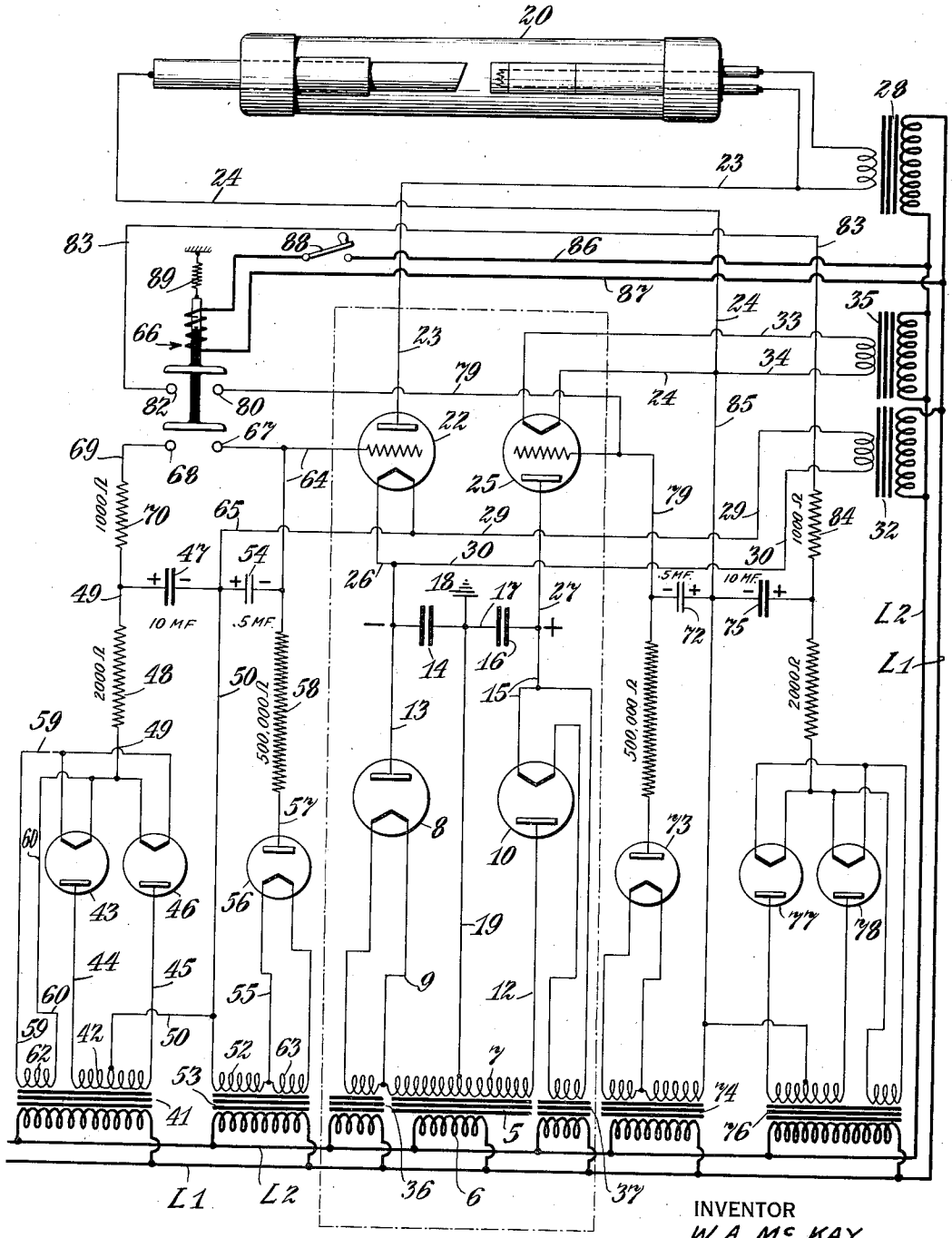
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SHORT EXPOSURE X-RAY SYSTEM

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INVENTOR
W. A. Mc. KAY.
BY M. F. Reges
ATTORNEY

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SHORT EXPOSURE X-RAY SYSTEM

William A. McKay, Essex Fells, N. J., assignor to Westinghouse Lamp Company, a corporation of Pennsylvania

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My invention relates to X-ray apparatus and has particular reference to such an apparatus for taking short exposure X-ray photographs. A system of this general type is shown and described in the copending application of Montford Morrison, Serial No. 582,933, filed December 21, 1931 and my present invention constitutes an improvement thereon.

