April 19, 1927. 1,625,328

A. MUTSCHELLER

CONVERTIBLE X-RAY MACHINE

Filed March 1, 1923 2 Sheets-Sheet 1

FIGURE 1

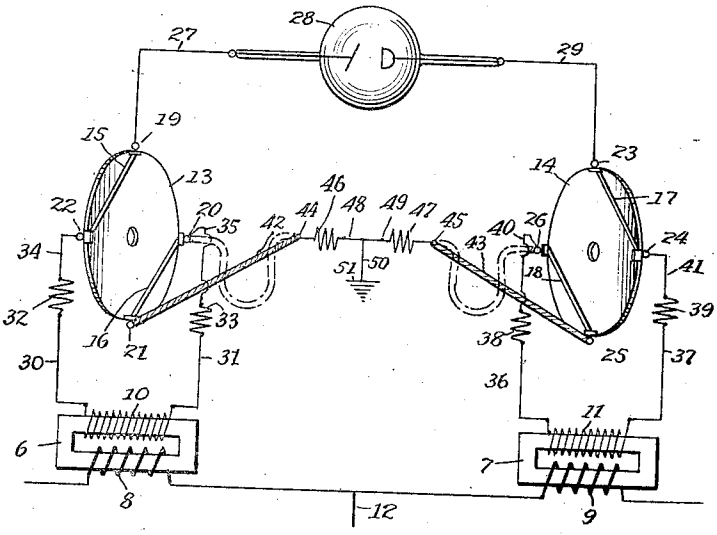
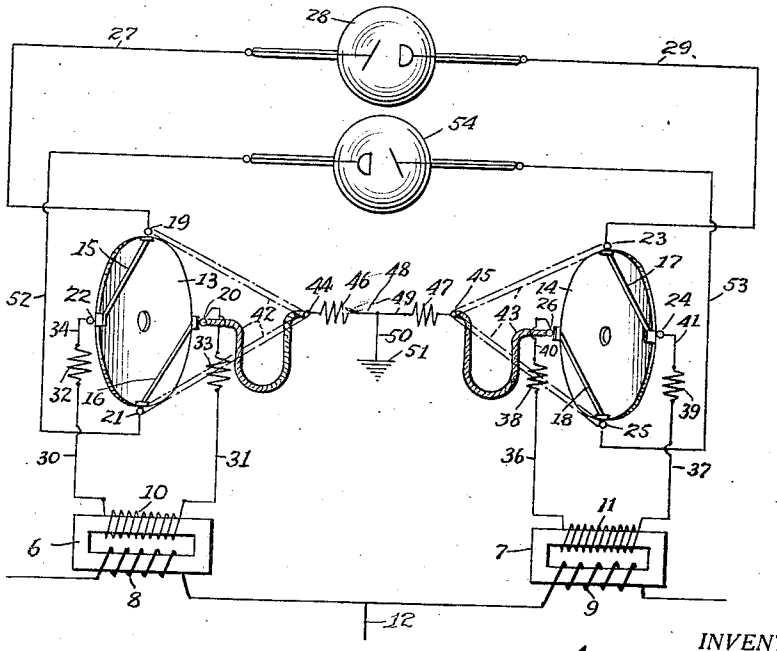


