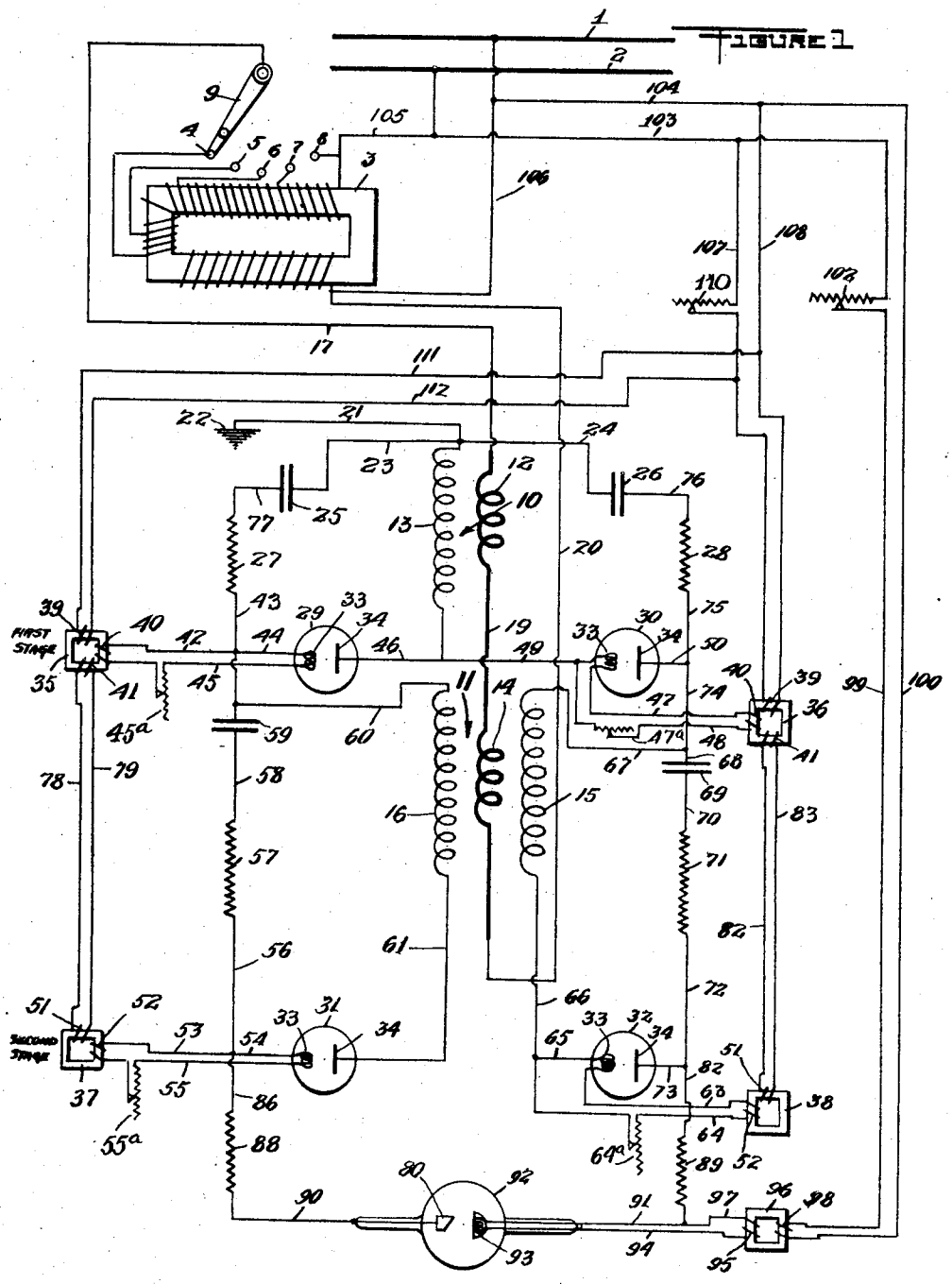
Sept. 15, 1931. A. MUTSCHELLER 1,823,463

