

[54] **ENERGY TRANSMISSION APPARATUS**

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[51] Int. Cl.**A61b 19/00**

[58] Field of Search 128/1, 399, 395; 119/39, 37, 119/40, 33; 350/96, 1; 240/1; 219/347, 385, 391, 407

[56] **References Cited**

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[57] **ABSTRACT**

Energy transmission apparatus for controlling neonate body temperature consisting of a support platform for infant support, a heat source in proximity to the platform, energy guides surrounding the platform which transmit and guide heat energy from the heat source to the platform, and a heat control for controlling changes of the heat source in accordance with body temperature changes of the neonate in order to maintain the body temperature constant.

6 Claims, 7 Drawing Figures

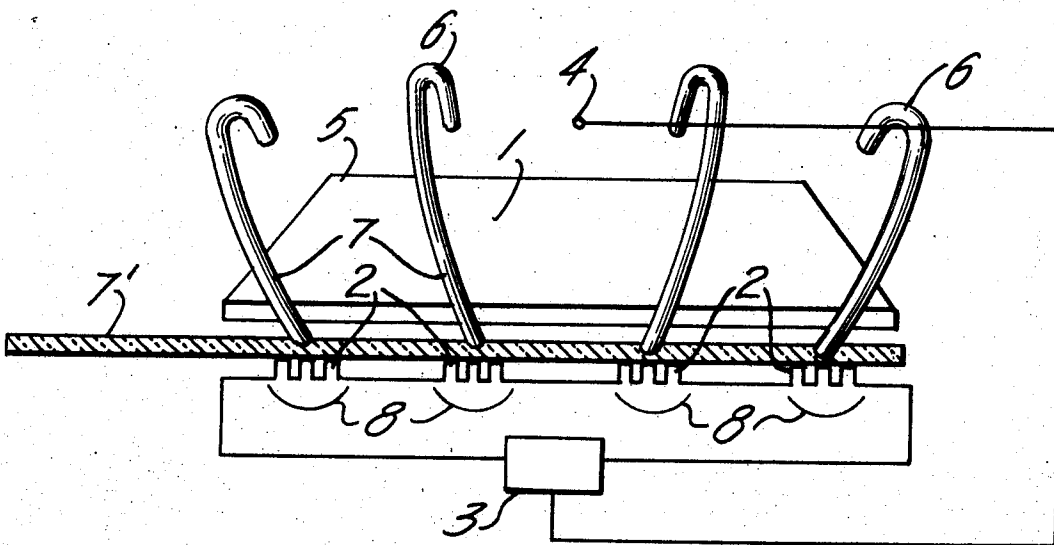


FIG. 1

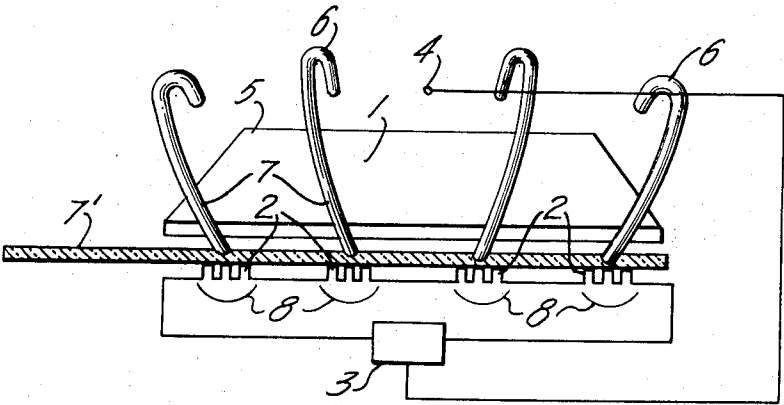


FIG. 2

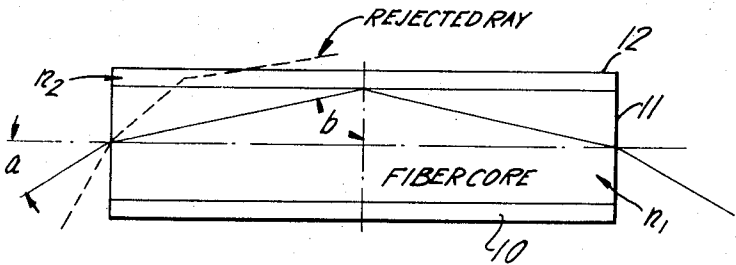


FIG. 3a

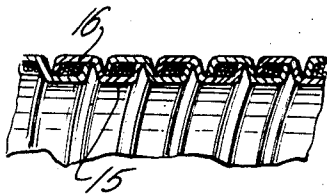
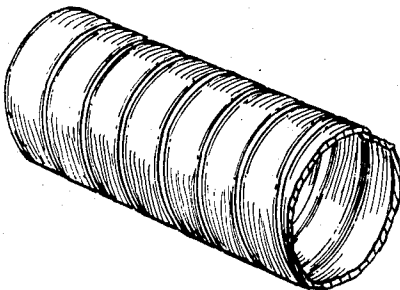


FIG. 3

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FIG. 4

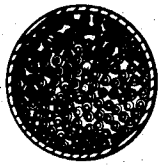


FIG. 4a

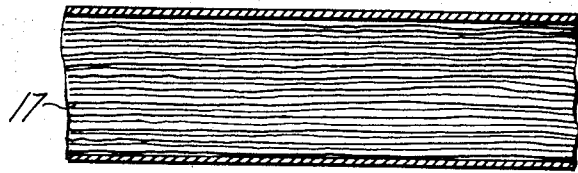
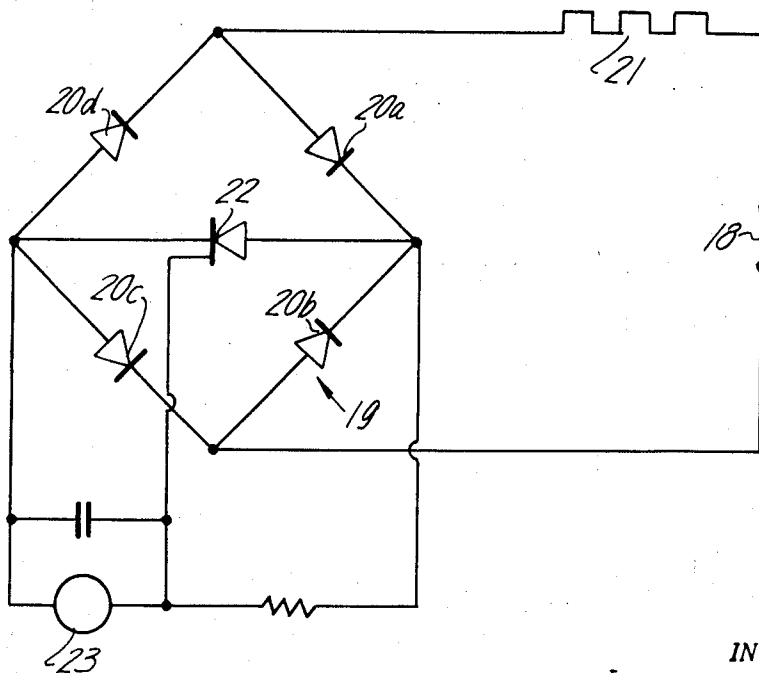


FIG. 5



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ENERGY TRANSMISSION APPARATUS