In the system shown in the above noted application a high tension source of electrical energy is arranged to supply unidirectional current to an energy storage device, which upon being completely charged is caused to discharge through the X-ray tube thus energizing the same with attendant generation of X-rays. A switching device comprising a thermionic discharge device is connected in a series circuit with the X-ray tube and energy storage device which is operable to prohibit discharge of the energy storage device until the latter is charged to its full capacity. Upon the accumulation of the desired charge of energy in the energy storage device the series connected discharge device is operable in response to actuation by an operator to cause substantially instantaneous discharge of the energy storage device with resultant energization of the X-ray tube until the complete charge of the energy storage device is dissipated.

It has been found, however, that while the series connected discharge device is positively operable for the purposes intended at X-ray operating potentials of approximately 75 to 100 kilovolts no discharge device is, up to the present time, known to the art which will satisfactorily prohibit discharge of an energy storage device of large capacity or the flow of current from a high potential source having a potential in excess of 100 kilovolts.

This is due to the fact that the materials of which the electrodes of the controlling discharge devices are constructed are inherently limited to a rather definite maximum potential. When the electrodes of the device are subjected to this maximum potential, or the same exceeded, this high potential causes the emission of electrons from the metallic electrodes commonly referred to as "cold discharge".

It naturally follows that when this device is connected in series with the X-ray tube and the high potential source and a discharge occurs in the controlling discharge device energy is immediately supplied by the source to the X-ray tube with attendant generation of X-rays at undesired times. Moreover, even when the high potential to which the controlling discharge device is subjected is maintained slightly below the maximum potential the same can withstand without "cold discharge" occurring, this potential frequently has a destructive effect upon the device upon operation thereof due to the substantially instantaneous rush of current therethrough if the potential is too near the maximum the device can withstand without breakdown.

By my present invention I obviate these present difficulties by interposing a three electrode thermionic discharge device between the high potential source and the anode of the X-ray tube and a similar discharge device between the high potential source and the cathode of the X-ray tube. This arrangement subjects one of these discharge devices to a potential having a positive polarity equal to only one half of the total potential of the source and the other discharge device to a negative potential likewise equal to one half the total potential of the source.

The control electrode or grid of each respective discharge device is impressed with a potential from separate auxiliary sources to prevent energization of the X-ray tube and these auxiliary sources are simultaneously rendered operative to cause each respective discharge device to become inoperative to prevent and operative to cause energization of the X-ray tube by the high tension source.

Accordingly each respective discharge device, being subjected to only one half the potential of the source and capable of blocking currents of approximately 1000 milliamperes at 100 kilovolts, enables the construction of a short exposure X-ray system in which the X-ray tube may be energized by a potential substantially double that of such system heretofore known to the art.

Moreover, while I have shown my present invention as adapted to an X-ray system for the taking of short exposure X-ray photographs wherein the X-ray tube receives energization from an energy storage device as shown in the aforementioned copending application, it is to be understood that the same is readily applicable to X-ray systems of various other types. For example, by the employment of my present invention energization of the X-ray tube may be so controlled that instead of causing the entire energy of an energy storage device to discharge substantially instantaneously through an X-ray tube I may make this discharge gradual over any desired period of time regardless of the magnitude of the potential accumulated in the energy storage device. By the utilization of a discharge device in series with each of the electrodes of the X-ray

tube, or if preferred in series with each other and the grounded electrode of the X-ray tube, to control energization of the latter it is not only feasible to employ my present invention with high pulsating potential X-ray systems for the taking of radiographic exposures but the same is equally adaptable to deep therapy systems of exceedingly high potential.

Inasmuch as each of the controlling discharge devices when connected in series with each of the electrodes of the X-ray tube is subjected to only one half the potential of the source the total potential of the latter may be increased to an extent even greater than that at which breakdown of the individual discharge devices will occur. Thus by interposing additional discharge devices in series with each other and each of the electrodes of the tube in tandem arrangement the potential to which each device is subjected is further reduced with the addition of each pair of devices. When it is desired to cause energization of the X-ray tube it is merely necessary to cause the simultaneous operation of all of the controlling discharge devices.

It is accordingly an object of my invention to provide a system for taking short exposure X-ray photographs in which the energy supplied by a high potential source to the X-ray tube may be controlled accurately with respect to the time and quantity.

Another object of my invention is the provision of a switching means in the high tension circuit of an X-ray tube system which is subjected to only one-half the total potential supplied to the X-ray tube and operative to normally prevent the flow of energy from the source to the tube, but readily operable to cause instantaneous energization of the tube.