FIGURE 2



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FIGURE 3

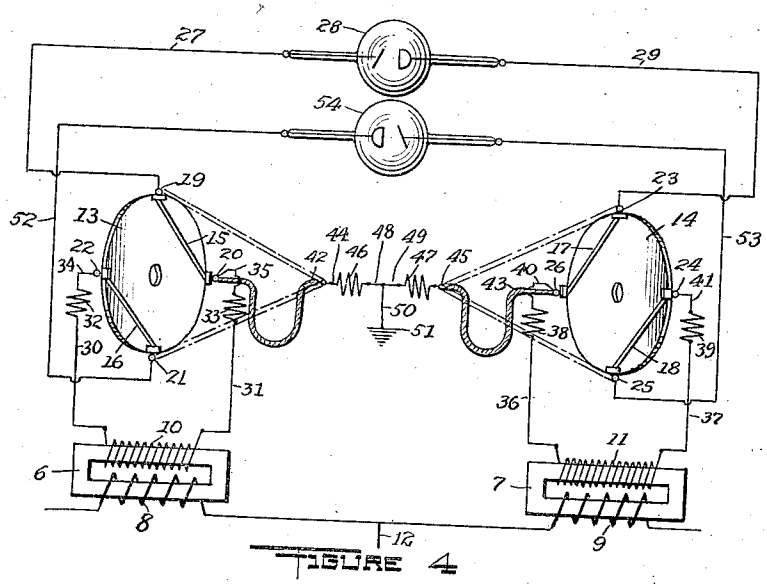


FIGURE 4

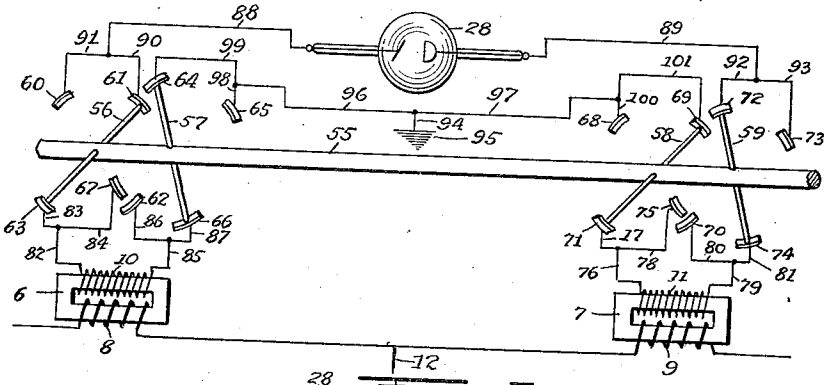
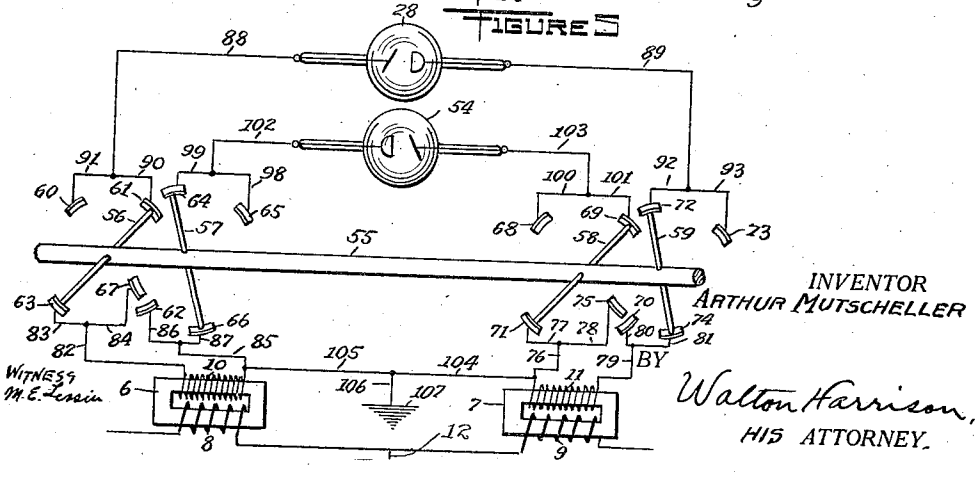


FIGURE 5



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UNITED STATES PATENT OFFICE.

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CONVERTIBLE X-RAY MACHINE.

Application filed March 1, 1923. Serial No. 622,025.

My invention relates to convertible X-ray machines, that is, to X-ray machines so constructed and arranged that they may be easily and quickly adapted for use with a single X-ray tube or with a pair of X-ray tubes, as the case may be.

