May 27, 1941. W. F. WESTENDORP 2,243,591

ELECTRIC VALVE CONVERTING APPARATUS

Filed July 29, 1939

Fig. 1.

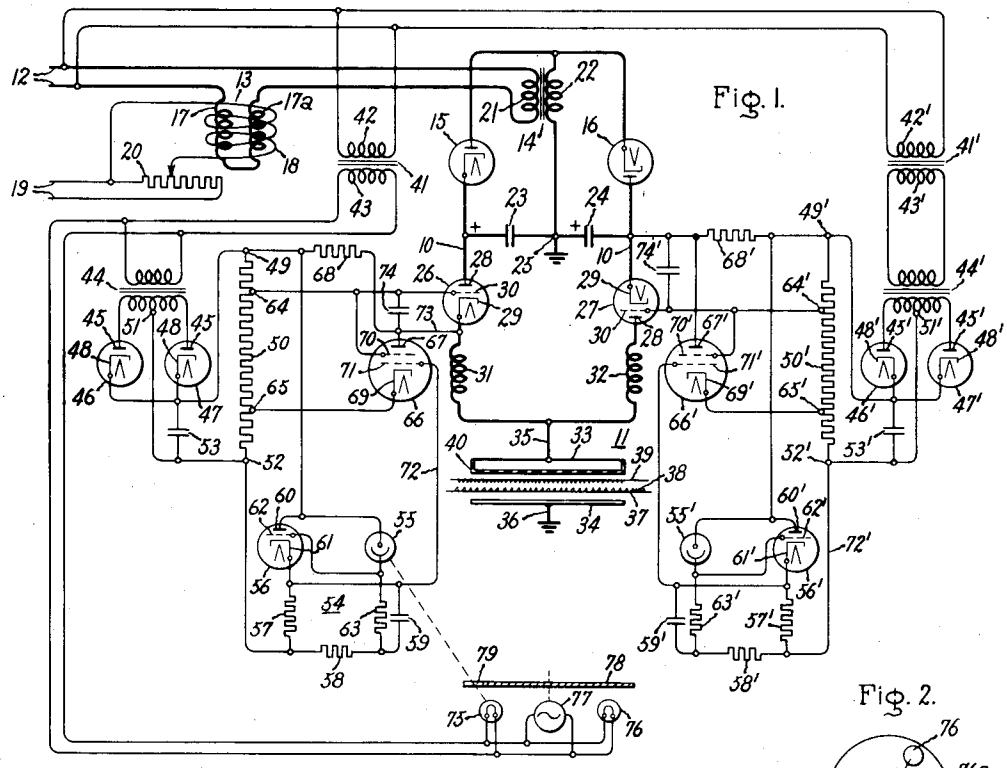


Fig. 2.

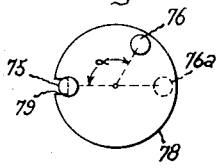
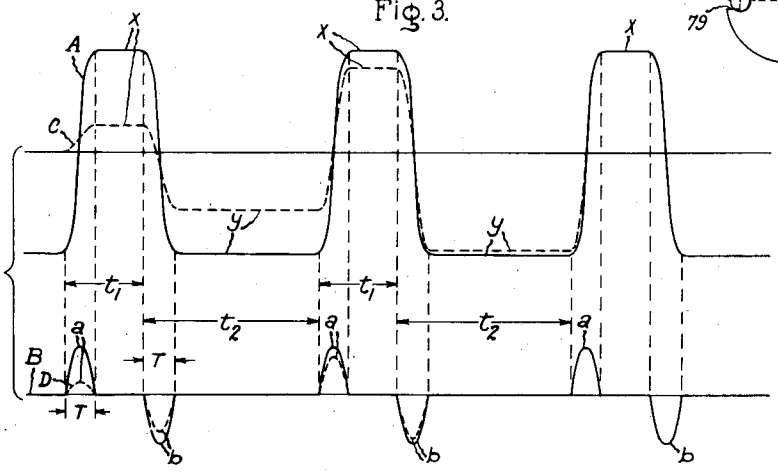


Fig. 3.



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Willem F. Westendorp,
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His Attorney.