In a hospital environment where newborn infants are confined, especially those undergoing surgery, the survival probability of such infants, especially of premature and sick newborns, has been enhanced in recent years by the maintenance of these infants in a zone of thermal neutrality, (i.e., a temperature at which oxygen consumption is a minimum).

Tiny and sick infants are unable to support a normal temperature in a thermally hostile environment. There is a definite degree of heat loss by premature neonates, and unless such heat loss is compensated for by some external source, severe metabolic demands will be made on the infant which he cannot sustain or meet, and his overall condition rapidly deteriorates to the extent that his chances for survival become suspect and brain damage would ensue. The primary concern of this application is the development of apparatus that will maintain the neonate in the neutral zone (optimum body temperature of the infant) during surgical procedures. It is a fact that in most cases under surgical conditions that hemo-thermia problems are enhanced by the anesthetic suppression of the thermo-regulatory mechanism of the body. It is absolutely necessary to replace the infant's heat loss when such losses occur during clinical, nursery and surgical situations aforementioned. Further, by the use of controlled and directed heat toward the neonate, it is possible to maintain satisfactory and comfortable temperatures for the hospital staff, particularly in the operating room.

It is therefore a primary object of the invention to provide a system for maintaining a neonate at a temperature that is in the zone of thermal neutrality.

