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(54) APPARATUS FOR THE APPLICATION OF R.F. ENERGY TO BIOLOGICAL SUBSTRATES IN HUMAN AND/OR ANIMAL THERAPY

(71) I, HARRY HENRY LEVEEN, a Citizen of the United States of America of 800 Poly Place, Brooklyn, New York 11209, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for the application of R.F. energy to biological substrates. Said apparatus is used in human and/or animal therapy.

In accordance with the present invention, there is provided an apparatus for the application of radio freqeuncy electromagnetic energy to a biological substrate in human and/or animal therapy which apparatus comprises generator means for the generation of radio frequency electromagnetic power, and applicator means for applying the radio frequency power output of said generator means to a said biological substrate, said applicator means including a plurality of applicator pairs for setting up a radio frequency electro magnetic field therebetween when connected to said radio frequency generator means, switching means for coupling the power output of said radio frequency generator means selectively across each said pair, one pair at a time, and control means for actuating said generator means and said switching means to couple said power output to each of said applicator pairs automatically in predetermined sequence.

The apparatus is especially advantageous in the necrosis of tumors in cases where a high level of energy is required over a long period of treatment, e.g. several hours in some cases. It can maintain a constant level of R.F. energy input on the tumor target while at the same time minimising skin surface heating and skin burn irritation.

In the use of the apparatus, the applicators, conveniently plates of each pair, are placed parallel to each other along an axis extending through the target tumor mass, but the individual pairs are aligned on different axes, such that the portals of entry, ie. the surfaces of the body against which the applicators are positioned, differ. The various axes of paired applicators of course intersects at the tumor mass within the body. The various sets of pairs are operated such that when R.F. energy is applied to one pair, the other pairs are unenergized and inactive. When the first pair is shut off by the switching means, the next pair is automatically activated and so on in sequence through the remaining pairs, activating one pair at a time.

According to a preferred arrangement, the control means includes a plurality of timer means, each timer being associated with a respective applicator pair and with switching means in a manner whereby the duration of radio frequency power supply to each said applicator pair is determined by its associated timer means independently of the duration of radio frequency power supply to the or each other applicator pair. The control means preferably operates to deactivate said generator means when actuating said switching means to change the coupling of the R.F. power of said generator means from one to another of said applicator pairs.

The following description in which reference is made to the accompanying drawing is given in order to illustrate the invention. In the drawing:

FIG. 1 shows a block diagram the arrangement of the various component parts of the system; and

FIG. 2 illustrates the application of the invention in therapeutic treatment of a tumor.

In FIG. 1 the reference numeral 10 generally designates a radiofrequency power generator for generating radiofrequency electromagnetic power having a frequency of 13.56 MHz, R.F. generator 10 basically includes a crystal controlled signal generator 30 the output of which is connected to a power amplifier 40 capable of output of up to a kilowatt or more at the frequency of 13.56 MHz supplied by signal generator 30.

The apparatus also includes a control

mechanism 20 for controlling the operation of a coaxial switch mechanism 50 connected to the output of power amplifier 40 for selectively coupling the output of power amplifier 40 to any of three output circuits 61, 62 and 63 through matching networks, and forward power meters indicated generally by the reference numeral 60. Each output circuit 61, 62 and 63, includes a pair of shielded output leads connected across the output of the R.F. generator, in the illustrated case through matching networks 60 and switch 50, which lead to a pair of applicators in the form of plates, in the illustrated case denoted by the reference numerals A and A′ for output circuit 61, B and B′ for output circuit 62 and C and C′ for output circuit 63. Applicators A-A′, B-B′ and C-C′ are intended to be placed generally parallel to each other in pairs such as pair A and A′ with the tumor mass T located between them and with the applicators placed flat against the surface of the body in intimate contact with it. Generally, the pairs of applicators, such as A and A′, associated with each output, such as circuit 61, as shown in FIG. 2, are arranged such that they are aligned perpendicularly to an axis extending through the tumor mass T which is to be treated. In addition the various pairs of applicators are positioned such that the axes of alignment differ but all pass through and approximately intersect at the location of the tumor mass T.