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UNITED STATES PATENT OFFICE

2,243,591

ELECTRIC VALVE CONVERTING APPARATUS

Willem F. Westendorp, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application July 29, 1939, Serial No. 287,357

20 Claims. (Cl. 250—41.5)

My invention relates to electric valve converting apparatus and more particularly to an arrangement for producing a variable frequency alternating potential of a predetermined wave form and means for controlling the same.

In order to illustrate my invention I will describe a suitable arrangement and method of operation thereof for carrying it into effect in an apparatus for the manufacture of granular coated webs of such material as paper, cloth, and the like, wherein the abrasive or granular particles are deposited upon the web and orientated by electrostatic means, the electrostatic field being produced by an electric valve converting apparatus. It is, of course, understood that the scope of my invention is not limited to the particular application described, but rather is of general application wherever it is desired to produce by means of an electric valve converting apparatus a variable frequency alternating current wherein the frequency may vary within a wide range as for example from one to one hundred twenty cycles per second.

It has been found heretofore that better abrasive coated web can be produced by causing at least some of the granular particles deposited upon the web to become so orientated that the long dimension of each grain projects from the surface of the web. Satisfactory results have been obtained by using electrostatic means for projecting the above material upwardly and into engagement with the adhesively coated side of the web. In apparatus of this type the adhesively coated web is supported with the adhesively coated side facing downwardly whereby the grains when projected by the electrostatic means strike this downwardly positioned side and adhere thereto. The electrostatic means used in such apparatus has included a high tension electrode positioned above the coated web and a low tension electrode positioned beneath the coated side with a carrier means such as a canvas belt so positioned that the granular carrying side of the conveyor is between the lower electrode and the adhesively coated web. Although it has been found that a constant potential supplied to the load circuit will be satisfactory for some cases it is desirable in connection with the depositing and orientation of granular particles by electrostatic means to utilize an alternating potential of suitable frequency and wave form in most cases. The choice of frequency and wave form depends on the size and kind of the granular particles used. Sometimes it is desirable to utilize a very low frequency almost approaching a direct current perhaps as low as one cycle per second, while at other times it has been found desirable to use a much higher frequency. Furtheremore the wave form should preferably be flat-topped and the part of the cycle which renders the upper electrode negative should, for highest efficiency, be longer than the positive part of the cycle. Electric valve converting apparatus designed heretofore ordinarily comprises a transformer and it will be understood by those skilled in the art that a transformer which will operate with alternating currents having a frequency as low as one cycle per second would be very massive and expensive and would not be satisfactory for higher frequencies. Accordingly, I have designed an electric valve converting apparatus for producing a variable frequency alternating current output having a frequency as low as one cycle per second wherein the desired wave form may be obtained and I have dispensed with the use of expensive transformers which must be designed to operate at very low frequencies. Furthermore by my invention I provide an arrangement wherein without utilizing transformer means the output voltage is many times greater than the input voltage.

It is an object of my invention, therefore, to provide a new and improved electric valve converting apparatus.

It is another object of my invention to provide a new and improved electric valve converting apparatus for efficiently supplying a variable frequency alternating current load.

It is a further object of my invention to provide a new and improved electric valve converting apparatus for converting direct current having a potential of a given order of magnitude into an alternating current having potential many times higher than the direct current potential without the use of high voltage transformers.

It is a still further object of my invention to provide a new and improved electric valve converting apparatus wherein control means are provided to control the frequency within a wide range of frequencies starting as low as one cycle per second.

It is another object of my invention to provide a new and improved electric valve converting apparatus for supplying the electrostatic energy necessary in connection with the electrical deposition of granular particles.

It is another object of my invention to provide a new and improved electric valve converting apparatus for producing a flat-topped variable

frequency alternating current potential wherein the positive portion of the cycle differs from the negative portion.

In accordance with the illustrated embodiment of my invention I provide an electric valve converting apparatus wherein an alternating current, by means of rectifying means, is converted into a direct current energy which is stored in a pair of capacitors. The potential of this direct current is from three to twenty times lower than the ultimate alternating potential to be supplied to the load circuit. A neutral terminal is provided for the direct current circuit. A plurality of electric discharge valves and inductances interconnect said storage capacitors with a variable frequency alternating current load including spaced electrodes. By means of suitable control apparatus a variable frequency alternating current potential of flat-topped wave form may be produced, the frequency of which may vary within a wide range as for example, from one cycle per second to one hundred twenty cycles per second and the magnitude of which is from three to twenty times greater than the direct current potential stored in the capacitors. Furthermore, the positive and negative portions of the alternating current potential may differ in that the negative portion, for example, may be considerably longer than the positive portion if such characteristic is desired. A photoelectric control means is provided for controlling the output frequency. The apparatus is particularly adapted for use in connection with the manufacture of granular coated webs where the granular particles are projected against the adhesively coated surface of the web member by electrostatic means.