CONSTANT HIGH POTENTIAL GENERATOR

Filed March 17, 1924 2 Sheets-Sheet 1

FIGURE 1



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CONSTANT HIGH POTENTIAL GENERATOR

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FIGURE 2

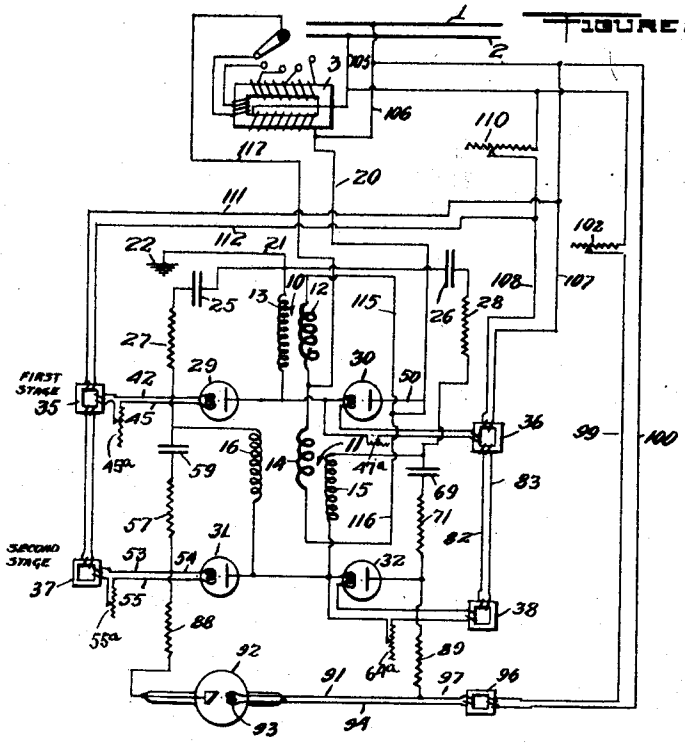


FIGURE 3

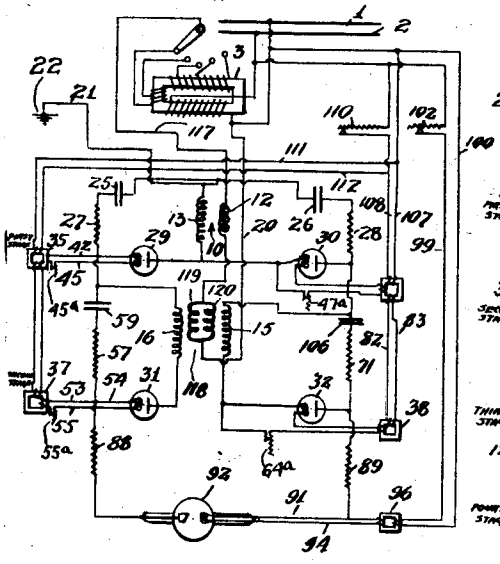
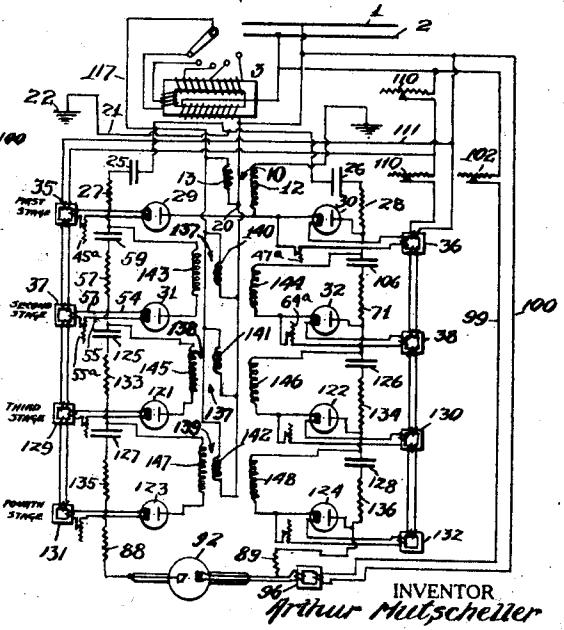


FIGURE 4



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1,823,463

UNITED STATES PATENT OFFICE

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CONSTANT HIGH POTENTIAL GENERATORS

Application filed March 17, 1924. Serial No. 699,626.

