This application is a continuation of my application Serial No. 688,219, filed October 4, 1957, and now abandoned.

The present invention relates to what is now recognized in the art as atherapeutic apparatus employed to administer electrotherapeutic treatments to living matter for the curing or abatement of diseases, infections, and the like, without the attendant discomforting limitations of heat generation.

In the utilization of diathermy apparatus for the treatment of living matter the passage of electrical current therethrough produces a thermal phenomenon with the maximum amount of current, and hence the treatment itself is limited by the heat tolerance of the animal body or living matter. Although such diathermy apparatus has its place in the art of therapeutic healing it has now been definitely established that atherapeutic apparatus utilizing pulsed high frequency radiation will produce far greater beneficial results because the electrical forces that can accordingly be applied are many times higher than those possible with diathermy apparatus since heat tolerance is no longer a factor, as such atherapeutic apparatus produces no significant heat.

There are however, certain limitations applicable also to atherapeutic apparatus the major one of which is the governmental regulations on the wave-length or frequency of the electromagnetic radiation generated by the apparatus which must be within an established range so as to eliminate, or at least minimize, interference with radio and television broadcasting. The problem has heretofore been the difficulty of producing an apparatus which remains reliably stable during operation while at the same time generating sufficient power within the legally prescribed frequency range as to achieve beneficial results from the treatment standpoint.

The beneficial results produced by the atherapeutic apparatus of the present invention are not fully understood but are predicated on the theory that by eliminating significant heat generation and applying electromagnetic radiations at a much higher voltage than is possible with diathermy apparatus, a very great stimulating effect is produced by the application of such radiations to the natural defense mechanism inherent in all living matter and especially the animal body. The atherapeutic apparatus as shown in my prior U.S. Patent No. 2,276,995 produced such stimulation by creating periodic high frequency pulses of very short duration with relation to the time intervals between pulses which were applied to a patient but the disadvantage of the apparatus as herein shown and described resided in its not being reliably stable as desired and at that time the problem of frequency range was not as acute as subsequent governmental regulations have made it.

It is accordingly an object of the present invention to provide an atherapeutic apparatus for the application of pulsed electrical energy of relatively short duration to living matter with an absence of significant heat generation and wherein such apparatus is reliably stable in its operation.

Another object of the present invention is the provision of an atherapeutic apparatus for the treatment of living matter by the application of pulsed electrical energy thereto of such relatively short duration that the generation of significant heat is eliminated and which apparatus operates within a permissible frequency range so as to not deleteriously affect radio and television broadcasting or reception.

Another object of the present invention is the provision of an atherapeutic apparatus for the treatment of living matter and particularly the animal body by the application of pulsed electrical energy thereto of such relatively short duration that the generation of significant heat is eliminated and which apparatus is reliably stable in its operation and the frequency of such pulsed energy is within a permissible range so as to not deleteriously affect radio and television broadcasting and reception.

Another object of the present invention is the provision of an atherapeutic apparatus for the treatment of living matter and particularly the animal body by the application of pulsed electrical energy thereto wherein the pulse frequency and duration of application can be varied over a comparatively wide range so as to produce the best beneficial therapeutic results to the various organs and tissues of the body and wherein the duration of application of such pulsed electrical energy is nevertheless of such relatively short duration that the generation of significant heat is eliminated.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing, wherein

FIGURE 1 is a block diagram showing the various sections of elements which make up the atherapeutic apparatus of the present invention, and

FIG. 2 is a schematic diagram of the electrical circuitry of the atherapeutic apparatus of the present invention and showing the manner in which the various elements forming part of the several sections of FIG. 1 are connected together and to each other within each individual section.

By reference now more particularly to the drawing and the following detailed description, the nature and principle of the invention will become apparent to those skilled in the art.

A "Pulse Transformer" 7 that in turn supplies positive pulses to the plate circuit of a "Radio-Frequency Power Amplifier" 8 shown in the top row of FIG. 1. Also shown in this top row in block form is the basic frequency controlling element which comprises a "Crystal Oscillator and Doubler" 9 connected to a "Radio-Frequency Amplifier and Doubler" 10 with this latter in turn connected to the "Radio-Frequency Power Amplifier" 8. The doubled oscillating output as pulsed by the "Pulse Transformer" is then supplied to a "Harmonic Filter" 12 which in turn feeds to the "Applicator" 13.