Another object of the invention is to provide a temperature control system which automatically replaces heat loss of a neonate in a surgical, nursery and clinical atmosphere.

Another object of the invention is to provide a controlled heat source system for neonates which in a surgical, clinical and nursery atmosphere may be selectively directed toward the neonate to substantially control its body temperature in a selective area.

Another object of the invention is to provide a self-compensating heat control system for neonates in a clinical atmosphere which compensates for heat loss in one area by adding heat in another area.

Another object of the invention is to provide flexible means of transmitting energy and the control thereof through a fiber optics system.

A still further object of the invention is to provide energy guide flexible tubular members having highly polished internal reflective surfaces for the transmission of radiant energy.

Other objects and advantages will become apparent from a reading of the specifications and a study of the accompanying drawings in which:

FIG. 1 is a diagrammatic configuration of a neonate heat control system according to the invention;

FIG. 2 is a diagrammatic view of a fiber optic transmitter capable of transmitting light energy illustrated for instructive purposes;

FIGS. 3 and 3a show partially sectionalized a hollow goose-neck energy transmission guide consisting of helically wrapped interlocking strips with the interior coated with a highly polished and reflective material such as gold;

FIGS. 4 and 4a show an energy guide composed of an assembly of finely drawn flexible fibers of an infra-red transmissive medium such as arsenic tri-sulfide;

FIG. 5 shows a detailed configuration of a schematic diagram showing one embodiment of a circuit for controlling radiant energy according to the invention.

Now describing the invention with respect to its various FIGURES and designating those elements with the same reference numbers when the functions are the same or similar, there is shown in FIG. 1 a diagrammatic drawing embodying the invention and comprising a supportable table or platform 1 disposed and having reposed thereon a neonate (not shown) capable of being kept at a constant body temperature, said temperature of the neonate being maintained at approximately 36° centigrade by the novel means herein described.

Below the table or platform 1, a source of radiant energy 2, disposed to give off energy in the form of infra-red radiation, is suitably placed and modulated by a servo-amplifier 3 having a sensing input 4 in proximity to the aforementioned neonate for monitoring his temperature and controlling the servoamplifier output accordingly. Flexible energy guides, such as fiber optic members 6, are conveniently placed about the edges of the table 5, the bottom portions of said members being placed in spaced proximity to the infra-red source 2 and the upper portion depending and directed toward said neonate in spaced proximity thereto. Reflectors 8 direct and focus the desired radiant energy into the energy guides. The fiber members 6 are each capable of receiving radiant or infra-red energy from the energy source 2, including the reflectors 8, at one end and capable of transmitting said energy to the other end in accordance with well-known fiber optics principles.

For example, merely by way of explanation, there is shown in FIG. 2 a fiber optic tube 10 for transmitting energy and composed of a fiber core 11 and surrounding cladding 12. It may be described as a core of glass surrounded by another glass which has a lower index of refraction. The fiber traps light energy within a defined critical angle a and, due to total internal reflection, transmits this light energy down the fiber to be emitted from the output at the same angle as it entered. The light energy is not transmitted through the cladding because the angle of incidence on the walls is greater than the critical angle b necessary for total reflection. The critical angle and the numerical aperture of the fiber will depend on the refractive indices of the two glasses. The numerical aperture (NA) defines the maximum acceptance angle at which the fiber can trap and reflect light energy. The relationship $NA = \sin a = \sqrt{n_1^2 - n_2^2}$ where n_1 and n_2 are the refractive indices of the two glasses, with incident ray travelling in air.

The fiber optic energy guides can be assembled in a flexible metallic or plastic tubing of such a nature that the output ends may be positioned and aimed at whatever portion of the platform or neonate desired. Helically wrapped goose-necked tubing provides the flexibility for aiming the radiant energy while it has the structural rigidity to maintain its position without any other support. Visible radiation may be incorporated in the spectral output of the energy sources in order to provide the means for observing the area irradiated by the thermal energy to permit optimum distribution of the energy to the neonate and surgical fields.

FIG. 1 further shows an optical filter 7' disposed to be placed between the heat source and energy guides to filter out light which might otherwise interfere with the surgeon's view of the operative field.

