

May 3, 1966

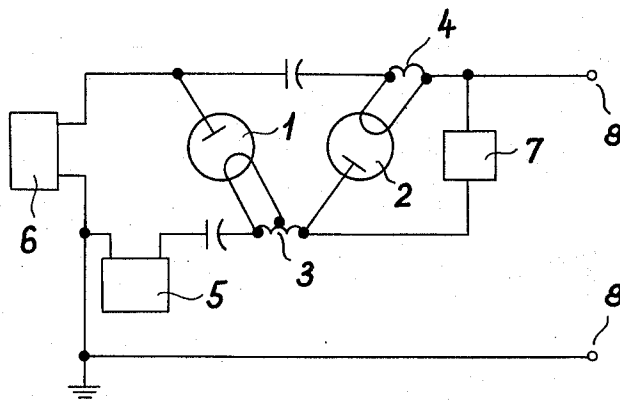
K. GANSZKY ET AL

3,249,843

HIGH VOLTAGE D.C. POTENTIAL SOURCE

Filed Nov. 19, 1962

2 Sheets-Sheet 1



PRIOR ART

Fig. 1

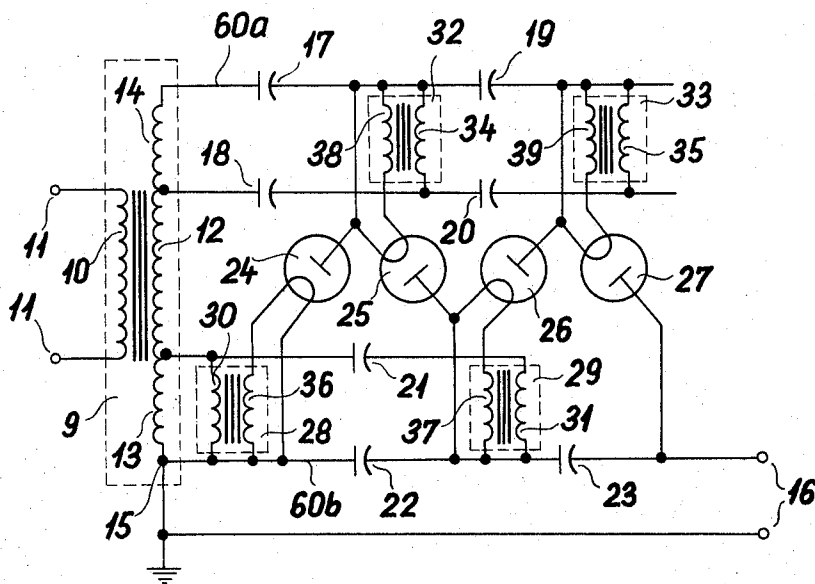


Fig. 2

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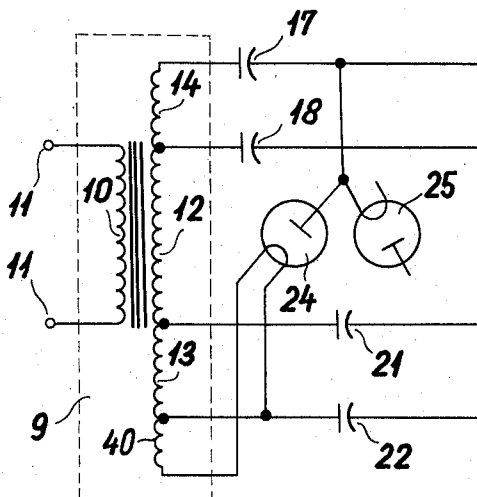


Fig. 3

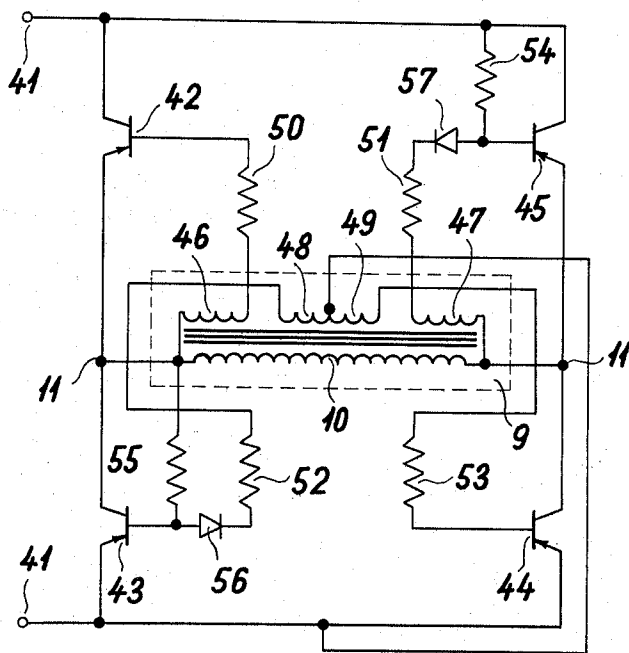


Fig. 4

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HIGH VOLTAGE D.C. POTENTIAL SOURCE