These above-mentioned elements all of which comprise the atherapeutic apparatus of the present invention are shown more in detail in FIG. 2 from which it will be noted that the "Pulse Voltage Control & High Voltage D.C. Supply" 5 includes an auto-transformer or the like 15 connected to the usual supply source L1-L2 of the customary commercial potential. By adjustment of the auto-transformer step-switch 16 any one of the steps is selectively applied to the primary winding 17 of a transformer 18 so that its secondary winding 19 will generate a constant voltage ranging from about 600 volts to 2000 volts, depending upon the setting of the auto-transformer step-switch 16 which determines the desired penetration of the pulsed voltage, as is further explained more in detail. As will be noted the output voltage from this
secondary winding 19 is rectified by a pair of rectifying valve tubes 20 and 22 so that full wave rectified D.C. charges a storage capacitor 23 through a choke input filter 24 at a maximum constant voltage of about 2 kv.-D.C. as shown between 5 and 6 in the bottom row of FIG. 1, since the midpoints of the secondary windings and one plate of the capacitor 23 are connected to ground. The thermionic cathodes of these rectifiers 20 and 22 receive low voltage heating current from a transformer 25 having its primary winding connected to the same source of supply L1-L2 as the auto-transformer 15. The circuit 23 includes the primary winding 26 of the "Pulse Transformer" 7 which is in the plate circuit of a pair of grid-controlled valve tubes 27 and 28, and forming a part of the "Pulse Generator Incorporating Pulse-Length & Frequency Control" 6 as shown in FIG. 1, the plate circuit is completed through an auto-transformer 29 to ground. The thermionic cathodes of the valve tubes 27 and 28 receive low potential heating energy from a suitable source, such as a transformer 30 having its primary winding connected to the same source of supply L1-L2 as that of auto-transformer 15 and low-voltage heating transformer 25, with the result that the plates and thermionic cathodes of these tubes 27 and 28 are thus connected in parallel. In addition to the above-mentioned valve tubes 27 and 28 the heating transformer 30, the "Pulse Generator Incorporating Pulse-Length & Frequency Control" 6, as the name implies, in a series of capacitor 32 operable connectable in the grid circuit for the valve tubes 27 and 28 by a pulse-length control switch 33, and a tapped resistor 34 also selectively connectable in this same grid circuit by a pulse-frequency control switch 35, which together control the pulse-length and frequency. The auto-transformer 29 operates in a manner heretofore explained, in conjunction with the series capacitors 32 and resistors 34, so that normally a negative potential is supplied to the grids of the valve tubes 27 and 28, effectively biasing them beyond cut-off.

When the negative bias leaks off the grids by leakage from the capacitors 32 through the resistors 34 sufficiently to allow passage of a small plate current in the valve tubes 27 and 28, this plate current flowing in the primary of the auto-transformer 29 tends to drive the grids of these valve tubes 27 and 28 positive, this in turn increasing the low-voltage heating transformer 25 to a voltage in their plate circuits from the charged high voltage storage capacitor 23 through the primary winding 26 of the pulse transformer 7 for a short period of time, until the core of the auto-transformer 29 becomes saturated by current flow in its windings, the series of capacitors 32 meanwhile having become charged by the flow of grid current to again apply a negative bias to the grids of valve tubes 27 and 28. It will thus be apparent that the time period during which the grids of valve tubes 27 and 28 are positive and these tubes hence conductive with energy flow through primary winding 26 of pulse transformer 7, depends upon the setting of pulse-length control switch 33 which selects the total number of capacitors 32 included in the series circuit at any time. The smaller the number of such capacitors included in the circuit by the setting of pulse-control switch 33 the longer will be the period required to recharge such capacitors to the value necessary to apply a negative bias to the grids of valve tubes 27 and 28 and hence the longer the pulse-length or duration due to energization of pulse transformer 7 from the storage capacitor 23, which ranges from about thirty to one hundred microseconds depending upon the precise setting of control switch 33.