Another object of my invention is the provision of an X-ray system for taking short exposure photographs employing a plurality of thermionic discharge devices in series with the X-ray tube and source of energization therefor, which are provided with control electrodes having a potential impressed thereupon normally preventing the flow through the respective discharge devices and consequently the X-ray tube and which are adapted to assist the flow of energy when impressed with an opposite polarity.

A further object of my invention is the provision of a system for taking short exposure X-ray photographs in which the energy for supplying the X-ray tube is taken from a condenser and in which the supply of energy therefrom is controlled with minute precision with an absence of appreciable time lag.

Still further objects of my invention will become apparent to those skilled in the art by reference to the accompanying drawing in which the single figure is a diagrammatic representation of a system for taking short exposure X-ray photographs showing one form which my invention may take.

Referring now to the drawing in detail I have shown a suitable source of commercial alternating potential, such as conductors L1 and L2. Connected to these conductors is a high tension heavy current generating system which is arranged to supply energy to the X-ray tube. This generator is shown in the central part of the accompanying figure enclosed by the dot and dash line therein shown. This generating system may be of any suitable type, such as a high tension transformer 5, the primary 6 of which is connected directly to the commercial source of potential L1 and L2.

The secondary winding 7 of this high tension transformer is connected to the cathode of a rectifying valve tube 8 by means of a conductor 9 and to the anode end of a similar valve tube 10 by means of a conductor 12. The anode of the valve tube 8 is connected by means of a conductor 13 to a condenser 14 and the cathode of the rectifying valve 10 is similarly connected by means of a conductor 15 to a condenser 16. These condensers 14 and 16 are in turn interconnected by means of a conductor 17 which is suitably grounded as shown at 18.

A conductor 19 interconnects these two condensers with the midpoint of the secondary winding 7 of the high tension transformer 5. This limits the insulation requirements of the high potential system to one-half the total output energy of this secondary winding 7. During alternating half waves of the alternating current cycle the energy generated in the secondary winding 7 is adapted to store relatively heavy currents of between 500 and 1,000 milliamperes at 100 kv. in the condensers 14 and 16, which are of a capacity sufficient to be charged with this energy.

Although I have shown what is termed in the art as half wave rectification, that is to say, the condensers are charged only during one-half wave of the alternating current cycle it should be readily understood that any other high voltage generating system is as readily adaptable for the generation of the requisite currents and that the same may be full wave rectification in lieu of half wave rectification, which I have shown merely for the purposes of simplicity.

An X-ray tube 20 has its cathode end connected to the anode of a thermionic discharge device 22 by means of a conductor 23, and the anode of the X-ray tube is connected by means of a conductor 24 to the cathode of a similar thermionic discharge device 25. The cathode of the discharge device 22 is connected by means of a conductor 26 to the negative plate of condenser 14 and in a similar manner the positive plate of condenser 16 is connected by means of a conductor 27 to the anode of a thermionic discharge device 25. This accordingly forms a discharge circuit for the condensers 14 and 16 which includes the X-ray tube 20 and the discharge devices 22 and 25 connected in series therewith. This circuit which supplies high potential energy to the X-ray tube, including the discharge devices 22 and 25, naturally subjects these latter devices to the same high potential current as that of the X-ray tube and it is essential they have the same current-voltage characteristics as the X-ray tube in order to withstand the same energy. The thermionic cathode of the X-ray tube 20 is arranged to receive low tension heating currents from a heating transformer 28, the primary of which is connected to the commercial source of supply L1 and L2.

In a similar manner the cathode of the thermionic device 22 is adapted to receive heating current through a pair of conductors 29 and 30 from a low tension transformer 32, the primary of which is connected to the commercial source of supply L1, L2 and the cathode of discharge device 25 receives heating current through a pair of conductors 33 and 34 from a low tension heating transformer 35, the primary of which is similarly connected to the commercial source of supply L1 and L2. The cathode of rectifying valve 8 receives heating current from a low tension trans-

former 36 and in a similar manner the cathode of rectifying valve 10 receives heating current from a low tension transformer 37, with the primaries of both of these latter transformers being also connected to the commercial source of supply L1 and L2.

The discharge devices 22 and 25 in addition to their anodes and cathodes are each provided with a control electrode in the form of a grid. The control electrode of each of these thermionic discharge devices is adapted to have a suitable potential from separate auxiliary sources impressed thereupon which is normally of sufficient magnitude to prevent a positive potential from being impressed upon the anode of the X-ray tube by the source, or condenser 16, and a negative potential from being impressed upon the cathode of the X-ray tube by the source or condenser 14 despite the high potential energy to which they are subjected. Consequently electrons are prohibited from flowing between the cathode and anode of each respective discharge device and the cathode and anode of the X-ray tube thus effectively preventing energization of the latter.