My invention, both as to its organization and method of operation, together with other and further objects thereof will best be understood by reference to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims. In the accompanying drawing Fig. 1 diagrammatically illustrates an embodiment of my invention for use with an apparatus for depositing granular particles upon an adhesively coated web by electrostatic means, Fig. 2 is another view of a portion of Fig. 1, while Fig. 3 represents certain operating conditions of the apparatus illustrated in Fig. 1.

Referring now to Fig. 1 of the drawing, I have illustrated therein an electric valve converting apparatus for transmitting energy from a direct-current circuit 10 to a high voltage load circuit 11. Since an alternating current source is more often available than a direct current source I have illustrated an arrangement for obtaining the direct current of direct current circuit 10 from alternating current circuit 12 through a variable impedance 13, transformer 14 and a plurality of electric discharge valves 15 and 16 operating as rectifiers. The variable impedance 13 may be any of the variable impedance means known to those skilled in the art. By way of example I have illustrated variable impedance means 13 as comprising a reactor the impedance of which is variable by saturation. Accordingly, I have illustrated impedance means 13 as comprising a pair of series connected reversely wound impedance coils 17 and 17a and a saturating coil 18. Saturating coil 18 is supplied with direct current from a suitable source 19 through variable resistance means 20 for controlling the impedance of impedance means 13 and hence controlling the voltage applied to transformer 14. The primary winding 21 of transformer 14 is connected in series with impedance means 13 and alternating current source 12, while the secondary winding 22 is connected in series with rectifiers 15 and 16 and storage capacitors 23 and 24. One half cycle of the alternating potential is rectified by the electric discharge valve 15 while the other half cycle is rectified by electric discharge valve 16, and after a few cycles a steady state direct current potential appears across storage capacitors 23 and 24 thus providing a suitable source of direct current energy for direct current circuit 10, the voltage of which may be suitably controlled by the variable impedance means 13. A neutral terminal 25 is provided in connection with the direct current circuit 10 which may be suitably grounded as shown. The provision of this neutral terminal affords an advantage in that direct current power may be supplied during both cycles of the alternating current load circuit 11. Each terminal of direct current circuit 10 is connected to one of the electrodes of one of the electric discharge devices 26 and 27. I have illustrated the terminal of direct current circuit 10 associated with capacitor 23 as connected with the anode 28 of electric discharge valve 26 while the other terminal of the direct current circuit associated with capacitor 24 is connected with the cathode 29 of electric discharge valve 27. Electric discharge valve 26 is also provided with a cathode 29 and a control electrode 30 and electric discharge valve 27 is provided with an anode 28 and a control electrode 30. Inductances 31 and 32 are connected in series with electric discharge valves 26 and 27, respectively. The load circuit 11 comprises a pair of spaced electrodes 33 and 34. Electrode 33 is connected with inductances 31 and 32 by means of lead 35 while electrode 34 is connected to ground through lead 36. I have illustrated my electric valve converting apparatus as applicable for coating webs of such material as paper, cloth or the like, with granular particles. Accordingly, I have illustrated a moving belt 37 carrying granular particles 38 and arranged to pass over the grounded lower metal electrode. Above this belt and moving in the same direction I have illustrated adhesively coated paper or cloth 39, the sticky side of which is downward. Both the belt 37 and adhesively coated web 39 are mounted between electrodes 33 and 34. Upper electrode 33 is covered with an insulating surface 40 shown in cross section made of some poorly conducting material with a high dielectric constant, the conductivity and dielectric capacity of which should be such that corona may be formed between electrodes 33 and 34 but yet that direct break-down is prevented. Although I have illustrated electrode 33 as comprising a plate member the bottom and edge surfaces of which are covered with insulating material 40, it will be understood that this electrode may consist of metal bars or other conducting material suitably embedded in an insulating medium.