My invention relates to constant high potential generators, of the type in which the voltage attainable is relatively steady, notwithstanding irregularities and abrupt changes in the uses to which the high potential current, as developed, are applied.

My invention comprehends a method of and apparatus for developing and rendering constant potentials higher than have been ordinarily obtained heretofore except with very expensive apparatus and which at best have been found in practice very unreliable.

More particularly stated, I seek to practice the method above mentioned and also to produce a generator associated with the method and capable of use for many distinct purposes, and yet specially adapted for the excitation of X-ray tubes, such for instance as are now employed in the therapeutic treatment of disease, and many related purposes.

Heretofore in this art there have been sporadic efforts to develop and constantly maintain high potentials by means of apparatus supposedly suitable for the purpose, but all such efforts have been more or less unsuccessful in practice, chiefly because of the fragility of the various component electrical parts of the apparatus, causing breakdowns to take place or weaknesses to make their appearance, whenever the apparatus was used for developing very high potentials sufficiently steady for any valuable purpose. Hence the result of all such attempts has been that, if the apparatus was capable of developing a voltage high enough to have a fair degree of usefulness, such voltage could not be maintained steadily except for a very short time; and in instances where the apparatus could be made to work successfully for substantial periods of time, the potentials permissible for this purpose were necessarily in practice quite limited.

By my invention I seek to overcome the difficulties above mentioned and several others, by means of an apparatus which offers the advantages stated below:

First, I arrange a number of condensers and transformers, in connection with a number of vacuum tube valves provided with heated cathodes, in such manner as to build up very high voltages and maintain them steadily, and yet so that only a small fraction of the total electrical strain attainable with the apparatus as a whole is brought to bear upon any one of the members just mentioned. For this reason I am able to produce an apparatus which as a whole is capable of generating exceedingly high voltages without interruption, and without damage to the various mechanical parts employed, at least for long periods of time. Following the same idea further I can increase the voltage to practically any degree required, by grouping in series a number of separate sections, each section as a whole contributing to the sum total of the entire voltage of the apparatus; or in other words arranging a number of sections in series so as to render cumulative the separate voltages generated by the several respective sections.

Second, I can so construct and connect the several sections as to adjust the phase lag of one section relatively to another, in such manner that the potential impulses applied to and developed in the respective sections are thereby rendered asynchronous. This renders the potential less fluctuating, or in other words, more nearly constant.

Third, by my special arrangement of various component parts of the apparatus as above stated, I am enabled to utilize to great advantage certain capacity effects of the various parts, this arrangement being of assistance in steadying the potential of the apparatus as a whole and facilitating the cumulation of considerable quantities of electrical charge at very high potential.

Fourth, the apparatus as a whole is so constructed and arranged that a portion thereof, in series with the terminals and remotely connected therewith, is grounded; and the various parts exposed to extremes in potential are connected with and arranged symmetrically in relation to the part thus grounded. This arrangement renders it practicable, in attaining extremely high potentials, to carry various parts at potentials which are not excessive as compared with the zero potential of the earth. The particular arrangement of the various parts here con-

templated, and particularly of certain secondary windings in one or more of the transformers employed, also renders it practicable to produce a larger number of electric impulses, suitable for charging the condensers or their equivalent, than could ordinarily be obtained with any of the older types of apparatus.

Reference is made to the accompanying drawings forming a part of this specification and in which like reference characters indicate like parts throughout the several figures.