Accordingly the auxiliary source for the control electrode of the discharge device 22 comprises a transformer 41, having its primary winding connected to the source of supply L1, L2 and its secondary winding 42 connected at one end to the anode of a rectifying valve 43 by means of a conductor 44, and its remaining end is connected by means of a conductor 45 to the anode of another rectifying valve 46. The thermionic cathodes of the respective valves 43, 46 are connected together and to one plate of a condenser 47, through a resistance 48, by means of a conductor 49. The midpoint of the secondary winding 42 is in turn connected, by means of a conductor 50, to the negative plate of the condenser 47 and to one end of the secondary winding 52 of a transformer 53, the primary of which is connected to the source of supply L1, L2, and in addition the conductor 50 is connected to the positive plate of a second condenser 54.

The remaining end of the secondary winding 52 is connected by means of a conductor 55 to the cathode of a rectifying valve 56 and the anode of this latter valve is connected by means of a conductor 57 through a high resistance 58 to the negative plate of the condenser 54. The cathodes of the rectifying valves 43 and 46 receive heating current from a low tension source of supply through a pair of conductors 59 and 60 which extend to a low tension secondary winding 62, and in a similar manner the cathode of rectifying valve 56 receives heating current from a low tension secondary winding 63, with both of these secondary windings 62 and 63 comprising a tertiary winding wound upon the core of the transformers 41 and 53, or, if preferred, may extend to separate heating transformers.

This auxiliary source of potential is arranged to store energy during each half wave of the alternating current cycle in the respective condensers 47 and 54 which are arranged to discharge at desired periods of time through an output circuit. A conductor 64 extends from the negative plate of condenser 54 to the control electrode of the discharge device 22 and a similar conductor 65 extends from the cathode of the thermionic discharge device 22 to the positive plate of condenser 54 and negative plate of condenser 47.

Accordingly upon energization of the transformer 53 the secondary winding 52 will supply energy to the condenser 54 during a half wave of the alternating current cycle. For example, when one end of the winding 52 to which the conductor 55 is connected has a negative polarity electrons will flow therefrom through conductor 55, rectifying valve 56, conductor 57 and high resistance 58, through the negative plate of the condenser 54 and thence from the positive plate of condenser 54 through conductor 50 back to the remaining end of secondary winding 52. The condenser 54 is of such capacity as to be stored with energy having a potential of approximately 5,000 volts and as the negative plate thereof is connected by means of conductor 64 to the control electrode of the discharge device 22, a negative potential at this voltage will be impressed upon the control electrode of the latter discharge device. This is of sufficient magnitude to prevent the flow of electrons from the cathode to the anode of the discharge device 22 and consequently prevents any energy from the condenser 14 flowing to the cathode of the X-ray tube 20.

At the same time that energy is being stored by the transformer 53 in the condenser 54 the secondary winding 42 will store energy in the condenser 47. Accordingly regardless of the particular polarity of either end of the secondary winding 42 electrons will flow through conductor 50 to the negative plate of condenser 47 and thence from the positive plate through conductor 49, resistance element 48, and thence by means of either the valve 43 or 46, and conductors 44 and 45 respectively, back to one end of the secondary winding 42 depending upon the instantaneous polarity of either end of this winding. For example, if the end of the winding 42 to which the conductor 44 is connected is at a given instant positive with respect to the midpoint of the winding electrons will flow through the valve 43 and conductor 44 back to the winding 42, while at this given instant the opposite end of the winding 42 must necessarily be negative and consequently electrons will not flow through the rectifying valve 46. However, when this end becomes positive and the end to which the valve 43 is connected becomes negative then electrons pass through rectifying valve 46 and conductor 45 back to the opposite end of winding 42.

Upon initial energization of the transformer 41 from the source of supply L1, L2 the resistance element 48 functions to limit the initial surge of energy supplied to the condenser 47 to protect the insulation of this transformer.

It is well recognized that the phenomena of operation of condensers upon being initially charged is similar to a direct short circuit impressed upon the source due to the sudden rush of current to the condenser until the same become charged. This would ordinarily impress a very heavy load upon the valve tubes 43 and 46, but due to the reaction of the resistance element 48 this is prohibited, as well as an initial heavy surge upon the transformer 41. Also the resistance element 58 functions to limit the initial surge of energy supplied to the condenser 54 to protect the valve tube 56 and transformer 53, and in addition causes an IR drop in this circuit to the current flow in order to impress a non-fluctuating negative potential upon the grid of discharge device 22.

