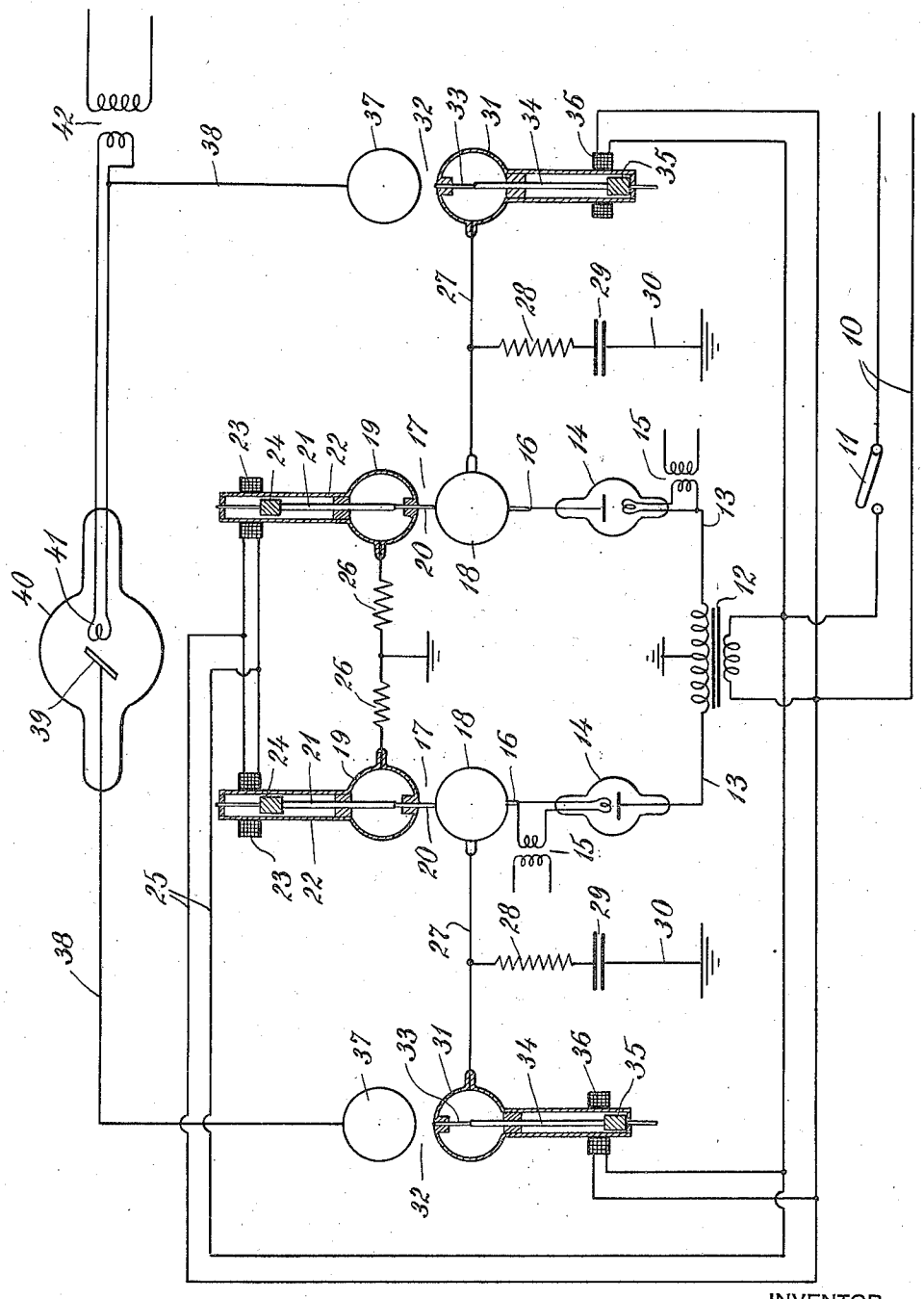
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X-RAY APPARATUS

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X-RAY APPARATUS

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This invention relates to X-ray systems, and is concerned more particularly with a novel X-ray system including a condenser, the system of the invention being so constructed that the discharge of the condenser may be controlled. The new system affords special advantages when used for the operation of X-ray tubes in the making of radiographs with a bucky grid, and an adaptation of the invention for that use will accordingly be described for purposes of explanation, although it is to be understood that the utility of the invention is not restricted to that specific application.

In the making of bucky radiographs, it is highly important that the exposure be terminated before the bucky grid movement ceases, but the systems now in common use for making such radiographs cannot include condensers, because the current flow through the X-ray tube cannot be terminated in this manner but dies down gradually with the current curve displaying a slope to zero instead of an abrupt substantially vertical fall.