Figure 1 is a diagram illustrating one form of my apparatus, in which I increase the potential by two successive stages and by the use of two distinct sections connected in series and each taking care of a stage, the two sections acting cumulatively; the primary transformer windings being in this instance in series with each other.

Figure 2 is a diagram showing a form of my apparatus differing from that appearing in Figure 1 by the fact that the primary transformer windings are in parallel with each other, instead of in series.

Figure 3 is a diagram of still another form, in which the primary transformer windings are given another arrangement.

Figure 4 is a diagram showing a form of my apparatus in which the potential is raised by four successive stages, and in which there are four sections each controlling a stage, these four sections acting cumulatively and together developing a very great potential which is exceedingly steady and reliable.

I will first describe the mechanism shown in Figure 1.

A pair of power mains appear at 1, 2 and are used for supplying alternatng current, which may be of the kind conventionally employed for power and lighting work.

An auto-transformer appears at 3 and is provided with tap buttons 4, 5, 6, 7 and 8, through which the voltage is controlled by means of a switch lever 9.

A pair of step-up transformers are shown at 10 and 11. The transformer 10 is provided with a primary winding 12 and a secondary winding 13. The transformer 11 is provided with a primary winding 14 and a pair of secondary windings 15, 16. A wire 17 is connected with the primary winding 12, and extends therefrom to the switch lever 9.

A wire 19 extends from the primary winding 12 to the primary winding 14, and from the primary wnding 14 a wire 20 leads to the auto-transformer 3.

A wire 21 leads from the secondary winding 13 to the ground at 22, this wire being preferably but not necessarily centrally located as regards the general layout of the apparatus.

Connected with the ground wire 21 are two wires 23, 24, the wire 23 leading to a condenser 25, and the wire 24 leading to another condenser 26.

Adjacent to the condensers 25, 26, are a pair of fixed resistances 27, 28, and a pair of vacuum tube valves 29, 30.

Spaced a little distance from the vacuum tube valves 29 and 30 are two other vacuum tube valves 31, 32. The vacuum tube valves 29, 30, 31, 32, may all be of similar construction. Each of them is provided with a cathode 33, consisting of a filament adapted to be heated by a current passing through it, and with an anode 34, these parts being of the usual or any desired construction customarily employed in vacuum tube valves.

Associated with the vacuum tube valves are a number of small transformers 35, 36, 37, 38, equal to the number of valves, and used for supplying currents for heating the filaments.

The transformers 35, 36 are alike, each being provided with a primary winding 39, and with two secondary windings 40 and 41. A wire 42 is connected with the secondary winding 40 of the transformer 35, and is also connected with a wire 43, leading to the fixed resistance 27. A wire 44 is connected with the wires 43 and 42, and leads therefrom to the cathode 33 of the vacuum tube valve 29. A wire 45 leads from this cathode back to the winding 40 of the transformer 35. Connected with this wire 45 is a variable resistance 45*a*, for controlling the currents from the secondary winding 40, used for heating the adjacent cathode 33. A wire 46 is connected with the anode 34 of the vacuum tube valve 29.

A wire 47 is connected with the cathode 33 of the vacuum tube valve 30, and leads therefrom to the secondary winding 40 of the transformer 36. A wire 48 is connected with this winding 40 and with the cathode 33 of the vacuum tube valve 30, and also with a wire 49, this last mentioned wire being connected with the wire 46 and with the secondary winding 13. The wire 48 is also connected with a variable resistance 47*a*, for controlling the currents used for heating the adjacent cathode 33 of the vacuum tube 30. A wire 50 is connected with the anode 34 of this vacuum tube valve 30.

The two transformers 37, 38 are alike, each being provided with a primary winding 51 and a secondary winding 52. A wire 53 is connected with the secondary winding of the transformer 37 and with another wire 54, the latter leading to the cathode 33 of the vacuum tube valve 31. From this cathode 33 a wire 55 leads back to the said secondary winding 52.