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5 Claims. (Cl. 321-15)

This invention relates to high D.C. voltage sources of the type utilizing a cascade voltage multiplying circuit including thermionic valves and, more particularly, to an improved high D.C. voltage source of this type in which both the relatively high thermionic valve operating potentials and the relatively low filament heating circuit potential are supplied from a single transformer without requiring special insulation of the filament heating circuits against the effects of the relatively high potential.

As is well known to those skilled in the art, electrostatic coating operations, electrostatic elimination of foreign materials such as dust and tar from gases, the testing of insulators with direct current, and other similar applications require a D.C. potential source of such a nature that, from a low voltage input, there may be derived a D.C. potential of up to 100 kv. As short circuits and breakdowns of equipment occur in service, a requirement of such sources is that they must be able to tolerate such conditions without damage.

In presently known high D.C. potential sources of the mentioned type, a relatively low D.C. voltage has been derived from an A.C. voltage and has then been boosted to the desired high potential by suitable means such as, for example a voltage multiplier circuit, for example a Grein or cascade circuit. In such arrangements employing thermionic valves, such as thermionic rectifiers, the fact that the filament heating circuits require potentials very much lower than the operating potentials of the valves has posed problems in supplying the filament heating current. Various expedients have been employed to solve these problems. One of these has been the use of separate generators mounted on a common drive shaft in insulated relation to each other. A simpler arrangement has involved separately supplying the rectifier operating potential from a transformer connected to a high frequency source. However, these expedients have rendered high D.C. potential sources unduly expensive and complex.

An object of the present invention is to avoid the foregoing difficulties as well as to avoid the necessity for the use of two separate sources of input potential, as well as to avoid the use of dynamos, generators, or other moving machinery, mounted in insulated relation to each other on a common drive shaft.

Accordingly, the present invention is directed to a high D.C. potential source utilizing an input transformer connected to a source of A.C. potential and thermionic valves in a cascaded rectifying and voltage multiplying circuit, but characterized in that potentials derived solely from the transformer secondary windings may be used both for the operating potentials of the thermionic valves and for the cathode filament heating circuits. As stated, the operating potentials have a value of several times the potential required for the filament heating circuits. The invention circuit is characterized by the use of condensers to isolate the filament heating circuits from the D.C. potential, and also by the fact that it is not necessary to provide special high voltage insulation for the windings of the filament heating transformers to protect them against the very high operating potentials of the thermionic valves.

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More particularly, in accordance with the present invention, the transformer has three secondary windings connected in series. The potentials of the two end windings are applied to the primary windings of respective cathode heating supply transformers. The connections are so arranged that, with respect to a pair of cathode heating circuit supply transformers connected to one end secondary winding, the primaries thereof have their corresponding terminals connected to each other through condensers arranged in parallel with each other. This arrangement is used for both end secondary windings, each of which supplies respective pairs of cathode heating circuit supply transformers. By utilizing an arrangement of this type, the condensers, in addition to isolating the cathode heating circuits from direct current, operate, in pairs, for the function of multiplying the potentials of the thermionic rectifiers which are connected in cascade.

In order to reduce the overall dimensions of the condensers, it is preferred that the main transformer be supplied from a high frequency source and, for this purpose, a transistor inverter circuit may be used to supply the high frequency A.C. input.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings. In the drawings:

FIG. 1 is a schematic wiring and block diagram illustrating a known type of high D.C. potential source such as mentioned above;

FIG. 2 is a schematic wiring diagram of a high D.C. potential source embodying the invention;

FIG. 3 is a partial schematic wiring diagram of a modified form of the high D.C. potential source illustrated schematically in FIG. 2; and

FIG. 4 is a schematic wiring diagram of a high frequency output transistor inverter circuit connected to the primary winding of the main transformer of the high D.C. potential source embodying the invention.

Referring to FIG. 1, a known form of high D.C. potential source comprises a pair of thermionic rectifier valves or tubes 1 and 2 connected in cascade with each other. The cathode heating potentials for the tubes 1 and 2 are derived from series type transformers 3 and 4.