More particularly stated, I use an X-ray machine comprising a pair of high tension transformers and a high tension rectifying switch connected with these transformers, the machine as a whole being adapted for sending high tension discharges through a single X-ray tube or through a pair of X-ray tubes as the case may be, depending upon the connections employed, these connections being so arranged to render the machine as a whole quickly and easily convertible at any time, for energizing either the single tube or the two tubes, as desired.

In order to understand the principles of my invention it may be well to bear in mind that in applying X-ray therapeutic treatment to certain malignant and deep-seated diseases by means of modern deep therapy X-ray apparatus it becomes necessary, at least at times, to continue the exposures for considerable periods. Because of this fact the number of cases which can be treated during a day or other given period of time, by means of an X-ray machine operated with but a single X-ray tube, is very sharply limited. This renders the treatment expensive for patients who are fortunate enough to find the apparatus available, and has a tendency to deprive other patients of their chances for treatment, at least from a given machine.

The conditions just mentioned have in some instances led up to the practice of using a pair of deep therapy X-ray tubes arranged for treating two patients at once, the X-ray tubes being connected with and energized alternately by a single X-ray machine. This practice has resulted in considerable economy, and an increase of satisfaction upon the part of the patients.

However there is one serious disadvantage associated with the use of a pair of X-ray tubes energized by a single X-ray machine as just mentioned. That is, in order to render the system advantageous it is necessary to have two patients requiring the same sort of X-ray treatment, both qualitative and quantitative. This is not always practicable. Again, if the machine is adapted in the usual manner for energizing a pair of X-ray tubes alternately, and it happens that only one patient is present so that only one of the X-ray tubes can be used in the relation here contemplated, the machine will not be in proper balance for the purpose of energizing a single tube only. Hence under the conditions just stated the operator must either run the machine at a disadvantage, or make a number of changes in the electrical connections in order to adapt the mechanism for use with a single tube, or must run one of the X-ray tubes idle, so that in either case a loss of some kind must take place.

By my invention I seek to take a deep therapy X-ray machine of the usual or any preferred construction and to render this machine easily and quickly convertible in order that it may be used indiscriminately with a pair of tubes or with a single tube, so that it can be quickly and easily converted from one to the other of the two uses thus contemplated. I have found that the machine can be completely converted by a very simple manipulation, usually nothing more than shifting the position of one or two flexible cords.

I also find it practicable to so construct and arrange the apparatus that when the simple manipulation is made so as to use two X-ray tubes, neither of these tubes is energized except under conditions when both of the tubes are subjected to current impulses at maximum potentials; and whereby at any given instant, when one tube of the pair is being energized, the other tube is not subjected to any difference of potential, of an impulse either direct or inverse.

I have made the further discovery that the machine can be converted as here contemplated, without discarding any of the advantages which have recently been developed in connection with X-ray deep therapy, such for instance as the use of damping resistances, short sectors, oscillation preventing devices, etc.

My invention is of special value in protecting the X-ray tubes from accidential and undesirable potential stresses; or in other words, in obliterating or reducing to a minimum all potential strains likely to be thrown upon the X-ray tube or tubes, except those which are absolutely necessary for the production of the X-rays.

Reference is made to the accompanying

drawings forming a part of this specification, and in which like reference characters indicate like parts throughout all of the figures.

Figure 1 is a diagram showing my invention as applied to an X-ray machine, and the latter as adapted for use with a single X-ray tube.

Figure 2 is a diagram showing the same X-ray machine, but as adapted for use with a pair of X-ray tubes.

Figure 3 shows the same machine and parts as Figure 2, but with the rectifying disks as momentarily occupying different positions from those they occupy in Figure 2.

Figure 4 is a diagram showing my invention as applied to another form of X-ray machine, the latter being connected for use with a single X-ray tube.

Figure 5 is a diagram showing the X-ray machine indicated in Figure 4, but as used in connection with a pair of X-ray tubes energized alternately, and arranged for treatment of two patients.

A pair of high tension transformers are shown at 6 and 7, and are provided with primary windings 8 and 9 and secondary windings 10 and 11. The primary windings are connected with each other by aid of a wire 12, and are energized in the manner well understood in this art.