An alternate energy guide configuration, shown in FIG. 3, consists of a hollow metallic goose-neck 15 comprised of helically-wrapped interlocking strips 16 with the interior gold-plated to enhance the infra-red reflection. In procedures other than neonatal thermoregulatory systems, the hollow energy guide could be significantly more efficient than the fiber optic guides. Application of this invention to the controlled and rapid warming of surgical fields whose temperature has been depressed for medical purposes, such as open-heart surgery, could advantageously use the hollow energy guide technique.

A further energy guide configuration is shown in FIG. 4 and comprises an assembly of finely drawn, flexible fibers 17 of an infra-red transmissive medium such as, for example, arsenic trisulfide. These, too, would be incorporated into a goose-neck tube for positioning and aiming. Although the decomposition products of the former might be toxic, and economic considerations might preclude the use of silver in comparison to the other techniques described above, specific applications might indicate significant advantages of one form of energy guide over the others.

There is shown in FIG. 5 a representative circuit for providing power and controlling the heat source. In particular it is comprised of an ac voltage source 18 connected to a full-wave bridge rectifier array 19 containing rectifier elements 20a, 20b, 20c, 20d, be they electron tubes or solid-state diodes. The bridge output is connected to a resistive element or heater 21. The heater may take on the form of infra-red lamps, glow-heaters, and the like, so as to produce the necessary radiant energy.

The bridge 19 has connected thereto a solid state semiconductor control device and amplifier 22 having a sensor device or probe 23 suitably connected and disposed to change its resistive value to permit a change in the bias conditions of said amplifier so as to affect a change in the duty cycle of the current being conducted. For example, for some part of one-half cycle of the voltage source, current flows through rectifier 20a, servo-amplifier 22 and rectifier 20c to the output load 21. On the reverse cycle, current flows from voltage source through rectifier 20b, servo-amplifier 22, in same direction as previously and, finally, through 20d and again to the external load. Hence, any change in the probe resistance changes the current flow to the output load circuit.

The external sensor or probe is generally placed in contact proximity to the neonate or within its rectal orifice or core. The energy guides may be positioned and aimed by means of integral focusing goose-necks to assure complete control over the amount and direction of heat being transmitted. It is also possible to have more than one sensing probe to provide thermal control over the body temperature of the neonate under varying conditions.

It may be appreciated that if for any reason one of the energy guides were obstructed or removed to provide greater accessibility, then because of the nature of

the feed-back control system, the temperature change or heat loss would be compensated for by an increased output from the other guides. Hence, it is possible to increase or decrease the number of guides without any degradation of the thermal control system.

The invention herein presented provides means for the transmission and control of energy through fiber optic energy guides and in a broader sense has applications in industrial process control by permitting energy to be directed to areas that have to be precisely controlled.

While the invention has been described and illustrated with respect to a certain particular preferred embodiment which gives satisfactory results, it will be understood by those skilled in the art, after understanding the principle of the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended, therefore, in the appended claims to cover all such changes and modifications.

Having defined the invention, what is claimed is:

1. Energy transmission apparatus for controlling neonate body temperature changes comprising, a support platform for supporting said neonate, a heat source in proximity to said platform, fiber optic members composed of optical fibers in proximity to said platform and heat source, and disposed to receive and transfer heat from said source to said platform, and control means including a sensor interposed said platform and heat source, and disposed to control heat generated from said source in response to temperature changes sensed by said sensor to maintain constant body temperature of said neonate.

2. Energy transmission apparatus according to claim 1 and further including reflectors in proximity to said fiber optic members for reflecting energy from said heat source to said fiber optic members.

3. Energy transmission apparatus for controlling neonate body temperature changes comprising a support platform for supporting said neonate, a heat source in proximity to said platform, energy guide means in proximity to said platform and heat source, said energy guide means including tubular flexible guides, and disposed to receive and transfer heat from said source to said platform, and control means including a sensor interposed said platform and heat source, and disposed to control heat generated from said source in response to temperature changes sensed by said sensor to maintain constant body temperature of said neonate.

4. Energy transmission apparatus according to claim 3 and wherein said tubular flexible guides are composed of helically wrapped interlocking gold plated strips configured to provide flexibility and enhance energy reflection.

5. Energy transmission apparatus according to claim 3 and wherein said tubular flexible guides have internal arsenic tri-sulphide flexible fibers.

6. Energy transmission apparatus according to claim 3 and wherein said energy guide means further include reflectors for reflecting energy from said heat source to said tubular flexible guides.

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