of a tube and an electrical conductor according to the present invention;

Figure 4A is a sectional view of the tube and an electrical conductor in Figure 4;

5 Figure 5 is a perspective view of another embodiment of a tube and an electrical conductor according to the present invention;

Figure 5A is a sectional view of the tube and electrical conductor in Figure 5;

Figure 6 is a perspective view of yet another embodiment of a tube and an electrical conductor according to the present invention;

10 Figure 7 is a perspective view of yet another embodiment of a tube and an electrical conductor according to the present invention; and

Figure 8 is a perspective view of a tube holder according to the present invention holding a combination tube and electrical conductor in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

15 Referring now to the drawings, and in particular to Figure 1, a system according to the present invention is referred to by numeral 10. System 10 infuses patient infusion medium 11 into a patient 12 from a medium reservoir 14. Examples of such patient infusion media would include blood plasma, platelets, saline solution, glucose solution, chemotherapy treatment, intravenous feeding and intra-abdominal infusion. The patient infusion medium flows from the
20 reservoir to the patient through tubes 16, 18 and 20.

Referring also to Figure 2 and Figure 3, an electrical conductor 22 is in direct contact with tube 18, and an electric circuit 24 heats the electrical conductor in a controlled manner when activated. The electric circuit includes a power source such as twelve volt battery 26 or dc power source 28 which runs from an ac wall socket, either of which can power a regulated voltage
25 circuit 30, which in turn provides regulated voltage 32. Electric circuit 24 senses the temperature T1 of the patient infusion medium at the discharge end of the tube and also senses the temperature T2 at the electrical conductor and shuts down regulated voltage source 30 if either temperature T2 of the electrical conductor reaches a temperature which might damage the tube or temperature T1 of the patient infusion medium at the discharge end of the tube reaches a
30 temperature which might endanger the patient.

In one arrangement, the electrical conductor 22a is, at least in part, a metal deposited on

the portion of the tube by metal ionization. One suitable such metal is aluminum. In other arrangements, electrical conductor 22a includes woven carbon fiber substantially surrounding the tube or is some conductor woven into the tube. Referring to Figure 5, in one arrangement, the tube is made up of a plurality of layers 18a and 18b, and electrical conductor 22c is co-extruded
5 between two layers of the tube. In a number of arrangements, the electrical conductor comprises one or more metal wires: referring to Figure 4, a metal wire 22b forming a spiral around tube 18a; referring again to Figure 5, one or more metal wires 22c woven around tube 18a. Referring now to Figure 6, in one arrangement, tube 18c includes multi-lumen tubing, and electrical conductor 22d occupies at least one of the lumens, the central lumen as illustrated.

10 Referring to Figure 7, in another arrangement, electrical conductor 22e is in direct contact with the patient infusion medium 11. In one version of this arrangement, the electrical conductor is, in part, a wire running inside a portion of the tube.

Referring to Figure 8, one arrangement of a system according to the present invention further includes a tube holder 34, and portion 18 of the tube in contact with the electrical
15 conductor is coiled around the tube holder, substantially conforming to the shape of the tube holder. Tube holder 34 includes two surfaces 36 and 38 wherein sections of tube 18 are substantially linear along each surface. The two surfaces are connected to each other at each end by one of two surfaces 40 and 42 wherein sections of the tube are substantially curved, so that the coiled tube forms a substantially flat package.

20 From the foregoing it will be seen that this invention is well adapted to attain all of the ends and objectives hereinabove set forth, together with other advantages which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and
25 is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the figures of the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