Any suitable control means well known to those skilled in the art may be used to control the conductivity of electric discharge valves 26 and 27 by impressing suitable control potentials on control electrodes or grids 30 thereof. One well known means for accomplishing this result is the mechanical commutator. However, in Fig. 1 I have illustrated a photoelectric control circuit for electric discharge valves 26 and 27. The con-

trol circuit for electric discharge valve 26 is identical with that of electric discharge valve 27 and hence only the former will be described, the corresponding elements of the latter being designated by the same numerals marked with a prime. A supply potential for the control circuit may be obtained from any suitable source of alternating current and in Fig. 1 I have illustrated the control potential as being obtained from alternating current circuit 12 through transformer 41 which has its primary winding 42 connected across the alternating current circuit 12. The secondary winding 43 of transformer 41 is connected in series with the primary winding of rectifier transformer 44, the secondary winding of which is connected, respectively, to the anodes 45 of electric discharge valves 46 and 47 arranged to operate as a biphase rectifier. Each of these electric discharge valves 46 and 47 is provided with a cathode 48 which is connected to the positive terminal 49 of potentiometer 50. The midpoint 51 of the secondary winding of rectifier transformer 44 is connected to the negative terminal 52 of potentiometer 50. A suitable smoothing capacitor 53 is connected across the direct current output of the biphase rectifier which includes electric discharge valves 46 and 47. An amplifying circuit 54 is connected across terminals 49 and 52 of the potentiometer 50 and comprises a photoelectric cell 55, a high vacuum amplifier tube 56 and a self biasing circuit including resistor 57, resistor 58 and by-pass capacitor 59. Amplifier tube 56 comprises an anode 60, a cathode 61 and a grid or control electrode 62. The grid or control electrode 62 is connected to the cathode of photoelectric cell 55 while the anodes of amplifier tube 56 and photoelectric cell 55 are both connected to the positive terminal 49 of potentiometer 50. The cathode 61 of amplifier tube 56 is connected through resistor 57 to the negative terminal 52 of the potentiometer 50. The cathode of the photoelectric cell 55 is connected through resistor 63 and resistor 58 to the negative terminal 52 of potentiometer 50. By-pass condenser 59 is provided so that the self biasing circuit will not cause deamplification of amplifier circuit 54 and its purpose will be explained in greater detail in connection with the operation of the apparatus. Potentiometer 50 is also provided with terminals 64 and 65. A four-element high vacuum control valve 66 has its anode 67 connected to terminal 49 of the potentiometer 50 through resistor 68, while its cathode 69 is connected to terminal 65 of potentiometer 50. The screen grid 70 of valve 66 is connected to terminal 64 of potentiometer 50. Grid or control electrode 71 of control valve 66 is connected by means of lead 72 to the cathode of amplifier tube 56. The anode 67 of control valve 66 is connected by means of lead 73 to the cathode of electric discharge valve 26 while the control electrode 30 of electric discharge valve 26 is connected to terminal 64 of potentiometer 50. A smoothing capacitor 74 is connected across the grid to cathode circuit of electric discharge valve 26.

In order to supply beams of light to energize photoelectric cells 55 and 55', I have provided a pair of light sources 75 and 76 which may comprise any suitable forms known in the art. These light sources 75 and 76 have been illustrated as incandescent lamps supplied with alternating current from the secondary winding 43 of transformer 41 although it will be understood by those skilled in the art that any suitable source of electrical energy will serve equally well. A variable speed alternating current motor 77 is drivingly connected to a disk 78 mounted on a suitable shaft so as to rotate between sources of light 75 and 76 and photoelectric cells 55 and 55'. A suitable opening 79 cut into the periphery of disk 78 allows a beam of light from source 75 to periodically fall upon photoelectric cell 55 and correspondingly allows a beam of light from source 76 to periodically fall upon photoelectric cell 55'. The frequency of the alternating potential supplied to load circuit 11 will be identical with the revolutions per second of rotating disk 78 in the arrangement illustrated in Figs. 1 and 2 where only a single opening 79 is provided in disk 78. It will be understood, however, that more openings or slots may be provided, for example, two slots displaced by 180 degrees in which case variable speed motor 77 will make only half as many revolutions per second as the frequency of load circiut 11. In Fig. 2 the two sources of light 75 and 76 are illustrated as being mounted approximately 120 degrees from one another. However, it will be understood that the angular position α of these light sources relative to one another may be controlled so as to control the length of the positive and negtaive portions of the alternating potential of load circuit 11. For example, if light source 76 were moved to the dotted position 76a in Fig. 2 so as to be displaced 180 degrees from light source 75, it will be understood that the positive and negative portions of the alternating potential of load circuit 11 would then be equal.