A wire 56 is connected with the two wires 53, 54, and with a resistance 57. From this resistance a wire 58 leads to a condenser 59. A wire 60 is connected with this condenser and with the wire 43, and also with the sec-

ondary winding 16. A wire 61 leads from this secondary winding to the anode 34 of the vacuum tube valve 31.

A wire 63 is connected with the cathode 33 of the vacuum tube valve 32, and leads therefrom to the secondary winding 52 of the transformer 38. A wire 64 is connected with this secondary winding and with two wires 65, 66, the wire 65 being connected with the cathode 33 of the vacuum tube valve 32, and the wire 66 being connected with the secondary winding 15. The wire 64 is connected with a variable resistance 64*a*, for controlling the currents used for heating the cathode 33 of the vacuum tube 32.

A wire 67 is connected with the secondary winding 15 and with a wire 68 which leads to a condenser 69. From this condenser a wire 70 leads to a fixed resistance 71. A wire 72 is connected with this resistance, and with a wire 73 which leads to the anode 34 of the vacuum tube valve 32.

A wire 74 is connected with the wires 67, 68, and also with a wire 50 and a wire 75. The wire 50 leads to the anode 34 of the vacuum tube valve 30, and a wire 75 leads to the fixed resistance 28. From this resistance a wire 76 leads to the condenser 26.

A wire 77 leads from the condenser 25 to the fixed resistance 27.

A wire 78 is connected with the secondary winding 41 of the transformer 35, and leads therefrom to the primary winding 51 of the transformer 37. A wire 79 is connected with the secondary winding 41 of the transformer 35, and leads therefrom to the primary winding 51 of the transformer 37.

The secondary winding 41 of the transformer 36 is connected with a wire 82, which leads therefrom to the primary winding 51 of the transformer 38. A wire 83 leads from the secondary winding 41 of the transformer 36 to primary winding 51 of the transformer 38.

A wire 90 is connected with the fixed resistance 88, and with the anode 80 of an X-ray tube 92. This X-ray tube is provided with a cathode 93, consisting in this instance of a filament adapted to be heated. Connected with this cathode are two wires 91, 94. The wire 94 leads to the secondary winding 95 of a heating transformer 96. A wire 97 is connected with this secondary winding, and with the wire 91 and the fixed resistance 89.

The heating transformer 96 is provided with a primary winding 98. Connected with this primary winding are a pair of wires 99 and 100, the wires 99 and 100 being connected with a variable resistance 102, which may be a rheostat of ordinary form. A wire 103 is connected with the wire 99, and the wire 104 is connected with the wire 100.

The wire 103 is connected with a wire 105 which leads from the main 2 to the winding of the auto-transformer 3. The wire 104 leads to the wire 106, which extends from the main 1 to the winding of the auto-transformer 3. A wire 107 is connected with the wires 99 and 103, and also with a variable resistance 110, which may be a rheostat of ordinary construction. A wire 108 is connected with the wires 100 and 104 and with the primary winding 39 of the transformer 36.

A wire 111 is connected with the wire 108, leading therefrom to the primary winding 39 of the transformer 35. A wire 112 is connected with the wire 107 and with primary winding 39 of the transformer 35.

The various condensers, fixed resistances, variable resistances and variable inductances are severally used in the manner well known in this art, and need no detailed explanation.

The several transformers 35, 36, 37 and 38 are used as above stated, for heating the respective cathodes 33 of the vacuum tube valves 29, 30, 31, 32.

In practice, changes are made in the potential of the apparatus, by manipulating the auto-transformer 3; and changes are made in the amperage by varying the variable resistances 110, serving as filament regulators.