CLAIMS

1. A system for infusing a medium into a patient from a medium reservoir comprising, in combination:
 - a) a tube, around or through which the patient infusion medium flows from an input end which receives from the reservoir to a discharge end which flows to the patient;
 - b) an electrical conductor in contact with a portion of the tube; and
 - c) an electric circuit which heats the electrical conductor when activated.
2. A system according to Claim 1, wherein the electrical conductor comprises a metal deposited on the portion of the tube.
3. A system according to Claim 2, wherein the metal comprises a conductive alloy.
4. A system according to Claim 1, wherein the electrical conductor comprises woven carbon fiber substantially surrounding the tube.
5. A system according to Claim 1, wherein the electrical conductor is woven into the tube.
6. A system according to Claim 1, wherein the tube comprises a plurality of layers and the electrical conductor is co-extruded between two layers of the tube.
7. A system according to Claim 6, wherein the electrical conductor comprises one or more metal wires.
8. A system according to Claim 1, wherein the electrical conductor comprises a metal wire forming a spiral around the tube.
9. A system according to Claim 1, wherein the electrical conductor comprises a metal wire forming a spiral around the tube.
10. A system according to Claim 1, wherein the tube comprises multi-lumen tubing, and wherein the electrical conductor occupies at least one of the lumens.
11. A system according to Claim 1, further including a tube holder comprising two surfaces wherein sections of the tube are substantially linear along each surface, and the two surfaces are connected to each other at each end by one of two surfaces wherein sections of the tube are substantially curved, wherein the portion of the tube in contact with the electrical conductor is coiled around the tube holder, substantially conforming to the shape of the tube holder.
12. A system for infusing a medium into a patient from a medium reservoir comprising, in combination:

a) a tube, around or through which the patient infusion medium flows from an input end which receives from the reservoir to a discharge end which flows to the patient;

b) an electrical conductor in contact with the patient infusion medium; and

c) an electric circuit which heats the electrical conductor when activated.

13. A system according to Claim 12 wherein the electrical conductor comprises a wire inside a portion of the tube.

14. A system for infusing a medium into a patient from a medium reservoir comprising, in combination:

a) a tube, around or through which the patient infusion medium flows from an input end which receives from the reservoir to a discharge end which flows to the patient;

b) an electrical conductor in contact with a portion of the tube; and

c) an electric circuit which heats the electrical conductor in a controlled manner when activated.

15. A system according to Claim 14, wherein the electric circuit comprises a power source which heats the electrical conductor and wherein the electric circuit senses the temperature of the patient infusion medium at the discharge end of the tube and also senses the temperature of the electrical conductor.

16. A system according to Claim 15, wherein the electric circuit shuts down the power source if either the temperature of the conductor reaches a temperature wherein it might damage the tube or the temperature of the patient infusion medium at the discharge end of the tube reaches a temperature which might endanger the patient.

17. A system according to Claim 16, wherein the electrical conductor comprises a metal deposited on the portion of the tube.

18. A system according to Claim 17, wherein the metal comprises a conductive alloy.

19. A system according to Claim 16, wherein the electrical conductor comprises woven carbon fiber substantially surrounding the tube.

20. A system according to Claim 16, wherein the electrical conductor is woven into the tube.

21. A system according to Claim 16, wherein the tube comprises a plurality of layers and the electrical conductor is co-extruded between two layers of the tube.

22. A system according to Claim 21, wherein the electrical conductor comprises one or more metal wires.

23. A system according to Claim 16, wherein the electrical conductor comprises a metal wire forming a spiral around the tube.

24. A system according to Claim 16, wherein the electrical conductor comprises one or more metal wires woven around the tube.

25. a system according to Claim 16, wherein the tube comprises multi-lumen tubing, and wherein the electrical conductor occupies at least one of the lumens.

26. A system according to Claim 16, further including a tube holder comprising two surfaces wherein sections of the tube are substantially linear along each surface, and the two surfaces are connected to each other at each end by one of two surfaces wherein sections of the tube are substantially curved, wherein the portion of the tube in contact with the electrical conductor is coiled around the tube holder, substantially conforming to the shape of the tube holder.