To supply the cathode heating transformers 3 and 4, a high frequency A.C. source 6 is required in addition to the input power transformer 5. A special impedance element 7 by-passes the high frequency current relative to the high D.C. potential output derived across the terminals 8. This known type of high D.C. potential source is rendered unduly expensive because of the additional special high frequency elements which must be provided to supply the filament heating potentials.

As compared to this known high D.C. potential source, the arrangement of the invention has outstanding advantages. Referring to FIG. 2, which illustrates an embodiment of the invention, a voltage multiplier circuit, in the form of a cascade circuit, is supplied from a transformer 9 having a primary winding 10 connected, through terminals 11, to a suitable A.C. potential source. Transformer 9 has three secondary windings 12, 13 and 14, which are connected in series, with the two end windings 13 and 14 having, preferably, the same number of turns as the intermediate winding 12. One terminal 15 of the series connected windings 12, 13 and 14 is connected to one high D.C. potential output terminal 16.

The voltage multiplier cascade circuit includes capacitors 17 through 23 and thermionic rectifier valves 24 through 27. The cathodes of valves 24 and 26 are connected to one terminal of an end winding 13, and the circuit connected across the terminals of this end winding includes capacitors 21 and 22 for blocking direct current.

The cathode heating currents for the valves 24 and 26 are supplied by means of cathode heating transformers 28 and 29. These transformers 28 and 29 have primary windings 30 and 31 which are connected, in parallel, across the secondary winding 13 of transformer 9, and have secondary windings 36 and 37, respectively, each connected in the cathode heating circuit of a valve 24, 26. It will be noted that corresponding terminals of the primary windings 30 and 31 are connected to each other across the pair of parallel capacitors 21 and 22, respectively.

The condensers 17 and 19 are connected in a conductor 60a extending from the outer terminal of end winding 14, and the condensers 22 and 23 are connected by a conductor 60b extending from the outer terminal of end winding 13. The cathodes of valves 25 and 27 are connected to conductor 60a, and it will be noted that the cathode of valve 25 is connected to the end terminal of secondary winding 14 through condenser 17, and that the cathode of valve 27 is connected to the cathode of valve 25 across a condenser 19, both for the purpose of blocking direct current.

The cathode heating current for the valves 25 and 27 is provided by cathode heating transformers 32 and 33 each having a primary winding 34 or 35, respectively, and a secondary winding 38 or 39, respectively. The secondary windings are each connected in series in the respective cathode heating circuit. The primary windings 34 and 35 are connected in parallel across the terminals of the secondary windings 14 of transformer 9. However, it will be apparent that primary winding 34 is connected across secondary winding 14 through the medium of a pair of parallel capacitors 17 and 18, and corresponding terminals of primary windings 34 and 35 are interconnected across a pair of parallel capacitors 19 and 20. It will be noted that the conductors 60a and 60b have impressed, between them, the full potential across the series connected secondary windings 12, 13 and 14, and thus this full potential is impressed across each of the diodes 24-27.

Despite the fact that the capacitors 17 through 22 have the supply current for the transformers 28, 29, 32 and 33 passing therethrough, it will be noted that these capacitors are mutually connected in parallel in pairs, such as 17-18, 19-20, and 21-22, according to the normal flow of direct current. Thus, they further form the capacitors of the voltage multiplying cascade circuit, and function for the multiplication of the output voltage.

In the embodiment of the invention shown in FIG. 3, the design of the circuit differs from that shown in FIG. 2 only in the provision of a separate cathode heating winding 40 constituting a secondary winding of the transformer 9, the winding 40 supplying the cathode heating current for the valve 24. In this arrangement, the hot cathode of the valve 24 is at the same potential as one terminal of the secondary winding 13 of transformer 9, and in the normal flow of D.C. potential. The hot cathodes of the other thermionic valves, 25, 26 and 27, are heated in the same manner as shown and described in connection with FIG. 2.

Since the cathode heating transformers 28, 29, 32 and 33 have potentials supplied thereto across capacitors 21, 22, and 17, 18, 19 and 20, which serve to by-pass the D.C. voltage components, and as the impedances of the capacitors are inversely proportional to the frequency of the A.C. supply, it is desirable to use a source of high frequency A.C. potential to supply the primary winding 10 of the main transformer 9. As illustrated in FIG. 4, primary winding 10 of transformer 9 may be supplied from terminals 41, connected to a D.C. potential source, through a known type of transistorized inverter circuit capable of providing a high frequency A.C. output potential.