When it is desired to impress a positive polarity upon the control electrode of the rectifying valve 22 I permit the connection of the positive plate of condenser 47 thereto by closure of a suitable relay 66. A contact terminal 67 of this relay is

connected to the control electrode of the discharge device 22 and a similar contact terminal 68 is connected by means of a conductor 69 through a resistance element 70 to the positive plate of the condenser 47. Upon operation of the relay 66 the contact terminals 67 and 68 are bridged thus causing positive current to flow from the condenser 47 through resistance element 70, conductor 69, terminals 68 and 67 and conductor 64 to the grid of the device 22, and as the cathode of the device 22 is connected by means of conductor 65 to the negative plate of the condenser 47 current will flow in the cathode grid circuit.

The positive polarity supplied by the condenser 47 is of much less magnitude than the negative potential impressed upon the control electrode by the condenser 54 and is of approximately 1,200 volts. As this condenser 54 is fully charged at the time of closure of the contact terminals 67 and 68 and the respective plates thereof are of different polarity with respect to the condenser plates 47, a portion of the energy of the condenser 47 will be absorbed by the condenser 54 until the respective plates thereof assume a polarity similar to the plates of condenser 47 to which it is now directly connected.

Upon operation of the relay and the supply of a positive polarity to the control electrode with attendant current flow in the grid cathode circuit, the resistance element 70 functions to cause a slight IR drop in this circuit as well as to cause a slight time delay in the change of polarity of the respective plates of the condenser 54 following operation of the relay.

Accordingly the potential impressed upon the control electrode of the device 22 is instantaneously reversed from negative to positive without interrupting the auxiliary source which supplies a potential thereto and upon consummation of this reversal of potential electrons will flow from the cathode to the anode of the device 22 and accordingly to the cathode of X-ray tube 20. It must be appreciated, however, that energization of the X-ray tube will not follow upon operation of discharge device 22 alone because of the fact that the high tension source of supply comprising the condensers 14 and 16 is not completely connected to the X-ray tube due to the interposition of the thermionic discharge device 25 between the anode of the X-ray tube and the condenser 16.

The control electrode of this discharge device 25 is likewise supplied with a potential from an auxiliary source of supply which is in all respects identical to that just described relative to the control electrode of the discharge device 22. This auxiliary source comprises a condenser 72 which impresses a negative potential upon the control electrode of the discharge device 25 and is adapted to be charged through a rectifying valve 73 from a transformer 74 in the same manner as described relative to the condenser 54 by the transformer 53. Likewise a condenser 75 which upon operation of the relay 66 is arranged to impress a positive polarity upon the control electrode of the device 25, as hereinafter more fully explained, receives energization from a transformer 76 through a pair of rectifying valves 77 and 78 in the identical manner as described with reference to the transformer 41 and the rectifying valves 43 and 46. The resistance elements shown in this auxiliary source function in the same manner as described relative to the respective elements 48, 58, and 70.

A conductor 79 connects the negative plate of condenser 72 to the control electrode of the discharge device 25 and also extends to a stationary contact terminal 80 of relay 66. A second contact terminal 82 of this relay 66 is connected by means of a conductor 83 through a resistance 84 to the positive plate of condenser 75 and the cathode of the discharge device 25 is connected by means of a conductor 85 to the positive and negative plates of condensers 72 and 75 respectively in the same manner as the conductor 65 connects the cathode of device 22 to the respective condensers 47 and 54.

The operation of this auxiliary source of supply is identical with that previously described for reversing the polarity of the potential impressed upon the control electrode of the discharge device 25, and further detail description thereof is believed unnecessary.

It can accordingly be readily appreciated that upon closure of the contact terminals 67 and 68 by the relay 66, with attendant reversal of the polarity impressed upon the control electrode of the discharge device 22, that this relay 66 likewise bridges the contact terminals 80 and 82 to cause simultaneous reversal of the polarity impressed upon the control electrode of the discharge device 25.

The operation of the reversal of the polarity of the respective auxiliary sources of supply for the control electrode of the discharge devices 22 and 25 immediately cause energization of the X-ray tube as electrons will flow from the high tension condenser 14 through discharge device 22, conductor 23 to the cathode of the X-ray tube 20, and thence from the anode thereof through conductor 24 and discharge device 25 back to the positive plate of condenser 16 by means of conductor 27. Accordingly the entire energy stored within the condensers 14 and 16 will be supplied to the X-ray tube.