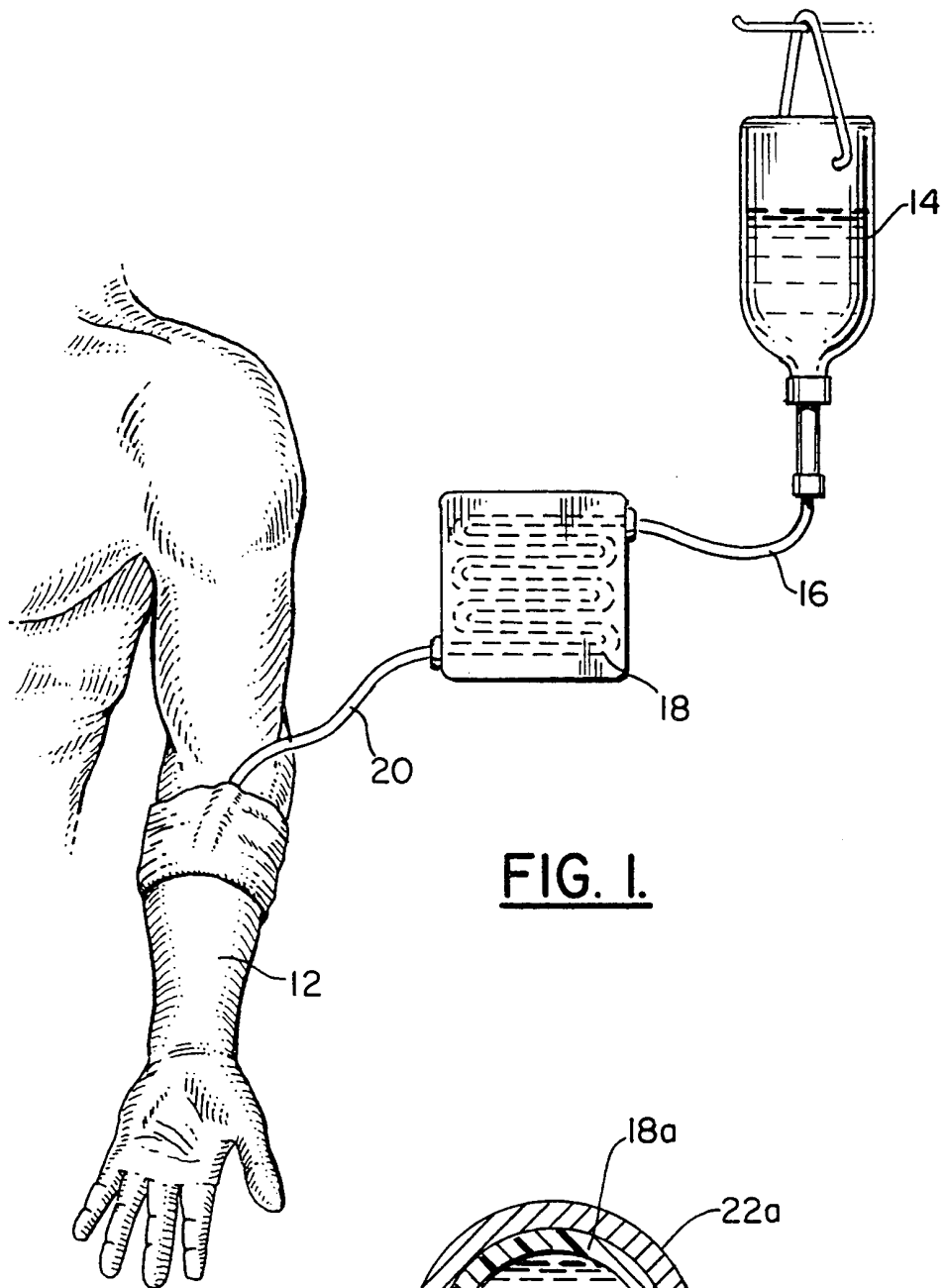


FIG. 1.

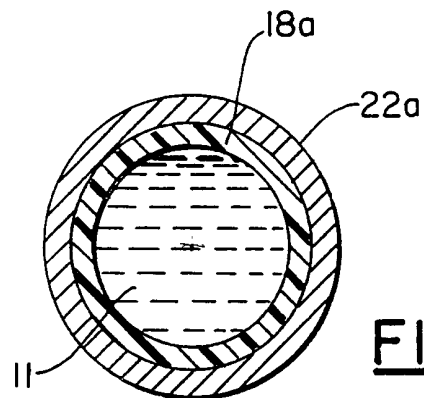


FIG. 2.