Likewise the pulse frequency, which generates a wave form such as shown between the "Pulse Generator, etc. 6 and "Pulse Transformer" 7 of FIG. 1, is determined by the setting of pulse-frequency control switch 35, since this selects the total amount of resistance of resistor 34 included in the regenerative grid circuit at any given moment and thus controls the rapidity with which the series capacitors 32 leak off to remove the negative bias from the grids of the secondary winding 26 and render the grids positive with such tubes becoming conductive, as above-described. The adjustment of pulse-frequency control switch 35 enables the athermepastic apparatus of the present invention to be adjusted for a pulse frequency of from sixty to six hundred cycles per second. The pulsed energy in the primary winding 26 of "Pulse Transformer" 7 at the frequency and duration as set by the control switches 33 and 35 is impressed upon the secondary winding 36 at a ratio of ten-to-one so that pulsed voltage at a maximum of about 20 kv., and in the wave form shown between blocks 7 and 8 of FIG. 1, is impressed upon the output plate circuit of "Radio Frequency Power Amplifier" 8, hereinafter described more in detail.

The "Crystal Oscillator and Doubler" 9 and which, as above-noted, constitutes the basic frequency controlling element comprises a crystal oscillator 37 connected across the control grid and cathode of a screen-grid oscillator tube 38 which definitely fixes the basic frequency at 6,780 megacycles. The plate circuit of the oscillator tube 38 receives unidirectional energy at about 250 volts from the secondary winding 39 of a transformer 40 which is rectified by a full wave rectifier tube 41 and impressed upon a filter arrangement comprising a pair of capacitors 43 and 44 having one plate grounded and shunted by a choke 45, as well as the oscillator elements comprising the parallel connected inductance 46 and variable capacitor 47, and such transformer secondary 39 also serves to supply a potential to the screen grid of the tube 38 through a limiting resistor 48. The output plate circuit of the oscillator tube 38 includes a coupling capacitor 51 which together with the oscillating elements comprising the inductance 46 and variable capacitor 47 operates to double the initial frequency of the crystal oscillator 37 so that the frequency supplied to "Radio-Frequency Amplifier Doubler" 10 is at 13.56 megacycles and has a sine wave form as shown between the blocks 9 and 10 of FIG. 1.

The "Radio-Frequency Amplifier Doubler" 10 of FIG. 2 comprises essentially all respects identical to that of the "Crystal Oscillator Doubler" 9 except that the initial input frequency supplied from capacitor 51 to the resistor 49 is the 13.56 megacycles output from the doubler 9. Again, however, the oscillator tube 50 receives energy from the same source as tube 38, namely, the secondary winding 39 as rectified by rectifier tube 42 with the result that the input frequency of 13.56 megacycles is again doubled so that the output frequency of the oscillating "Radio-Frequency Amplifier Doubler" 10 now is at 27.12 megacycles, which is within the range approved by FCC for athermepastic apparatus, and the wave form of such oscillations assumes the same sine wave form but of higher magnitude, as shown between the blocks 10 and 8 of FIG. 1. It will also be noted from FIG. 2 that the transformer 49 is provided with a low potential winding 53 which supplies heating energy to the internal of the output side of the oscillator tubes 54 and 50 and a similar low potential winding 53 likewise supplies heating energy to the thermionic cathode of rectifier 42, while the primary winding 54 of such transformer 49 is connected to the aforementioned supply source L1-L2.