In order to operate the relay 66 I connect the magnetic winding thereof to the commercial source of supply L1, L2 by means of a pair of conductors 86 and 87 through a suitable hand switch 88 and upon operation of the latter by an operator the relay 66 is energized to establish contact between the terminals 80, 82 and 67, 68 respectively.

After completion of the exposure the hand switch 88 is opened and the contact terminals 80, 82 and 67, 68 are again opened by retraction of the plunger of the relay by any suitable means, such as a coil spring 89. This again causes a negative potential to be impressed upon the grid of the respective discharge devices 22 and 25 and places the entire system in condition for another exposure upon recharging of the condensers 14 and 16.

It should be here noted that the high tension source comprising the transformer secondary winding 7 and condensers 14 and 16 is grounded at 18 thus necessitating, as before stated, insulation requirements to ground equal to one-half the total potential generated by this high potential source. Inasmuch as the anode of the X-ray tube is subjected to a positive polarity from this grounded high tension source this positive potential is not only equal to one-half that of the total potential of the source, but also equal to one-half that of the source to ground. This likewise applies to the cathode of the X-ray tube relative to the high tension source and ground wherein a negative potential is supplied to the cathode. This accordingly subjects the respective discharge devices 22 and 25 to one-half the

total potential of the source and also one-half the potential of the source to ground. Moreover, as the potential impressed upon discharge device **25** is positive with respect to ground and that of discharge device **22** negative with respect thereto separate auxiliary sources are necessarily required for impressing a potential upon the grids of the respective discharge devices.

In the operation of my system for taking short exposure X-ray photographs the cathodes of all the valve tubes and X-ray tube are first brought to incandescence and the transformers **41**, **53** and **74**, **76** connected to the commercial source of supply by means of a suitable switch or switches, not shown. This initially impresses a negative potential upon the control electrodes of the respective discharge devices **22** and **25** as the hand switch **88** is at this time in its normal or opened position. A suitable switch, not shown, is then closed which connects the primary winding **6** of the transformer **5** to the commercial source of supply L1 and L2, thus causing the high voltage heavy current condensers **14** and **16** to become fully charged, after which the switch is opened to prevent any repetition of charging of the condensers immediately following their discharge.

The hand switch **88** is then closed to cause operation of the relay **66** with attendant reversal of the polarity impressed upon the control electrodes of the respective discharge devices **22** and **25** in the manner previously explained. This immediately enables substantially an instantaneous discharge of the condensers **14** and **16** through the X-ray tube upon the consummation of reversal of the polarity impressed upon the control electrodes of the discharge devices **22** and **25** with attendant generation of X-rays by the X-ray tube.

It thus becomes obvious to those skilled in the art that I have provided an X-ray system for taking short exposure X-ray photographs in which current flow in a high potential circuit and energization of the X-ray tube is positively prevented by means of thermionic discharge devices, which are provided with control electrodes.

By impressing a negative potential upon the control electrodes of these devices having sufficient magnitude the high tension heavy current is completely blocked and energization of the X-ray tube prevented. Upon reversal of this potential impressed upon the control electrodes from negative to positive substantially instantaneous energization of the X-ray tube simultaneously occurs without variation in the energy supplied thereto and consequently a uniform intensity of the X-rays emanating from the X-ray tube results. Moreover as the respective discharge device is connected in series with one side of the high tension source and one of the respective electrodes of the X-ray tube each discharge device is subjected to only one half the total potential of the high voltage source.

Although I have shown and described one specific embodiment of my invention I do not desire to be limited thereto as other modifications of the same may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed:

1. An X-ray system for taking short exposure X-ray photographs comprising means for storing an electrical charge, an X-ray tube provided with an anode and a cathode and connected to said means, and means connected to said first mentioned means and said X-ray tube and normally operative to entirely prevent said X-ray tube from being supplied with energy from said first mentioned means, said last mentioned means including an evacuated discharge device interposed between said first mentioned means and the anode of said X-ray tube and an evacuated discharge device interposed between said first mentioned means and the cathode of said X-ray tube, said last mentioned means being operable to cause said first mentioned means to instantaneously supply energy to said X-ray tube.

2. An X-ray system for taking short exposure X-ray photographs comprising means for storing an electrical charge of high potential and current, an X-ray tube having an anode and a cathode and connected to said means, an evacuated discharge device connected to said means and to the anode of said X-ray tube, a second evacuated discharge device connected to said means and to the cathode of said X-ray tube, means connected to each of said discharge devices for positively preventing current flow therethrough and consequently from said first mentioned means to the anode and cathode of said X-ray tube, and means associated with said last mentioned means and operable to cause the same to become instantaneously ineffective to prevent and operative to cause current flow through each of said discharge devices from said first mentioned means to the anode and cathode of said X-ray tube.