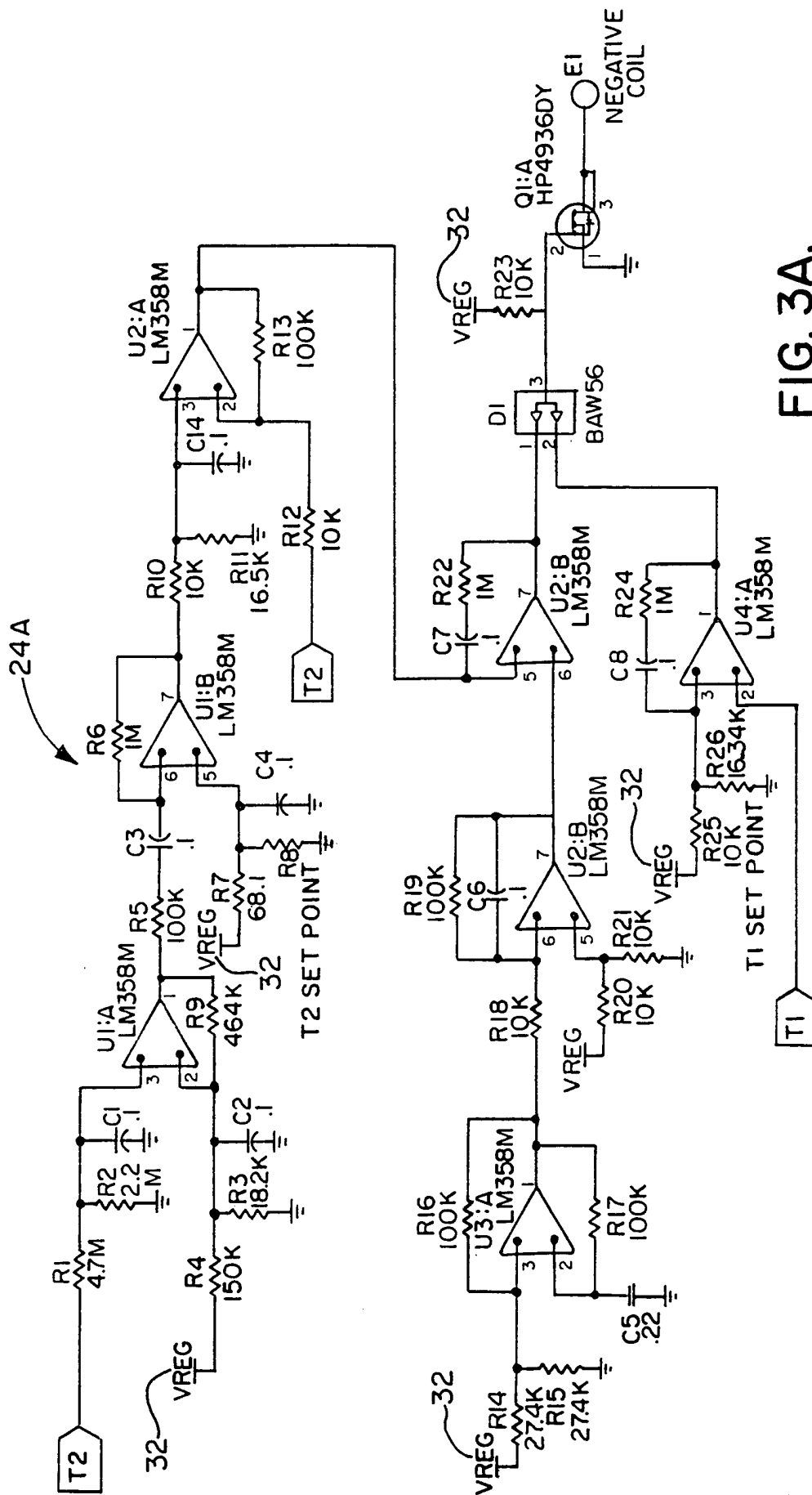


FIG. 3A.