The present invention is accordingly directed to the provision of a novel system which includes apparatus by which the result specified can be obtained, and in the new system, the flow of current through the tube can be terminated substantially instantaneously. In one form of the new system which includes a pair of condensers, the current flow through the tube is cut off by the opening of a switch in the line supplying current to the high potential transformer, and practically simultaneously with the opening of that switch the tube circuit is opened at both ends of the tube and the condensers are discharged. In this circuit, a substantially constant potential is employed; in another form of the system, the discharge is at a rapidly falling potential, but in each case the potential curve is free of pulsations or large ripples and this makes it possible to obtain bucky radiographs free of grid marks.

For a better understanding of the invention, reference may be had to the accompanying drawing in which one form of the novel system suitable for the operation of an X-ray tube to be used in the making of radiographs is illustrated diagrammatically.

In the circuit shown, current is supplied through a line 10 including a switch 11, which may be manually operated, to the low potential side of a step-up transformer 12, the high tension coil of which is grounded at its mid-point. In the transformer leads 13 are the usual valve tubes 14, the filaments of which are supplied by filament transformers 15.

The leads 16 from the valve tubes are connected to switches generally designated 17 and these switches are preferably of the construction disclosed in my Patent No. 1,941,081, December 26, 1933, each switch including a pair of spheres 18, 19, respectively, with each transformer lead connected to one of the spheres 18. The sphere 19 of each switch contains a rod 20 of metal which is movable into and out of the sphere and is connected to a rod 21 of insulating material which extends out through an opening in the sphere and lies within guides in a tube 22, one end of which lies within a solenoid 23. An iron core 24 is carried on the rod 21 within the tube 22, and the solenoids 23 of the two switches are connected in parallel to supply wires 25 which are connected to supply wires 10. So long as the solenoids are de-energized, the rods 20 extend out of their spheres and contact with the spheres 18, thus connecting the spheres conductively, but upon energization of the solenoids by the closing of the switch 11, the rods 21 are raised to draw the metal rods 20 into the spheres 19, thus establishing an air gap between the spheres 18 and 19 of each switch 17.

The sphere 19 of each switch is connected through a resistance 26 to ground, and the sphere 18 is connected by a line 27 through a resistance 28 to one plate of condenser 29, the other plate of which is connected by a line 30 to ground. Each line 27 is also connected to one sphere 31 of a switch 32 similar to switch 17, the sphere 31 containing a metal rod 33 movable into and out of the sphere and mounted on a rod 34 of insulating material on which is mounted the iron core 35 acted on by solenoid 36. A line 38 leads from the sphere 37 of one switch 32 to the anode 39 of the X-ray tube 40, while the sphere 37 of the other switch 32 is connected by a line 38 to the filament 41 of the tube, the filament being supplied by a filament transformer 42.

With the arrangement described, it will be apparent that so long as switch 11 is open, the rod 20 of each switch 17 will bridge the gap between the spheres 18 and 19 of the switch, and the switches will thus be closed. With the switches in this condition, both plates of both condensers 29 are grounded, one plate of each condenser being permanently grounded and the other plate being grounded through a switch 17. Similarly, with switch 11 open, the leads to the tube will both be disconnected since the rod 33 of each switch 32 lies in its down position and the spheres

31 and 37 of each switch are separated by an air gap.

When the switch 11 is closed, the solenoid 23 of switches 17 and the solenoids 36 of switches 32 are simultaneously energized. The conducting rods 20 of each switch 17 are immediately moved upward out of contact with the sphere 18, so that both switches 17 are open. The conducting rods 33 of each switch 32 are also moved upward and contact with sphere 37, bridging the air gap, so that both switches 32 are closed. With the circuit in this condition and assuming that the left-hand end of transformer 12 is of positive polarity, current flows through valve tube 14 and sphere 18 at the left, part of the current then flowing to condenser 29 at the left to charge the condenser, and the remainder flowing through switch 32 to the X-ray tube 40. The ungrounded plate of condenser 29 at the right is then negatively charged, current flowing through the valve tube 14 at the right back to the transformer. When the polarity of the transformer is reversed, the charge on condenser 29 at the left flows through the X-ray tube and the connections illustrated to the ungrounded plate of condenser 29 at the right. This circuit consequently supplies current to the X-ray tube at substantially constant potential.

When the flow to the tube is to be cut off, the switch 11 is opened, whereupon the solenoids 23 and 36 of switches 17 and 32, respectively, become de-energized, and the rods 20 and 33 move down by gravity. The downward movement of the rods 20 causes the gap between spheres 18 and 19 of switches 17 to be closed and the downward movement of rods 34 of switches 32 causes gaps to be established between spheres 31 and 37 of switches 32. The closing of switches 17 grounds the charged plate of each condenser 29 and the closing of switches 17 may be effected without disruptive discharges and with the formation of only minor arcs, which quickly disappear as the rods 20 drop down and contact with spheres 18.