3. An X-ray system for taking short exposure X-ray photographs comprising an X-ray tube having an anode and a cathode subjected to high potential electrical energy upon energization of said tube, a pair of electron discharge devices each having an anode, a cathode, and a control electrode, a primary and a secondary circuit, said X-ray tube and discharge devices being connected in series in said secondary circuit, said devices having current voltage characteristics corresponding to said X-ray tube and subjected to the same potential as impressed respectively upon the anode and cathode of said X-ray tube upon energization of the same, means for impressing a predetermined negative potential and a predetermined positive potential upon the control electrode of one of said discharge devices, means for impressing a predetermined negative potential and a predetermined positive potential upon the control electrode of the other of said discharge devices, and means included in both of said last mentioned means and operable at will for simultaneously altering the potential impressed upon the control electrode of both of said discharge devices.

4. An X-ray system for taking short exposure X-ray photographs comprising a source of direct current of high potential, an X-ray tube having an anode and a cathode and connected to said source, an electron discharge device having an anode, a cathode, and a grid, and interposed between said source and the anode of said X-ray tube, an electron discharge device having an anode, a cathode, and a grid, and interposed between said source and the cathode of said X-ray tube, means for impressing a non-fluctuating negative charge upon the grid of said first mentioned discharge device to prevent the potential of said source from being impressed upon the anode of said X-ray tube, means for impressing a non-fluctuating negative charge upon the grid of said second mentioned discharge device to prevent the potential of said source from being impressed upon the cathode of said X-ray tube, and means associated with both of said last mentioned means

and operable to cause the same to change the sign of the charge impressed upon the grid of each respective discharge device and cause said source to energize said X-ray tube.

5. In an X-ray system for taking short exposure X-ray photographs the combination of an X-ray tube having an anode and a cathode, a pair of thermionic discharge devices each provided with an anode, a cathode, and a control electrode, a condenser of high potential and large current capacity connected in a series circuit with said discharge devices and said X-ray tube for energizing the latter, means for storing energy in said condenser, means normally operative to impress a negative potential upon the control electrode of one of said discharge devices to prevent said condenser from impressing a potential upon the anode of said X-ray tube, means normally operative to impress a negative potential upon the control electrode of the other of said discharge devices to prevent said condenser from impressing a potential upon the cathode of said X-ray tube, and means associated with both of said last mentioned means and operable to cause both of said means to instantaneously remove the negative potential from the control electrode of each respective discharge device and impress a positive potential thereupon to cause the simultaneous discharge of said condenser through each of said discharge devices with attendant energization of said X-ray tube.

6. In an X-ray system for taking short exposure X-ray photographs the combination of an X-ray tube having an anode and a cathode, a source of potential for energizing said X-ray tube, a thermionic discharge device connected with the anode of said X-ray tube and said source, a second thermionic discharge device connected with the cathode of said X-ray tube and said source, each of said discharge devices being provided with an anode, a cathode, and an element normally operative to offer an artificial resistance to the flow of current therethrough and consequently from said source to the anode and cathode of said X-ray tube, and means for rendering the element of each respective device inoperative to prevent the flow of current and operative to assist the flow of current, through each device and from said source to said X-ray tube.

7. An X-ray system for taking short exposure X-ray photographs comprising an X-ray tube having an anode and a cathode subjected to high potential electrical energy upon energization of said tube, a source of unidirectional high potential energy for supplying a high positive potential to the anode and a high negative potential to the cathode of said X-ray tube, means interposed between said source and the anode of said X-ray tube having current voltage characteristics corresponding to that of said X-ray tube and subjected to the same positive potential supplied by said source and operative to prevent said source from impressing a positive potential upon the anode of said X-ray tube, means interposed between said source and the cathode of said X-ray tube having current voltage characteristics corresponding to that of said X-ray tube and subjected to the same negative potential supplied by said source and operative to prevent said source from impressing a negative potential upon the cathode of said X-ray tube, and means associated with both of said last mentioned means and operative to cause said source to supply a high positive and negative potential to said X-ray tube for the purpose of energizing the latter.