A pair of rectifying disks are shown at 13 and 14. The disk 13 carries a pair of connectors 15 and 16, and the disk 14 similarly carries a pair of connectors 17 and 18. Disposed about the disk 13 are contact brushes 19, 20, 21 and 22, and about the disk 14 are disposed brushes 23, 24, 25 and 26. From the brush 19 a conductor 27 leads to a single X-ray tube 28, and from the latter a conductor 29 leads to the brush 23. Connected with the secondary winding 10 are two wires 30 and 31, which lead to resistances 32 and 33, and from the latter two wires 34 and 35 lead to the two brushes 22 and 20. Connected with the secondary winding 11 are two wires 36 and 37, leading to resistances 38 and 39, and from these resistances two wires 40 and 41 lead to the respective brushes 26 and 24. A pair of conductors 42 and 43, preferably cords or flexible cables, are connected to conductors 44 and 45, these conductors being connected with resistances 46 and 47. These resistances are by means of wires 48 and 49 connected with a wire 50, which is grounded at 51.

The conductors 42 and 43 can be readily detached from the respective brushes 21 and 25, and attached to the brushes 20 and 26, as indicated by full and broken lines in Figure 1.

The machine thus shown is ready for use in connection with the single X-ray tube, as indicated in Figure 1. For this purpose the conductors 42 and 43 are connected as indicated by full lines in this figure.

The apparatus thus far described is merely the usual form of X-ray machine, as arranged to operate with a single X-ray tube; with the exception, however, that the conductors 42 and 43 are specially arranged in accordance with my invention, so as to be easily shifted back and forth, as indicated by full and broken lines in this figure.

I do not consider it necessary to describe in detail the general construction and action of the mechanism as a whole. However, for the purpose of throwing light upon the office performed by the conductors 42 and 43 while occupying the positions indicated for them by full lines in Figure 1, I will trace one of the circuits, as follows: Secondary winding 10, wire 30, resistance 32, wire 34, brush 22, connector 15, brush 19, wire 27, X-ray tube 28, wire 29, brush 23, connector 17, brush 24, wire 41, resistance 39, wire 37, secondary winding 11, wire 36, resistance 38, wire 40, brush 26, connector 18, brush 25, conductor 43, wire 45, resistance 47, wires 49 and 48, (grounded through wire 50), resistance 46, wire 44, conductor 42, brush 21, connector 16, brush 20, wire 35, resistance 33, and wire 31, back to secondary winding 10. The rectifying disks 13 and 14 are rotated synchronously with reversals in the direction of the alternating current employed for energizing the high tension transformers 6 and 7, and hence it follows that the discharges through the single X-ray tube must always have the same direction in accordance with practice well known in this art.

In order to adapt the X-ray apparatus shown in Figure 1 for use with a pair of X-ray tubes instead of with a single tube, I simply disconnect the conductors 42 and 43 from the brushes 21 and 25, and connect them with the brushes 20 and 26. That is, I shift the conductors 42 and 43 from the positions indicated for them by full lines in Figure 1 into the positions indicated for them by dotted lines in said figure. This done, they appear as indicated in Figure 2. I now add two wires 52 and 53, by connecting them to the brushes 21 and 25, and also add an X-ray tube 54, by connecting it with the wires 52 and 53, all as indicated in Figure 2.

I will now trace the circuits through which the two X-ray tubes 28 and 54 are energized alternately, as indicated in Figures 2 and 3. Referring more particularly to Figure 2, a secondary circuit may be traced as follows: Secondary winding 10, wire 30, resistance 32, wire 34, brush 22, connector 15, brush 19, wire 27, X-ray tube 28, wire 29, brush 23, connector 17, brush 24, wire 41, resistance 39, wire 37, secondary