The operation of the apparatus illustrated in Fig. 1 may best be understood by reference to Fig. 3 representing certain operating characteristics of the electric valve converting apparatus illustrated in Figs. 1 and 2 wherein curve A illustrates the steady state alternating potential of load circuit 11 for one operating condition while curve B illustrates the corresponding steady state current flowing in load circuit 11. Curve C shown dotted in Fig. 3 represents the alternating potential of load circuit 11 under starting conditions for the same operating condition while dotted curve D represents the corresponding alternating current of load circuit 11 before the steady state condition represented by curve B obtains. Alternating potential from source 12 is rectified by rectifiers 15 and 16 and after a few cycles a steady state direct current potential appears across storage capacitors 23 and 24 thus furnishing a source of direct current energy for direct current circuit 10. Upon the application of an impulse of control potential upon control electrode 30 of electric discharge valve 26 positive with respect to cathode 29, a half wave discharge is initiated in electric discharge valve 26 which allows current to build up in the inductance coil 31. This current reaches a maximum value and then decreases again transferring all the energy of coil 31 to the load circuit 11, and impresses a high positive potential very nearly twice the potential of capacitor 23 upon electrode 33. When electrode 33 has reached its maximum voltage the current tends to reverse in coil 31 but is kept from doing so by the valve action of the electric discharge valve 26. Electrode 33 is therefore left positively charged and has obtained its energy indirectly from direct current circuit 10, its potential being very nearly twice that of capacitor 23. This charge is retained by electrode 33 for an interval of time depending entirely upon the