8. In an X-ray system for taking short exposure X-ray photographs the combination of an X-ray tube having an anode and a cathode subjected to high potential energy upon energization of said tube, a source of grounded unidirectional high potential energy having a potential with respect to ground at least no greater than one-half the total potential of said source for supplying a positive potential to the anode and a negative potential to the cathode of said X-ray tube, means interposed between said source and the anode of said X-ray tube subjected to a potential corresponding to that of said source with respect to ground and operative to prevent said source from supplying a positive potential to the anode of said X-ray tube, means interposed between said source and the cathode of said X-ray tube subjected to a potential corresponding to that of said source with respect to ground and operative to prevent said source from supplying a negative potential to the cathode of said X-ray tube, and means electrically associated with both of said last mentioned means and operable to cause the same to simultaneously become inoperative to prevent and operative to cause said source to supply a high positive and negative potential to said X-ray tube for the purpose of energizing the latter.

9. In an X-ray system for taking short exposure X-ray photographs the combination of an X-ray tube having an anode and a cathode subjected to high potential energy upon energization of said tube, a source of unidirectional high potential electrical energy for supplying a high positive potential to the anode and a high negative potential to the cathode of said X-ray tube, a thermionic discharge device provided with an anode, a cathode, and a grid, and interposed between said source and the anode of said X-ray tube, said device having current voltage characteristics corresponding to that of said X-ray tube and subjected to the same positive potential supplied by said source to said X-ray tube, an auxiliary source of relatively low potential connected to the grid of said discharge device and normally operative to impress a negative potential upon said grid to prevent a high positive potential being supplied by said high potential source to the anode of said X-ray tube, an auxiliary source of potential adapted to be connected to the grid of said discharge device for supplying a positive potential thereto, a thermionic discharge device provided with an anode, a cathode, and a grid and interposed between said source and the cathode of said X-ray tube, said second mentioned device having current voltage characteristics corresponding to that of said X-ray tube and subjected to the same negative potential supplied by said source to said X-ray tube, an auxiliary source of relatively low potential connected to the grid of said last mentioned discharge device and normally operative to impress a negative potential upon said grid to prevent a high negative potential being supplied by said high potential source to the cathode of said X-ray tube, an auxiliary source of potential adapted to be connected to the grid of said second mentioned discharge device for supplying a positive potential thereto, and a relay electrically associated with all of said auxiliary sources and operable in response to actuation by an operator to cause both of said auxiliary sources supplying a negative potential to the grids of the respective discharge devices to become ineffective and to connect the remaining auxiliary sources to the

grids of the respective discharge devices for the purpose of impressing a positive potential thereupon, to enable said high potential source to supply a positive and negative potential to said X-ray tube and energize the same.

10. An X-ray system for taking short exposure X-ray photographs comprising an X-ray tube having an anode and a cathode subjected to high potential electrical energy upon energization of said tube, a source of grounded unidirectional high potential energy having a potential with respect to ground at least no greater than one half the total potential of said source for supplying a positive potential to the anode and a negative potential to the cathode of said X-ray tube, a thermionic discharge device provided with an anode, a cathode, and a grid and interposed between said source and the anode of said X-ray tube, said device having a current voltage characteristic corresponding to that of said X-ray tube and subjected to the same positive potential supplied by said source to the anode of said X-ray tube and to a potential corresponding to that of said source with respect to ground, an auxiliary source of electrical energy connected to the grid of said discharge device and normally operative to impress a negative potential upon said grid to prevent a high positive potential being supplied by said high potential source to the anode of said X-ray tube, an auxiliary source of potential adapted to be connected to the grid of said discharge device for impressing a positive potential thereupon, a thermionic discharge device provided with an anode, a cathode, and a grid, and interposed between said source and the cathode of said X-ray tube, said device having a current voltage characteristic corresponding to that of said X-ray tube and subjected to the same negative potential supplied by said source to the cathode of said X-ray tube and to a potential corresponding to that of said source with respect to ground, an auxiliary source of electrical energy connected to the grid of said last mentioned discharge device and normally operative to impress a negative potential upon said grid to prevent a high negative potential being supplied by said high potential source to the cathode of said X-ray tube, an auxiliary source of potential adapted to be connected to the grid of said second mentioned discharge device for impressing a positive potential thereupon, and a relay electrically associated with all of said auxiliary sources and operable in response to actuation by an operator to cause both said auxiliary sources supplying a negative potential to the grids of the respective discharge devices to become ineffective and to connect the remaining auxiliary sources to the grids of the respective discharge devices for the purpose of impressing a positive potential thereupon to enable said high potential source to supply a positive and negative potential to said X-ray tube and energize the same.

WILLIAM A. McKAY.