winding 11, wire 36, resistance 38, wire 40, brush 26, cord 43, wire 45, resistance 47, wires 49 and 48 (grounded through wire 51), resistance 46, wire 44, cord 42, brush 20, wire 35, resistance 33, and wire 31, back to secondary winding 10. The circuit thus traced energizes the X-ray tube 28. The rectifying disks 13 and 14, being now turned into the positions indicated for them in Figure 3, and the direction of the current through the secondary windings being reversed, another secondary circuit may now be traced as follows, reference being more particularly made to Figure 3: Secondary winding 10, wire 30, resistance 32, wire 34, brush 22, connector 16, brush 21, wire 52, X-ray tube 54, wire 53, brush 25, connector 18, brush 24, wire 41, resistance 39, wire 37, secondary winding 11, wire 36, resistance 38, wire 40, brush 26, cord 43, wire 45, resistance 47, wire 49 (grounded through wire 50), wire 48, resistance 46, wire 44, cord 42, brush 20, wire 35, resistance 33, and wire 31, back to secondary winding 10. The circuit thus traced energizes the X-ray tube 54, but has no effect upon the tube 28.

It will be noted that the two X-ray tubes 28 and 54 are energized alternately, and that whenever either of them is energized it receives the added potential of both of the secondary windings 10 and 11. In other words the two secondary windings are in series with each other for the purpose of energizing the X-ray tube 28, and are also in series with each other for the purpose of energizing the X-ray tube 54. It will also be seen that each of these tubes is completely inert while the other is being energized.

Starting, now, with the mechanism arranged as indicated in Figures 2 and 3 and as above described, I may wish to throw either of the X-ray tubes 22 or 54 out of action, so as to operate with only a single tube. In order to do this, I merely disconnect the cords 42 and 43 from the brushes 20 and 26, and connect them with the brushes 21 and 25 if I wish to use X-ray tube 28 alone; or, I connect the cords with the brushes 19 and 23 if I wish to use the X-ray tube 54 alone.

It may happen that for many reasons I may prefer one of these tubes to the other, in this connection. For instance one of the tubes may for the time being happen to occupy a location more favorable than the other for the particular work in contemplation, or one of the tubes may be in better condition than the other, or an individual patient might express a preference as between the two tubes. It is desirable, therefore, that the operator can select either of the tubes for active use and thus leave the other tube temporarily idle.

In order to use the tube 28 and render the tube 54 idle, I merely disconnect the cords 42 and 43 from the brushes 20 and 26, and connect them with the brushes 21 and 25. This arranges the secondary circuit as contemplated by Figure 1, and as above described at length with reference to that figure. That is to say, although the tube 54 and its connections are present, no difference of potential is developed through the tube 54 in any position of the rectifying disks 13 and 14, and yet the X-ray tube 28 is repeatedly energized, and receives the potential developed by both of the secondary windings 10 and 11, as above described with reference to Figure 1.

Suppose, next, that the operator wishes to render the tube 54 active and the tube 28 idle. To do this he simply disconnects the cords 42 and 43 from the brushes 21 and 25, and connects them instead to the brushes 19 and 23. A circuit may now be traced through the tube 54, as follows: Secondary winding 10, wire 30, resistance 32, wire 34, brush 22, connector 15, brush 19, cord 42 (now in its new position), wire 44, resistance 46, wire 48 (grounded through wire 50), resistance 47, wires 49 and 45, cord 43 (now connected with the brush 23), through this brush to connector 17, brush 24, wire 41, resistance 39, wire 37, secondary winding 11, wire 36, resistance 38, wire 40, brush 26, connector 18, brush 25, wire 53, X-ray tube 54, wire 52, brush 21, connector 16, brush 20, wire 35, resistance 33, and wire 31, back to the secondary winding 10.

No difference of potential is now developed through the X-ray tube 28, so that this tube now remains idle and totally inert.

In Figure 4, I show my invention as adapted for use in connection with a single X-ray tube, energized by a type of rectifying switch now in common use but differing from the type contemplated by Figures 1, 2 and 3 inclusive.

A revoluble shaft 55 carrier a number of connectors 56, 57, 58 and 59, each in the form of a rod extending diametrically through the shaft 55, the connectors being staggered relatively to each other. Associated with the connector 56 are contact brushes 60, 61, 62 and 63, and associated with the connector 57 are other contact brushes 64, 65, 66 and 67. Similarly, in connection with the connectors 58 and 59 are shown a number of contact brushes 68, 69, 70, 71, 72, 73, 74 and 75.