For this purpose, transformer 9 is provided with additional secondary windings 46, 47 and 48, 49 which also

serve, in a known manner, for supplying operating potentials to the transistors 42 through 45 of the inverter circuit. This means for supplying a high frequency A.C. input potential has the further advantage that the current through primary winding 10 of transformer 9 can be limited by means of current limiting resistances 50, 52, 53, 51, respectively in the base circuits of transistors 42, 43, 44 and 45. Thereby, the current through the primary winding 10 of transformer 9 can be limited to a predetermined value so that damage to the high D.C. potential source can be prevented even in the event of extended short circuits of the high potential output terminals 16.

Starting resistances 54 and 55 provide for the initiation of current flow through transistor 43, primary winding 10, and transistor 45, when a D.C. potential is impressed across the input terminals 41. Diodes 56 and 57 prevent shunting of the base circuit of transistor 43 by the current limiting resistance 52 and the secondary winding 48, and prevent shunting of the base circuit of transistor 45 by the current limiting resistance 51 and the secondary winding 47, as might otherwise occur upon starting of the circuit by connection of the terminals 41 to a source of D.C. potential.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A high D.C. potential source comprising, in combination, a single input power supply comprising a transformer having a primary winding, arranged for connection to a source of A.C. potential, and three secondary windings connected in series with each other; a rectifying and voltage multiplying circuit including hot cathode thermionic diodes; a heating circuit for the hot cathode of each diode, each heating circuit including a cathode heating transformer having a secondary winding in circuit with the respective cathode and a primary winding connected across only a respective end winding of said series connected secondary windings; capacitor means effective to isolate each cathode heating circuit from the flow of direct current; and means applying the potential developed between the end terminals of said series connected secondary windings across each of said diodes; said single input power supply being the sole input supply for both the operating potentials of the thermionic diodes and the heating circuit for the hot cathodes.

2. A high D.C. potential source comprising, in combination, a single input power supply comprising a transformer having a primary winding, arranged for connection to a source of A.C. potential, and three secondary windings connected in series with each other; a rectifying and voltage multiplying circuit including capacitors and hot cathode thermionic diodes; a heating circuit for the hot cathode of each diode, each heating circuit including a cathode heating transformer having a secondary winding in circuit with the respective cathode and a primary winding connected across only a respective end winding of said series connected secondary windings; capacitor means, including pairs of parallel connected capacitors of said rectifying and voltage doubling circuit, effective to isolate each cathode heating circuit from the flow of direct current; and means applying the potential developed between the end terminals of said series connected secondary windings across each of said diodes; said single input power supply being the sole input supply for both the operating potentials of the thermionic diodes and the heating circuit for the hot cathodes.

3. A high D.C. potential source comprising, in combination, a single input power supply comprising a transformer having a primary winding and three secondary windings, the secondary windings being connected in series with each other; a source of high frequency A.C. po-

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tential connected to said primary winding; a rectifying and voltage multiplying circuit including hot cathode thermionic diodes; a heating circuit for the hot cathode of each diode, each heating circuit including a cathode heating transformer having a secondary winding in circuit with the respective cathode and a primary winding connected across only a respective end winding of said series connected secondary windings; capacitor means effective to isolate each cathode heating circuit from the flow of direct current; and means applying the potential developed between the end terminals of said series connected secondary windings across each of said diodes; said single input power supply being the sole input supply for both the operating potentials of the thermionic diodes and the heating circuit for the hot cathodes.

4. A high D.C. potential source, comprising, in combination, a single input power supply comprising a transformer having a primary winding, arranged for connection to a source of A.C. potential, and three secondary windings connected in series with each other; a rectifying and voltage multiplying circuit including capacitors and hot cathode thermionic diodes connected in cascade; a plurality of cathode heating transformers each having a secondary winding in a heating circuit for the hot cathode of a respective thermionic diode, said cathode heating transformers being arranged in two groups and the primary windings of the cathode heating transformers of each group being connected in parallel with each other across a respective end winding of said series connected secondary windings; the primary windings of each group having corresponding terminals interconnected to each other through a respective pair of said capacitors, with

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the capacitors of each pair being connected in parallel with each other; said pairs of parallel connected capacitors inhibiting the flow of direct current in the cathode heating circuits while functioning as voltage multipliers in said cascaded voltage multiplying circuit; and means applying the potential developed between the end terminals of said series connected secondary windings across each of said diodes; said single input power supply being the sole input supply for both the operating potentials of the thermionic diodes and the heating circuit for the hot cathodes.

5. A high D.C. potential source, as claimed in claim 4, including a high frequency A.C. potential source connected to the input of said first-mentioned primary winding.

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