Whenever the transformers 10 and 11 are thrown into action, the vacuum tube valves 29 and 30 are energized by impulses from the secondary winding 13, and the vacuum tube valves 31 and 32 are energized from the secondary windings 15 and 16. There is, however, a very important distinction to be noted as to the function performed by the vacuum tube valves 29 and 30. That is, the work of the valves 31 and 32 begins where the work of the valves 29 and 30 ends, so that the valves 31 and 32 are at a higher potential than the valves 29 and 30. Thus it will be noted that for the transformer 10 and parts immediately associated therewith there is one stage of potential developed, and for the transformer 11 and parts immediately associated therewith there is a second stage of potential developed.

Thus according to Figure 1 the apparatus may be considered as made up of two successive sections, one section being shown generally in the upper portion of the figure and in which the potential is developed to a predetermined degree, the other section being shown in the lower portion of this figure, and in which the potential is stepped up to a still higher degree.

In the form shown in Figure 2 the construction and action of the various parts is similar to that above described with reference to Figure 1, with the exception that in the structure shown in Figure 2 the connections for the primary windings 12, 14 are arranged a little differently. For this purpose the wire 117 is connected between the pri-

mary windings 12, 14, and by means of two wires 115, 116, these two windings are also connected with the wire 20. By this arrangement the primary windings 12, 14, are in parallel with each other with reference to the currents flowing through them from the auto-transformer 3, by means of the wires 117 and 20. This makes very little difference in the practical working of the apparatus as a whole. Its advantage lies in the fact that by placing the primary windings 12 and 14 in parallel with each other with reference to the circuit whereby they are energized, the potential of the primary circuit is higher than if the said primary windings were in series with each other.

In the form shown in Figure 3 no change is made in the transformer 10, but instead of the transformer 11 I use a transformer 118 in which are two primary windings 119, 120, arranged in parallel with each other with reference to the wire 117 with which they are connected, and also in parallel with each other with reference to the wire 20 with which they are likewise connected.

The transformers here contemplated are oil transformers, and the primary windings just mentioned may be parts of a single transformer or parts of two separate transformers, and may therefore be contained either together in a single transformer tank or separately in two such tanks.

In the form of my apparatus appearing in Figure 4, I add two complete sections for the purpose of developing very high potentials. While in the form shown in Figures 1 to 3 inclusive the voltage is increased by only two successive stages, in the form appearing in Figure 4 there are contemplated four successive stages whereby the potential is successively increased. Four vacuum tube valves 121, 122, 123, 124 are added, and also four condensers 125, 126, 127 and 128, along with an equal number of heating transformers 129, 130, 131 and 132. I add four fixed resistances 133, 134, 135, 136. No change is made in the transformer 10, but instead of the transformer 11 I use three transformers 137, 138 and 139. The three transformers are provided with primary windings 140, 141, 142, and with secondary windings 143, 144, 145, 146, 147, and 148, the secondary windings being arranged in pairs as shown, or being each with a separate primary and core contained in a separate tank.

The several primary windings 13, 140, 141 and 142 are connected with the wires 20 and 117, and are in parallel with each other with reference to these wires. The secondary windings 143 to 148 inclusive are arranged in pairs, each pair being in inductive relation with some one of the transformer windings 140, 141, 142, and hence are energized in the same way as the secondary windings 15, 16 are energized by the primary winding 14, as above described with reference to Figure 1.

Thus the apparatus indicated in Figure 4 may be considered as an extension of the apparatus shown in Figure 1, in the sense that while Figure 1 shows only two groups of potential developing elements, and consequently contemplates only two successive stages in the stepping up of the potential, the apparatus shown in Figure 4 comprises four sections, employed in such relation as to raise the potential step by step, by four successive stages. Other factors being equal, therefore, the maximum potential which can be developed by the apparatus shown in Figure 4 is considerably higher than the maximum potential which can be developed by the apparatus shown in any other figure.

I have found that by using four vacuum tube valves and four condensers, arranged generally as above described so as to raise the potential by two stages, it is practicable to develop and maintain continuously a constant potential of two hundred and fifty kilovolts, but without developing in any one section of the apparatus a maximum potential of more than one hundred and twenty-five kilovolts.