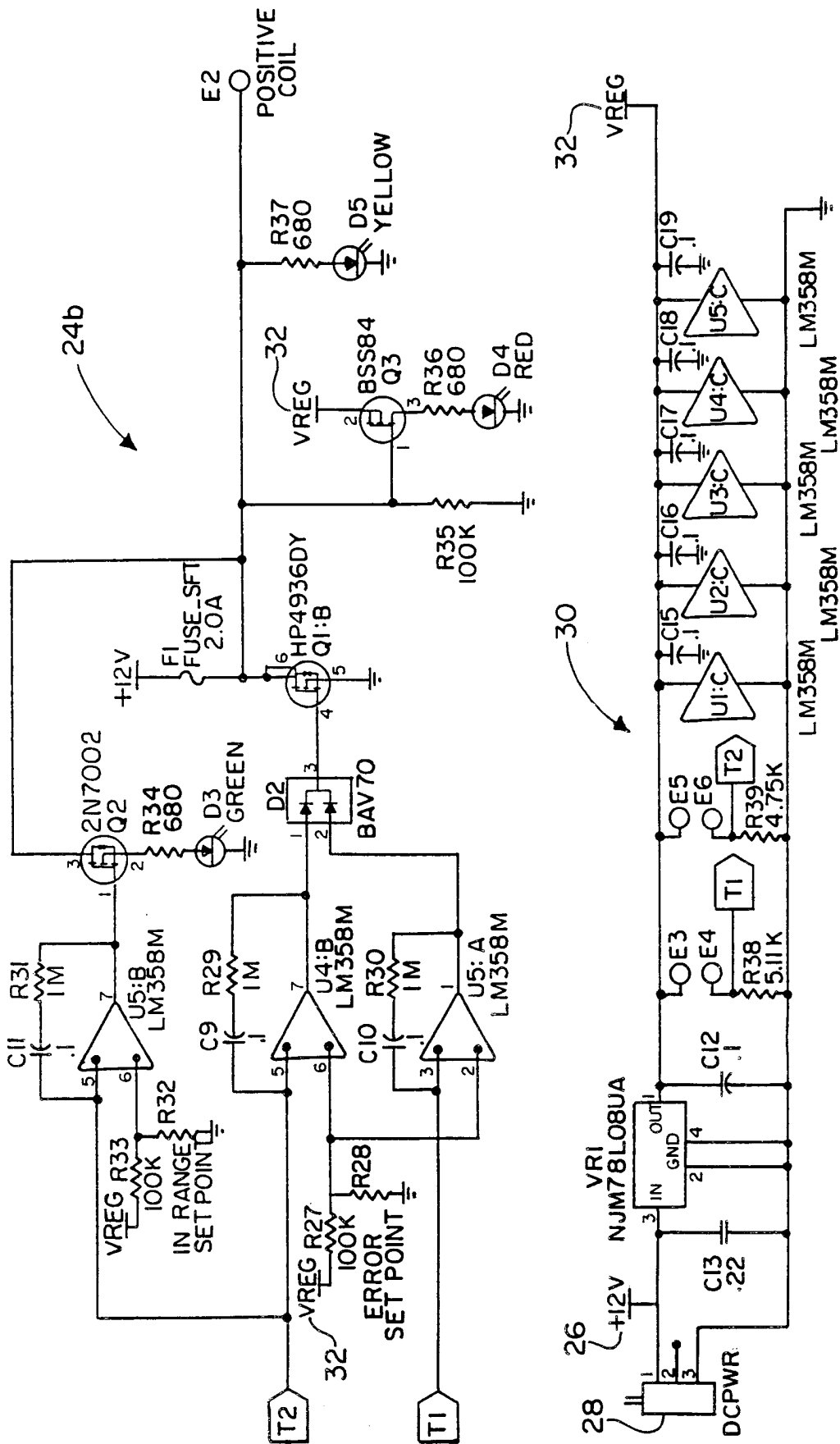


FIG. 3B.