Control mechanism 20 is a stepping switch or ring counter designed when actuated to advance repetitively through a series of three positions. Control mechanism 20 is arranged with suitable timers, switch logic, driving mechanisms and power supply to connect power sequentially through output lines 21, 22 and 23 to operate coaxial switch 50 to connect the output of power amplifier 40 through matching networks and meters 60 to output circuit 61, output circuit 62 and output circuit 63, respectively, as indicated schematically in FIG. 1.

Control mechanism 20 also has an "off" position in which lines 21, 22 and 23 are inactivated and no connection is made between power amplifier 40 and any of output circuits 61, 62 and 63. Control mechanism 20 also, as indicated by line 24, is arranged to activate generator 30 when any of lines 21, 22 and 23 is activated. Control mechanism 20 further is provided with three associated timers 25, 26 and 27 which are manually programable for a time period from zero to 15 minutes. Timers 25, 26 and 27 are associated through control mechanism 20 each with one output circuit 21, 22 and 23, respectively, to control the length of time such circuit is actuated when control mechanism 20 is actuated to operate such circuits in sequence. Thus timer 25, for example, controls the length of time in which output circuit 21 is actuated, and power is therefore connected through switch 50 to output circuit 61.

In operation, referring the FIG. 2 applicators A and A′, B and B′ and C and C′ are placed on the body in intimate contact with the skin. More specifically, applicators A-A′ are placed on opposite sides of the body parallel to each other centered on a axis extending through the location of the tumor mass T be treated. Applicators B-B′ are similarly placed but centered on a different axis, and applicator C-C′ are also similarly placed but on yet a third axis all of which approximately intersect within tumor mass T.

The operator thus has three timer knobs 25*a*, 26*a* and 27*a*, each with an arrow to be set at a time scale of from 0 to 15 minutes which is set manually. If knob 25*a* is set at 15 minutes and 26*a* and 27*a* at zero setting control mechanism 20 will activate circuit 61 to operate for 15 minutes and then shut off. If, however, timer knob 25*a* is set at 15 minutes, timer knob 26*a* at 15 minutes and also timer knob 27*a* at 15 minutes, then when control mechanism 20 is activated the first circuit 61 will operate for 15 minutes and energize applicators A and A′. Then in sequence switch 50 will deactivate circuit 61 and energize circuit 62 and its applicator B and B′ for 15 minutes. Following this interval switch 50 will deactivate circuit 62 and energize circuit 63 and its applicators C and C′ which are positioned at a different angle to the substrate and its submerged tumor T than either applicators A-A′ or B-B′.

The end result is a crossfire of the submerged tumor T from first applicators A-A′, then applicators B-B′ and finally applicators C-C′ on target but with a reduced skin contact time at any portal of entry of the input R.F. energy. This in a simplified version is how the present pre-timed sequence of multiple pairs of energy sources operates. The basic idea for such a system is to prevent an over extension of the dwell time of any high power energy input system at a single locus on the skin or as referred to herein "portal of entry" of the R.F. radiation. The impedence matching networks are essentially conventional and are designed to match line impedence with the impedence of the load between applicators. The forward power is typically in the range of 300-500 watts and this value is carefully monitored even though the present system permits a switch of the applicator from one locus to another.

The logic network in control mechanism

20 is so arranged that it will switch time from line 21 to line 22 to line 23, and hence from circuit 61 to circuit 62 to circuit 63 in sequence at the end of the designated time interval as earlier set on timers 25, 26 and 27. If there is a zero setting on any timer it will switch in sequence past that point to the next time interval. Therefore, if 26 and 27 are set at zero time 25 will be idefinitely recycled after its time has elapsed until the machine is turned off.

The switch logic of control mechanism 20, as indicated above, also controls by output 24 the output of the crystal controlled signal generator 30. This is necessary since the R.F. cannot be switched at high power output levels. Hence, the power output of signal generator 30 is momentarily cut off during the switching interval. When the output of 30 is temporarily interrupted the output from the power amplifier 40 falls to 0 making it possible to switch the R.F. at switch 50 from one coaxial cable to another.