grid control applied to electric discharge valve 27. The positive potential of electrode 33 is represented by the positive portion x of curve C and the current flowing through electric discharge valve 26 is represented by portion a of curve D. When a positive potential is applied to control electrode 30 of electric discharge valve 27 relative to its cathode 29, electric discharge valve 27 becomes conductive and the positive potential of electrode 33 is transferred to inductance coil 32 and a current illustrated by portion b of curve D, Fig. 3, flows through inductance 32 and electric discharge valve 27. At the end of the conducting cycle electrode 33 is charged with a high negative potential which is, except for losses, four times the potential of capacitor 23. This high negative potential is obtained from the direct current electrical energy stored in capacitor 24 and in addition from that previously stored in the capacitance of load circuit 11. The negative potential of load circuit 11 is represented by portion y of curve C. This process of alternately rendering electric discharge valves 26 and 27 conductive may be kept up with arbitrary intervals between firing provided these intervals are longer than the duration of the individual discharges. The energy stored in the dielectric capacity of load circuit 11 comprising spaced electrodes 33 and 34 increases every time the polarity of the potential across the electrodes is reversed and a high voltage at which the losses equal the input power may be reached in a few reversals so that the steady state alternating potential of curve A, from three to twenty times the potential of direct current circuit 10, and the steady state current conditions of curve B are soon obtained. This build up of voltage phenomena without the conventional transformer means is due to the series oscillating circuit involving an inductance and capacitance. Inductance coils 31 and 32 in addition to cooperating with the capacitance of load circuit 11 to produce the high voltage prevent a direct short circuit of the direct current source 10 in case of failure of one of the discharge valves 26 or 27. By means of the electric valve converting apparatus illustrated in Fig. 1 it is possible to produce an alternating potential on load circuit 11 of flat-topped wave form with unequal positive and negative portions as illustrated by curve A in Fig. 2. The portion of the alternating potential which renders electrode 33 negative is preferably longer in order to obtain high efficiency of the apparatus. This discharge interval T illustrated in connection with curve B of Fig. 2 is determined by the inductance of coils 31 and 32 and the capacitance of electrodes 33 and 34 of load circuit 11 and is represented by the formula $T=\pi\sqrt{LC}$ where L is the inductance of coil 31 or 32 and C is the capacitance between electrodes 33 and 34 of load circuit 11. In the above formula for the period T the effect of condensers 23 and 24 has been neglected since in practice the capacity of these condensers is usually quite large compared to the capacity of the electrodes of the load circuit and their effect on the time constant of the oscillating circuit is therefore very small. If the capacity of the electrodes 33 and 34 of the load circuit is so small that the energy loss in the work circuit tends to decrease the potential of these electrodes during one-half cycle of the alternating potential appearing across the electrodes, it is of course possible to increase the energy storage of the load circuit by connecting an additional capacitor in parallel with the electrodes. The length of the positive portion t_1 of the alternating potential of load circuit 11 illustrated by curve A in Fig. 2 and the length of the negative portion t_2 are determined by the control potentials provided for control electrodes 30 of electric discharge valves 26 and 27. The operation of the control circuits of electric discharge valves 26 and 27 will be briefly described. As is well understood by those skilled in the art, the biphase rectifier comprising electric discharge valves 46 and 47 provides a direct current potential across potentiometer 50 with terminal 49 being the positive terminal and terminal 52 the negative terminal. When no light is shining against photoelectric cell 55 no current is carried thereby and a small current flows through amplifier tube 56 and produces a self bias because of the potential drop in resistor 57. This bias is maintained during variations of light of less than one-half second duration because of filter capacitor 59 and resistor 58. When amplifier tube 56 carries a very small current, a high negative bias derived from the potentiometer terminals 52 and 65 is impressed upon control electrode 71 of control valve 66 thus completely shutting off any current flowing through control valve 66 and hence no current flows through resistor 68 so a high negative bias derived from the potentiometer terminals 49 and 64 is impressed across the grid to cathode circuit of electric discharge valve 26. If, however, a beam of light as from source 75 is suddenly (that is, during an interval of less than a half second) received by the photoelectric cell 55 this photoelectric cell will become conductive, carrying current which will produce a potential drop in resistor 63 and furthermore decreases the bias on control electrode 62 of amplifier tube 56 which immediately begins to conduct more current causing a much higher potential drop in resistor 57 and correspondingly removing the bias from control electrode 71 of control valve 66 which is thereby rendered conductive. Since control valve 66 becomes conductive the grid potential of control electrode 30 of electric discharge valve 26 becomes positive and electric valve 26 correspondingly becomes conductive. If the beam of light impressed upon photoelectric cell 55 lasts longer than one second amplifier tube 56 tends to bias itself to the new steady state condition and the amplification of circuit 54 drops and may drop enough to stop the flow of grid current in electric discharge valve 26. This self biasing feature of amplifier circuit 54 eliminates the interference caused by steady room light. The grid circuit of electric discharge valve 27 is identical with that just described for electric discharge valve 26 and renders electric discharge valve 27 conductive whenever a beam of light is suddenly directed upon photoelectric cell 55'. As indicated in Figs. 1 and 2, only a single opening 79 is provided in disk 78 so that the frequency of the alternating potential of load circuit 11 is determined by the revolutions per second of driving motor 77. The angular separation α of light sources 75 and 76 corresponds directly to the time intervals t_1 and t_2 shown in Fig. 3 and this angle in degrees equals

$$\frac{t_1}{t_1+t_2}\times 360$$

degrees, the mechanical and electrical degrees

in this case being equal. By means of the formula explained above any desired ratio of t_1 to t_2 may be obtained by adjusting the angular positions of light sources 75 and 76.

While I have shown and described my invention in connection with certain specific embodiments, it will, of course, be understood that I do not wish to be limited thereto, since it is apparent that the principles herein disclosed are susceptible of numerous other applications, and modifications may be made in the circuit arrangement and in the instrumentalities employed without departing from the spirit and scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an electric valve converting apparatus, a direct current source, a load circuit comprising a pair of electrodes mounted in spaced relationship, and means for producing an alternating potential across the electrodes of said load circuit of a much greater magnitude than the potential of said direct current circuit, including a serially connected inductance and electric discharge valve cooperating with the electrodes of said load circuit for controlling the transfer of energy between said source and said load circuit.

2. In an electric valve converting apparatus, a direct current source, a load circuit comprising a pair of spaced electrodes, a plurality of electric discharge valves and inductances interconnecting said source and said load circuit, said inductances and discharge valves cooperating with the capacitance of said load circuit for producing a high voltage alternating potential across said load circuit, and means for controlling the conductivities of said electric discharge valves to determine the frequency and wave form of said alternating potential.