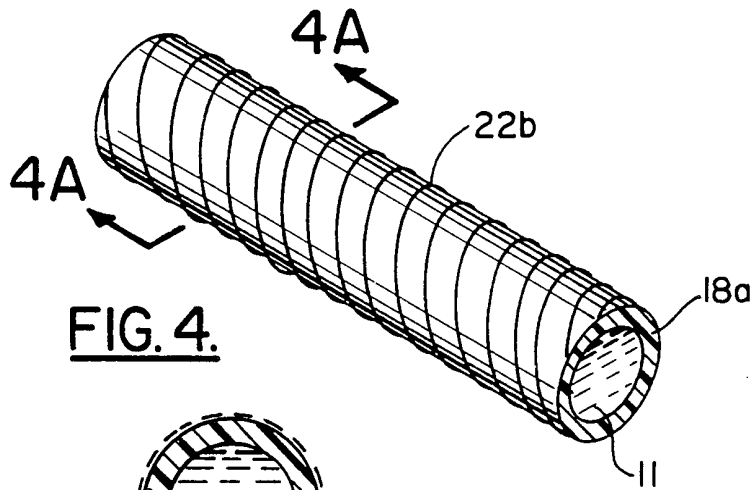


FIG. 4.

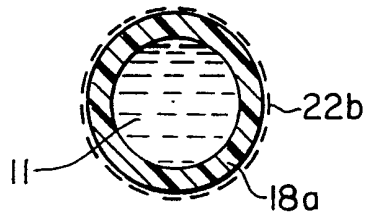


FIG. 4A.

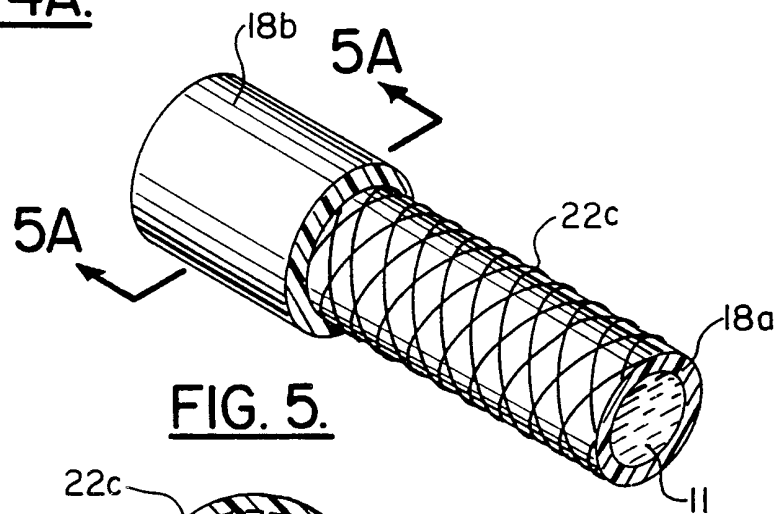


FIG. 5.

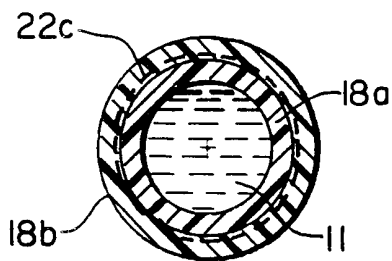


FIG. 5A.