These oscillations at a continuous frequency of 27.12 megacycles from the "Radio-Frequency Amplifier Doubler" 10 constitutes the drive for the aforementioned "Radio-Frequency Power Amplifier" 8. From FIG. 2 it will be apparent that the latter comprises a pair of push-pull power amplifier tubes 55 and 56 whose thermionic cathodes are heated from a low potential winding 57 of a
transformer 58 having its primary winding 59 connected to the aforementioned supply source L1 and L2. The control grids of these tubes, in turn, control the secondary winding 60 of the coupling transformer 62 whose primary winding 63 is in turn connected to the output or secondary winding 64 of the coupling transformer 65 of the "Radio Frequency Amplifier Doubler" 10, and a variable capacitor 66 shunts the secondary winding 69 which together form a tunable circuit. The screen grids of these power amplifier tubes 55 and 56 receive a direct current potential from the secondary winding 39 through rectifier 42 and a limiting resistance 67 while the plate circuit for such tubes 55 and 56 includes the inductance 68 and parallel connected variable capacitor 69 as well as the secondary winding of the "Pulse Transformer" 7 as previously mentioned.

From the foregoing it should thus be obvious that a pulsed plate voltage at a frequency of 60 to 600 cycles per second and at a maximum of 20 kv, is applied to a continuously driven amplifier at a predetermined constant radio-frequency of 27.12 megacycles which thus makes for more reliably stable operation than heretofore possible where the amplifier drive itself is likewise pulsed, and lower wattage tubes can be utilized without danger of overloading which has been one of the inherent disadvantages with previously known athermapeutic apparatus. As hereinbefore mentioned, the plate circuit of tubes 52 and 56 includes the primary winding of a coupling transformer 72 whose output secondary winding 73 is connected by a coaxial cable 74 through the low-pass or "Harmonic Filter" 12 to the "Applicator Head" 13. Such filter 12 contains a series connected inductance with parallel connected capacitors to eliminate harmonics which would otherwise effect the output of the apparatus and the "Applicator Head" 13 is provided with a tunable circuit comprising a coupled inductance and variable capacitor which is tuned to the same resonant frequency as the primary circuit of the "Harmonic Filter" 12.

From the foregoing detailed description it should be obvious to those skilled in the art that the athermapeutic apparatus of the present invention employs a crystal controlled oscillator whose output at 6.780 megacycles is amplified and doubled twice. This fixed frequency output of 27.12 megacycles is used to drive the grids of push-pull power amplifiers whose plate voltage is controlled by switching tubes in a pulse network which permits delivery of the energy through the applicator head to a patient in bursts of high intensity. Each pulse of energy is controlled as to duration by the pulse-length control switch and may be varied from about thirty to one hundred microseconds while the rate of pulse repetition is also adjustable by the pulse-frequency control over a range from about sixty to six hundred pulses per second as hereinbefore mentioned. It is also significant that in accordance with the present invention the output energy level, and which controls the penetration of the electrical radials, is also adjustable by the auto-transformer control in six steps with maximum peak power being about 1400 watts. However, since the output power is pulsed at a maximum rate of six hundred pulses per second, as above-stated, and each pulse lasts for the very short time of from thirty to one hundred microseconds, power is actually applied for only about three percent of the time which results in the average induced power being only about forty watts with virtually a complete absence of heat generation. This energy is transferred to the patient or animal body in the form of an electromagnetic field generated in the coil located in the "Applicator Head" which coil is tuned to resonance with the patient in the field. The "Low-Pass Filter" in the oscillator output circuit results in undesirables at harmonics so that the radio frequency is constantly maintained within the range approved by the Federal Communications Commission for athermapeutic apparatus.

Feed-back into the power line is limited by a suitable inductance-capacitance filter or network.

Although one form of the athermapeutic apparatus of the present invention may take has been hereinbefore described, it is to be understood that still other modifications thereof may be made without departing from the invention.

1. An ultra short wave athermapeutic apparatus for administering therapeutic treatments to a patient, said apparatus comprising: oscillation generating means for producing continuous high frequency electrical oscillations of predetermined frequency; separate pulse generating means for producing a series of electrical pulses, each having a duration which is very small compared to the interval between individual pulses; first control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means; and second control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means; and said first control means being operable to establish at a predetermined time value, the duration of each of the pulses produced by said pulse generating means; second control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means; said oscillation generating means electrically connected to and operable to deliver its output high frequency oscillations as signal excitation to said power amplifying means; said pulse generating means electrically connected to and operable to deliver its output pulses as established by said first and second control means as energization to said power amplifying means; said power amplifying means upon receiving the respective outputs of said oscillations generating means and said pulse generating means having as output, a series of high-frequency modulated electrical pulses; and said control means coupled to said responsive to the output of said power amplifying means for generating and introducing into the body of a patient in receptive proximity thereto, pulsed electromagnetic radiations having a predetermined frequency, a predetermined pulse duration, and a predetermined pulse repetition rate; and a tunable circuit comprising a pair of impedance elements one of which is variable and operable to tune said applicator means to the same resonant frequency as said power amplifying means.