It will be noted that in each form of my apparatus the wire 21, which is connected with the ground at 22, is located somewhat centrally; and that considering this wire as always at zero potential as compared with the earth, the high voltages attained in other portions of the apparatus, remote from this ground wire, are necessarily in degree symmetrical relatively to zero. If, for instance, the potential developed is 200,000 volts, the extremes of this potential are respectively, 100,000 volts above and below the zero of neutral potential of the earth.

The fixed resistances, of which there is one set in each section of the apparatus, serve to prevent sudden rushes of large current from one section to another, but of course do not prevent impulses of current from flowing into the condensers, so as to fill the same with electricity. Thus the potential developed within and by each section acts cumulatively in charging the several successive sets of condensers.

Since the condensers are capable of storing considerable charges of electricity, and since the potential developed is cumulative from section to section, it follows that large quantities of electricity can thus be collected and stored at high potentials. The charge thus built can be drawn upon as needed. It can be used as required, and when used at proper rate may be maintained practically constant.

If desired, the apparatus shown in Figure 1 can be modified by the insertion of a variable inductance between the primary windings 12 and 14, so as to produce a slight lag in phase as between the transformers 10 and

11. This arrangement enables the condensers 25, 26 to be charged at a slightly different instant from the condensers 59, 69.

The various heating transformers above described may be arranged as described in my Patent No. 1,481,876, dated January 29, 1924.

In connection with each apparatus above described I show an X-ray tube 92, operated entirely by means of the constant high potential generated. If an X-ray tube is thus employed, the radiation from it is far more homogeneous than that ordinarily produced by means of pulsating currents of high potential. This effects a great improvement in the efficiency of a given X-ray tube, this efficiency being quite pronounced when the tube is used in therapeutic X-ray treatment of disease. Because of the radiation being rendered more homogeneous, there is also less danger in using the X-rays at greater intensity. However. it should be understood that my use of an X-ray tube in the relation here contemplated is merely typical, and that the charge of high potential electricity generated by my apparatus may be employed in many distinct fields, independently of X-ray work.

I do not limit myself to the precise mechanism shown, as variations may be made therein without departing from my invention, the scope of which is commensurate with my claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is as follows:

1. A constant high potential generator, having a number of sections, each section containing a condenser, a vacuum tube valve connected with said condenser, a resistance and a source of high potential alternating current separate from said condenser and connected with said condenser and said valve and with said resistance for the purpose of charging said condenser with static electricity of one sign only, and connections between said sections for the purpose of enabling said sections to act cumulatively as a unit.

2. A constant high potential generator comprising a number of sections, each section containing a condenser and also a vacuum valve tube in the series with said condenser, a source of high potential alternating current separate from said condenser and from said vacuum tube valve, said source of high potential alternating current being connected with said condenser and with said valve for the purpose of charging said condenser with static electricity of one sign only, a resistance, and means for connecting said sections together in series through said resistance.

3. A constant high potential generator, comprising a number of potential transforming devices, connected in series with each other and each embodying a valve tube, together with a capacity and a resistance, said capacity and said resistance being separate from said valve tube and connected conductively in series therewith.

4. A constant high potential generator comprising a plurality of separate sections, each section containing a condenser and also containing a valve tube connected in series with said condenser, a source of high potential alternating current separate from said condenser and said valve tube, but connected with said condenser and with said valve tube for the purpose of charging said condenser with static electricity of one sign only, series connections from one section to another in order to facilitate raising the potential of one section relatively to another section, and resistances included in said series connections.

5. A constant high potential generator comprising a plurality of separate sections, each section containing a condenser together with a valve tube and a source of high potential alternating current, in series with said condenser, each section being so connected with the other sections that the condenser, the valve tube and the source of high potential alternating current of one section are always in series with the condenser, valve tube and source of high potential alternating current of each of the other sections, and resistances included in each section.

Signed at Long Island City, New York, in the county of Queens and State of New York, this 26th day of February, 1924.

ARTHUR MUTSCHELLER.