3. In an electric valve converting apparatus, a direct current circuit having a neutral terminal, a load circuit comprising a pair of electrodes mounted in spaced relationship, means including an electric discharge valve and an inductance connected in series relationship with a terminal of said direct current circuit and a terminal of said load circuit cooperating with the capacitance of said load circuit to produce a high voltage alternating potential across the electrodes of said load circuit from three to twenty times the potential of said direct current source.

4. In an electric valve converting apparatus, a direct current circuit having a plurality of terminals including a neutral terminal, a load circuit comprising a pair of electrodes mounted in spaced relation, an electric discharge valve and an inductance connected in series with each of a plurality of the terminals of said direct current circuit and one electrode of said load circuit, and means for controlling the conductivity of said electric discharge valves so as to produce an alternating potential of predetermined frequency in said load circuit.

5. In an electric valve converting apparatus, load circuit comprising a pair of spaced electrodes, a direct current source, means for transmitting energy from said direct current source to said load circuit to produce an alternating current potential across the electrodes of said load-circuit including an electric discharge valve interconnecting each terminal of said source and one electrode of said load circuit and inductance means connected in series with each of said electric discharge valves for limiting the current in said electric discharge valves, and means for controlling the conductivity of said electric discharge valves to determine the frequency of the alternating potential of said load circuit.

6. In an electric valve converting apparatus, a load circuit comprising a pair of spaced electrodes, a direct current source, means for transmitting energy from said direct current source to said load circuit to produce an alternating current potential across the electrodes of said load circuit including electric valves and inductance means connected in series therewith and cooperating with the capacitance of said load circuit to produce an alternating potential in said load circuit from three to twenty times the magnitude of the potential of said direct current source, and means for controlling the conductivity of said electric discharge valves to determine the frequency of the alternating potential of said load circuit.

7. In an electric valve converting apparatus for producing a flat-topped alternating potential, a direct current supply circuit having a neutral terminal, a load circuit comprising a pair of electrodes mounted in spaced relationship with one another, a plurality of electric discharge valves and inductances connected in series therewith and interconnecting said supply and load circuits, and means for controlling the conductivity of said valves for determining the frequency of the alternating potential of said load circuit.

8. In an electric valve converting apparatus, an alternating current source, rectifier means for converting said alternating current to direct current, energy storage means including a capacitor for storing said direct current electrical energy, a load circuit comprising a plurality of electrodes mounted in spaced relationship with one another, and electric valve means interconnecting said capacitor and said load circuit for successively transferring current therebetween in opposite directions to periodically reverse the charge on said electrodes, and means for controlling the conductivity of said electric valve means to determine the frequency of the alternating potential appearing across the electrodes of said load circuit.

9. In an electric valve converting apparatus, an alternating current source, rectifier means for converting said alternating current to direct current, energy storage means including a pair of capacitors provided with a neutral terminal for storing said direct current electrical energy, a load circuit comprising a plurality of electrodes mounted in spaced relationship with one another, and electric valve means and inductance means interconnecting said storage capacitors and said load circuit for producing an alternating potential of flat-topped wave form across the electrodes of said load circuit, and means for controlling the conductivity of said valve means to determine the frequency of the alternating potential of said load circuit.

10. In an electric valve converting apparatus, a load circuit comprising a pair of spaced electrodes, a direct current source including a storage capacitor, inductive means interconnecting said source and said load circuit and cooperating with the capacitance of said load circuit to form an oscillating circuit, a plurality of electric discharge valves for controlling the flow of current in said oscillating circuit, and means including a photoelectric cell for controlling the conductivity of said electric discharge valves to determine the frequency of the alternating potential of said

load circuit independently of the natural frequency of said oscillating circuit.

11. In an electric valve converting apparatus, a load circuit comprising a pair of spaced electrodes, a direct current source including a storage capacitor, a plurality of electric discharge valves and inductive means interconnecting said source and said load circuit, means for controlling the potential of said direct current source, and means including a photoelectric cell for controlling the conductivity of said electric discharge valves to determine the frequency and wave form of the alternating potential of said load circuit.

12. In an electric valve converting apparatus, a load circuit comprising a pair of spaced electrodes, a direct current source including a plurality of charged capacitors having a neutral terminal, a plurality of electric discharge valves and inductive means interconnecting said source and said load circuit, means for controlling the potential of said direct current source, and means including a photoelectric cell for controlling the conductivity of said electric discharge valves to determine the frequency of the alternating potential of said load circuit.