2. An apparatus as specified in claim 1, wherein said oscillation generating means includes a crystal for controlling the frequency of oscillation.

3. An apparatus as specified in claim 2, wherein the output of said crystal is multiplied in frequency to produce high frequency oscillations of predetermined frequency.

4. An apparatus as specified in claim 1, wherein a third control means is associated with said pulse generating means for independently adjusting to any one of a plurality of predetermined time values the potential of the pulses generated by said pulse generating means.

5. An ultra short wave athermapeutic apparatus for administering therapeutic treatments to a patient, said apparatus comprising: oscillation generating means for producing continuous high frequency electrical oscillations of predetermined frequency; separate pulse generating means for producing a series of electrical pulses, each having a duration which is very small compared to the interval between individual pulses; first control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means; and said first control means being
operable to independently establish at a predetermined time value, the duration of each of the pulses produced by said pulse generating means; second control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means, and said second control means being operable to independently adjust to any one of a plurality of predetermined time values, the interval between the initiation of each of the pulses produced by said pulse generating means to produce from about sixty to six hundred pulses per second; power amplifying means operable to amplify the oscillations produced by said oscillation generating means; said oscillation generating means electrically connected to and operable to deliver its output high frequency oscillations as signal excitation to said power amplifying means; said pulse generating means electrically connected to said and operable to deliver its output pulses as established by said first and second control means as energization to said power amplifying means; said power amplifying means upon receiving the respective outputs of said oscillation generating means and said pulse generating means having as fundamental frequency output, a series of high-frequency-modulated electrical pulses; applicator means coupled to and responsive to the fundamental frequency output of said power amplifying means for generating and introducing into the body of a patient in receptive proximity thereto, pulsed electromagnetic radiations having a predetermined frequency, a predetermined pulse duration, and a predetermined pulse repetition rate; and said applicator means having a circuit tunable to resonance while a patient is in the electromagnetic field emanating therefrom; and harmonic filter means electrically connected between the output of said power amplifying means and said applicator means and tuned to the fundamental frequency output of said power amplifier means.

6. An ultra short wave therapeutical apparatus for administering therapeutic treatments to a patient, said apparatus comprising: oscillation generating means for producing continuous high frequency electrical oscillations of a predetermined frequency; separate pulse generating means for producing a series of electrical pulses, each having a duration which is very small compared to the interval between individual pulses; first control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means, and said first control means being operable to independently adjust to any one of a plurality of predetermined time values, the duration of each of the pulses produced by said pulse generating means; second control means associated with said pulse generating means comprising a plurality of impedance elements and a switch operable to select the number of such elements associated at any time with said pulse generating means, and said second control means being operable to independently adjust to any one of a plurality of predetermined time values, the interval between the initiation of each of the pulses produced by said pulse generating means to produce from about sixty to six hundred pulses per second; power amplifying means operable to amplify the oscillations produced by said oscillation generating means; said oscillation generating means electrically connected to and operable to deliver its output high frequency oscillations as signal excitation to said power amplifying means; said pulse generating means electrically connected to and operable to deliver its output pulses as established by said first and second control means as energization to said power amplifying means; said power amplifying means upon receiving the respective outputs of said oscillation generating means and said pulse generating means having an output, a series of high-frequency-modulated electrical pulses; and applicator means coupled to and responsive to the output of said power amplifying means for generating and introducing into the body of a patient in receptive proximity thereto, pulsed electromagnetic radiations having a predetermined frequency, a predetermined pulse duration, and a predetermined pulse repetition rate; and said applicator means having a circuit tunable to resonance while a patient is in the electromagnetic field emanating therefrom.

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