A wire 76 is connected with the secondary winding 11 and with two wires 77 and 78, the wire 77 leading to the brush 71 and the wire 78 leading to the brush 75. A wire 79 is connected with the secondary winding 11 and with two other wires 80 and 81, the wire 80 leading to the contact brush 70 and the wire 81 leading to the contact brush 74.

The other secondary winding 10 is connected by wire 82 with two other wires 83 and 84, the wire 83 leading to the brush 63, and the wire 84 leading to the brush 67. A wire 85 is connected with the secondary winding 10, and with two wires 86 and 87, the wire 86 leading to the brush 62, and the wire 87 leading to the brush 66. Two wires 88 and 89 are connected with the X-ray tube 28. The wire 88 is connected with two wires 90 and 91, the wire 90 being also connected with the brush 61 and the wire 91 leading to the brush 60. The wire 89 is connected with two wires 92 and 93, the wire 92 being connected with the brush 72, and the wire 93 being connected with the brush 73. A wire 94 is connected with the ground at 95, and is also connected with two wires 96 and 97. The wire 96 is connected with a wire 98, leading to the brush 65, and with a wire 99, leading to the brush 64. The wire 97 is connected with two wires 100 and 101, the wire 100 leading to the brush 68, and the wire 101 leading to the brush 69.

With the mechanism shown in Figure 4 arranged as shown, and with the various movable parts occupying the positions here indicated for them, a secondary circuit may be traced as follows: Secondary winding 10, wires 82 and 83, brush 63, connector 56, brush 61, wires 90 and 88, X-ray tube 28, wires 89 and 92, brush 72, connector 59, brush 74, wires 81 and 79, secondary winding 11, wires 76 and 77, brush 71, connector 58, brush 69, wires 101, 97, (grounded by wire 94), wires 96 and 99, brush 64, connector 57, brush 66, wires 87 and 85, back to secondary winding 10.

Assuming that the revoluble shaft 55 now turns to an extent represented by 90 degrees or one fourth of a revolution, another secondary circuit may be traced as follows: Secondary winding 10, wires 82 and 84, brush 67, connector 67 (now engaging brush 67), brush 65, wire 98, wire 96 (now grounded by wire 94), wire 97, wire 100, brush 68, connector 58 (now engaging this brush), brush 70, wires 80 and 79, secondary winding 11, wires 76 and 78, brush 75, connector 59 (now engaging brush 75), brush 73, wires 93 and 89, X-ray tube 28, wires 88, and 91, brush 60, connector 56 (now engaging this brush), brush 62, wires 86 and 85, back to secondary winding 10.

Thus it will be seen that the direction of travel of current impulses through the X-ray tube is always the same relatively to the tube, notwithstanding the reversal in the direction of the flow of the current as it passes through the secondary windings.

In Figure 5 I show the same rectifying switch as that appearing in Figure 4, but used in connection with an additional X-ray tube 54. For this purpose, I connect the X-ray tube 54 with two wires 102 and 103, and connect the wire 102 with the wires 98 and 99, the wire 103 being connected with the wires 100 and 101. I also connect the secondary winding 11 and the wire 76 with a wire 104, and connect the secondary winding 10 and the wire 85 with another wire 105. I connect the wires 104, 105, with a wire 106, leading to the ground at 107.

With the mechanism shown in Figure 5 arranged as here shown, both of the X-ray tubes 28 and 54 are energized, each of the tubes receiving the added potential due to the use of the two secondary windings in series with each other, each tube being idle while the other tube is being energized.