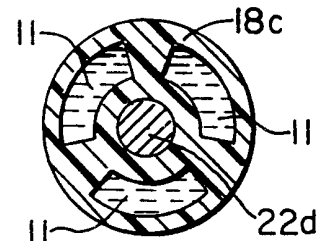
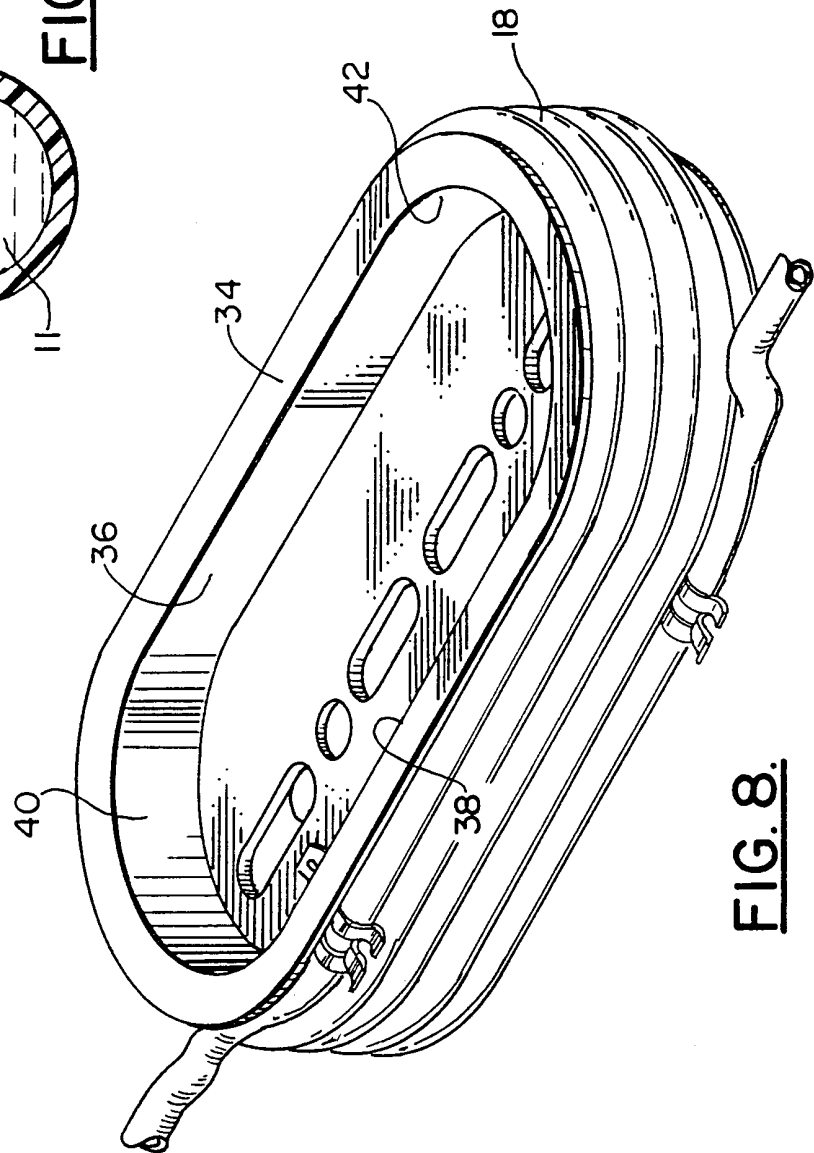
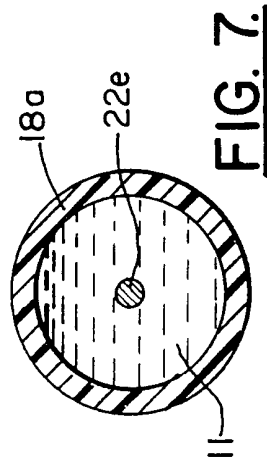


FIG. 6.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/19812

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :A61M 31/00
US CL :Please See Extra Sheet.

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. : 604/48, 65, 66, 67, 93.01, 131, 523, 524, 527

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X <u>Y</u>	US 5,211,626 A (Frank et al.) 18 May 1993, see column 10, lines 60- column 11, line 15.	1-3, 7, 12-18, 21, 22 <u>4-6, 8-11, 19, 20, 23-26</u>
Y	US 4,383,131 A (Clabburn) 10 May 1983, column 3, lines 4-5.	4-5, 8, 9, 19, 20, 23, 24
A, T	US 6,118,111 A (Price et al.) 12 September 2000, column 4, line 28 - column 6, line 12.	1-26

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
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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