13. An electric valve converting apparatus comprising a supply circuit and an alternating potential load circuit interconnected by a plurality of electric discharge valves, means for controlling the conductivity of said electric discharge valves to determine the frequency of the alternating potential of said load circuit, said last mentioned means comprising a photoelectric cell for controlling the conductivity of each of said discharge valves, a source of light, and means including a slotted rotating disk for determining the frequency with which a beam from said source of light may be projected against said photoelectric cell.

14. In an electric valve converting apparatus, a load circuit including a pair of electrodes mounted in spaced relationship with one another, a supply circuit, electric valve means for interconnecting said circuits and for transmitting energy therebetween, means for rendering said valve means conductive successively at unequal intervals to produce an alternating potential having a flat-topped wave form across the electrodes of said load circuit in which the positive and negative portions of the cycle of said alternating potential are of different duration.

15. An electric valve converting apparatus comprising a supply circuit and an alternating potential load circuit interconnected by a plurality of electric discharge valves, means for controlling the conductivity of said electric discharge valves to determine the frequency and wave form of the alternating potential of said load circuit, said last mentioned means comprising a photoelectric cell for controlling the conductivity of each of said electric discharge valves, a source of light for each photoelectric cell, means including a slotted disk rotating at variable frequency for determining the frequency with which a beam from said light sources may be projected against said photoelectric cells, the angular position of said sources of light relative to one another determining the wave shape of the alternating potential of said load circuit.

16. In an electric valve converting apparatus, a load circuit including a pair of electrodes mounted in spaced relationship with one another, a supply circuit, electric valve means interconnecting said circuits for transmitting an alternating potential of variable frequency to said load circuit, means including a plurality of photoelectric cells for controlling the conductivity of said electric valve means, and means for determining the variable frequency of the alternating potential of said load circuit including means for periodically effecting the operation of said photoelectric cells, said periodicity determining the frequency of said alternating potential.

17. In an electric valve converting apparatus, a load circuit including a pair of electrodes mounted in spaced relationship with an another, a supply circuit, electric valve means interconnecting said circuits for transmitting an alternating potential of variable frequency to said load circuit, means including a plurality of photoelectric cells for controlling the conductivity of said electric valve means and means for determining the variable frequency of the alternating potential of said load circuit including means for periodically effecting the operation of said photoelectric cells, said last mentioned means being controllable to control the wave shape of the alternating potential of said load circuit.

18. In an electric valve converting apparatus, an alternating potential load circuit including a pair of electrodes mounted in spaced relationship with one another, a supply circuit, electric valve means interconnecting said circuits for transmitting energy therebetween, a plurality of auxiliary electric valves and photoelectric cells for controlling the conductivity of said electric valve means, a plurality of sources of light for effecting the operation of said photoelectric cells and means for controlling the periodicity with which said light sources effect said photoelectric cells to determine the frequency and the wave form of said alternating potential of said load circuit.

19. In combination, a source of potential, a load circuit including a pair of spaced electrodes having capacitance, inductance means connected in series with said load circuit and cooperating therewith to form an oscillating circuit, and controlled electric valve means connected in series with said oscillating circuit for controlling the time of reversal of current in said oscillating circuit independently of the natural frequency of said oscillating circuit to control the frequency and wave form of the potential appearing across said electrodes.

20. In combination, a source of potential, a load circuit including a pair of spaced electrodes having capacitance, inductance means connected in series with said load circuit and cooperating therewith to form an oscillatory circuit, reversely connected electric discharge valves interconnecting said source of potential and said oscillatory circuit, one of said valves conducting current in a direction to charge said electrodes in one sense and the other of said valves conducting current in a direction to charge said electrodes in the opposite sense, and means for controlling the conductivity of said valves to determine the periods during which said electrodes are charged in each sense.

WILLEM F. WESTENDORP.

CERTIFICATE OF CORRECTION.

Patent No. 2,243,591. May 27, 1941.

WILLEM F. WESTENDORP.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, lines 3 and 4, for "Furtheremore" read --Furthermore--; page 2, second column, line 15, strike out "the" before "variable"; page 3, second column, line 21, for "circiut" read --circuit--; line 27, for "negtaive" read --negative--; page 4, first column, line 55, for "This" read --The--; page 5, first column, line 66, claim 5, before "load" insert --a--; page 6, second column, line 15, claim 17, for "an" before "another" read --one--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of July, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.