A secondary circuit may be traced, as follows: Secondary winding 10, wires 82 and 83, brush 63, connector 56, brush 61, wires 90 and 88, X-ray tube 28, wires 89 and 92, brush 72, connector 59, brush 74, wires 81 and 79, secondary winding 11, wire 104 (grounded by wire 106), and wire 105 back to secondary winding 10. This circuit energizes the X-ray tube 28. When the shaft 55 has turned to the extent of 90 degrees, or one fourth of a complete revolution, so as to shift the positions of the connectors 56, 57, 58 and 59 accordingly, another circuit may be traced as follows: Secondary winding 10, wires 82 and 84, brush 67, connector 57, brush 65, wires 98 and 102, X-ray tube 54, wires 103 and 100, brush 68, connector 58, brush 70, wires 80 and 79, secondary winding 11, wire 104 (grounded by wire 106), and wire 105, back to secondary winding 10.

Thus it will be seen that the X-ray tubes 22 and 54 are energized alternately, each to the maximum potential of the machine, and that each tube is idle at the precise moment when the other is energized.

It will also be noted that in order to use the rectifying switch shown in Figures 4 and 5 in two different ways, namely, with a single tube or with a pair of tubes, the machine can be easily and quickly converted, by merely shifting the position of a relatively small number of transient conductors.

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 device the character described comprising a pair of high tension transformers, a pair of high tension rectifying disks, connections from the secondary windings of said transformers to said rectifying disks, for the purpose of enabling said rectifying

disks to rectify the current impulses from said secondary windings, a pair of X-ray tubes connected with said rectifying disks, and a pair of flexible conductors connected with each other and with the ground, said flexible conductor being detachably connected with said rectifying disks and co-acting therewith for the purpose of energizing said X-ray tube, and being changeable by the operator relatively to said rectifying disks for the purpose of enabling said secondary windings to pass the high tension current impulses through either one or both of said X-ray tubes, as the operator may prefer.

2. In a device of the character described the combination of high tension transformers, high tension rectifying switches, electrical connections from said transformers to said electrifying switches, a plurality of X-ray tubes, conductors from said rectifying switches to said X-ray tubes for enabling them to be energized by transformer current impulses controlled by said rectifying switches, and a pair of flexible conductors connected with the ground and with each other, said flexible conductors being detachably connected with said rectifying switches and co-acting therewith for energizing one or both of said X-ray tubes, said flexible conductors each being changeable by the operator relatively to said rectifying switches, for the purpose of enabling said high tension transformers to pass high tension current impulses through one or both of said X-ray tubes, as the operator may prefer.

3. A convertible X-ray machine comprising high tension transformer mechanism, high tension switch rectifying mechanism, connections from said high tension transformer mechanism to said high tension switch mechanism, a plurality of X-ray tubes, connections from said X-ray tubes to said high tension switch X-ray mechanism for enabling the latter to energize said X-ray tubes, and a pair of flexible conductors in electrical communication with each other and detachably connected with said high tension switch mechanism, said flexible conductors being readily changeable from one part of said high tension rectifying switch mechanism to another part thereof, for enabling the operator to control the direction of discharges through said X-ray tubes.

4. In a device of the character described the combination of high tension transformers, high tension rectifying switches, conductors extending from said transformer to said rectifying switches, a pair of X-ray tubes, connections extending from said rectifying switches to said X-ray tubes, and a pair of flexible conductors connected with each other and detachably connected with said rectifying switches for the purpose of completing circuits from said transformers through said rectifying switches and said X-ray tubes, said flexible conductors being readily changeable by the operator from one part of a rectifying switch to another part thereof in order to enable the operator to control the direction of the travel through said X-ray tubes.

5. In a device of the character described the combination of a high tension transformer, high tension rectifying switches, connections from the secondary windings of said transformer to said high tension rectifying switches, a pair of X-ray tubes, connections from said X-ray tubes to said high tension rectifying switches, and a plurality of flexible conductors connected together and detachably connected with said rectifying switches, each of said flexible conductors being changeable by hand from one part of the rectifying switch to another part thereof, for controlling the direction of discharges through said X-ray tubes.

Signed at Long Island City, in the county of Queens and State of New York, this 10th day of February, 1923.

ARTHUR MUTSCHELLER.