With the circuit as described, it will be apparent that upon the closing of the supply switch 11, the connection between one plate of each condenser and ground is broken almost instantaneously and at the same time and quite as rapidly a circuit through the tube is established. Upon the opening of the switch 11, the current flow through the tube is cut off abruptly by a reversal of the events mentioned and the highly charged parts of the apparatus are all discharged. A curve illustrating the flow of current through the apparatus discloses that the current builds up rapidly to the maximum value and upon the opening of the switch 11 falls almost vertically to zero. The apparatus, therefore, makes it possible to obtain bucky pictures of a quality superior to that of pictures produced by former apparatus in that the exposure may be made with a condenser discharge.

Another effective use of the system described involves the disconnection of transformer 12 before switches 17 and 32 are operated. In that form of system, an additional switch similar to the switch 11 is placed in the supply line of the transformer beyond the points where the lines 25 are connected to the supply lines 10. In this modified form of the system, the additional switch can be opened to disconnect transformer 12 so that the discharge is at a rapidly falling potential, switch 11 being opened following the disconnection of transformer 12. With the system thus modified, the potential curve is free of pulsations or large ripples and this insures a bucky radiograph free of grid marks.

While I have disclosed a system embodying the principles of the invention and including a pair of condensers, a pair of switches controlling the connections between one plate of each condenser and ground, and a pair of switches controlling the connections between the tube and the source of energy, it is to be understood that the system may include only one condenser, and only one switch of each kind if desired.

What I claim:

1. In an X-ray circuit for making bucky radiographs, a transformer, an X-ray tube, a control switch for interrupting a source of current leading to the transformer, a pair of normally closed switches between the transformer and tube, a pair of normally open switches in said circuit, a pair of condensers, rectifying means between the transformer and condensers one plate of each condenser being connected to a contact of one of the closed switches and also to a contact of one of the open switches, the other plate of each of the condensers being grounded, the second contact of each of the closed switches being grounded and the second contact of each of the open switches being connected to the anode and cathode respectively of the X-ray tube.

2. In an X-ray circuit, a transformer, an X-ray tube adapted to be electrically connected thereto, a condenser having one of its plates grounded and its second plate connected to a point in the circuit between the tube and the transformer, a normally closed switch having one of its contacts grounded and its other contact connected to the second plate of the condenser, rectifying means between the transformer and condenser a normally open switch having one of its contacts connected to the second plate of the condenser and its other contact connected to the tube, and means for substantially simultaneously opening the normally-closed switch and closing the normally-open switch whereby the condenser is charged and the tube is energized.

3. In an X-ray circuit, a source of high tension current, an X-ray tube, a condenser having a first plate in circuit to the tube and a second plate grounded, rectifying means between the source of current and condenser, a switching device for initiating a charge to and abruptly terminating a charge from the condenser, said device including a pair of switches, one of which is normally closed and has a contact connected to the first plate of the condenser and its other plate grounded and the second switch being normally open and having a contact connected to the first plate of the condenser and its second contact connected to the tube, and means for substantially simultaneously opening one switch and closing the other.

4. In an X-ray system, a transformer, an X-ray tube adapted to be connected thereto, an open and a closed switch between the transformer and the tube, means for substantially simultaneously opening the closed switch and closing the open switch, a condenser having a grounded plate and having a second plate connected to the switches, rectifying means between the condenser and transformer, a connection between the normally open switch and the X-ray tube and a connection between the normally closed switch and ground whereby the second plate of the condenser will be grounded while said normally closed switch remains closed and will be charged and the cir-

cuit to the tube will be closed when said closed switch is opened and the normally open switch is closed.

5. An X-ray system including a transformer, an X-ray tube having anode and cathode connections to the transformer, cathode energizing means an open and a closed switch in circuit between the anode and the transformer, a second open and closed switch in circuit between the cathode of the tube and the transformer, means for opening both closed switches and closing both open switches substantially simultaneously, a condenser having a grounded plate and having a second plate connected to one of the open and one of the closed switches, a second condenser similarly connected to ground and to the other open and closed switches, rectifying means between said condensers and the transformer and a connection between both of the normally closed switches and ground whereby the second plate of each condenser will be grounded while the normally closed switches remain closed and will be charged and circuit to the tube anode and cathode will be closed when the closed switches are opened and the normally open switches are closed.

6. An X-ray circuit comprising, a transformer, an X-ray tube, the transformer adapted to be electrically connected to the electrodes of the tube, a condenser having one plate grounded and a second plate in circuit to the tube, a switch for controlling the connections between the transformer and tube, said switch being located between the X-ray tube and the condenser and transformer, rectifying means located between the condenser and transformer, a second switch connected to the ground and to the second plate of the condenser, said controlling switch being open whenever the ground switch is closed and vice versa, and means for operating said switches.

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