WHAT I CLAIM IS:

1. An apparatus for the application of radio frequency electromagnetic energy to a biological substrate in human and/or animal therapy which apparatus comprises generator means for the generation of radio frequency electromagnetic power, and applicator means for applying the radio frequency power output of said generator means to a said biological substrate, said applicator means including a plurality of applicator pairs for setting up a radio frequency electromagnetic field therebetween when connected to said radio frequency generator means, switching means for coupling the power output of said radio frequency generator means selectively across each said pair, one pair at a time, and control means for actuating said generator means and said switching means to couple said power output to each of said applicator pairs automatically in predetermined sequence.

2. An apparatus according to claim 1 in which said control means includes a plurality of timer means, each timer means being associated with a respective applicator pair and with the switching means in a manner whereby the duration of radio frequency power supplied to each said applicator pair is determined by its associated timer means independently of the duration of radio frequency power supplied to the or each other applicator pair.

3. An apparatus according to either of claims 1 or 2 in which said control means operates to deactuate said generator means when actuating said switching means to change the coupling of the R.F. power of said generator means from one to another of said applicator pairs.

4. An apparatus for the application of radio-frequency electromagnetic energy to a biological substrate in human and/or animal thereapy, substantially as hereinbefore described and illustrated by reference to the accompanying drawing.

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1592999 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

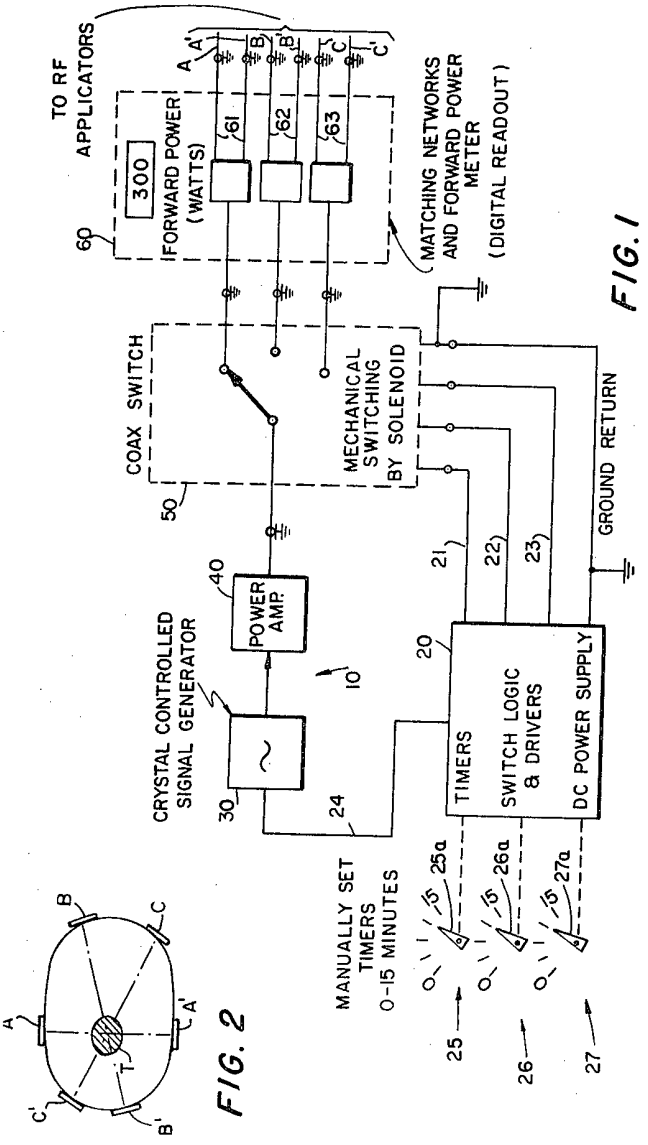

FIG. 1

FIG. 2