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X-RAY APPARATUS

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Fig. 1.

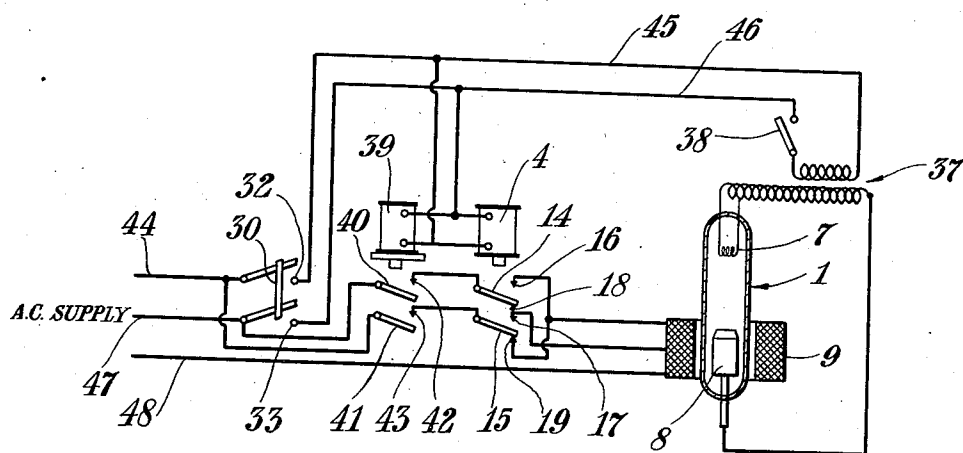
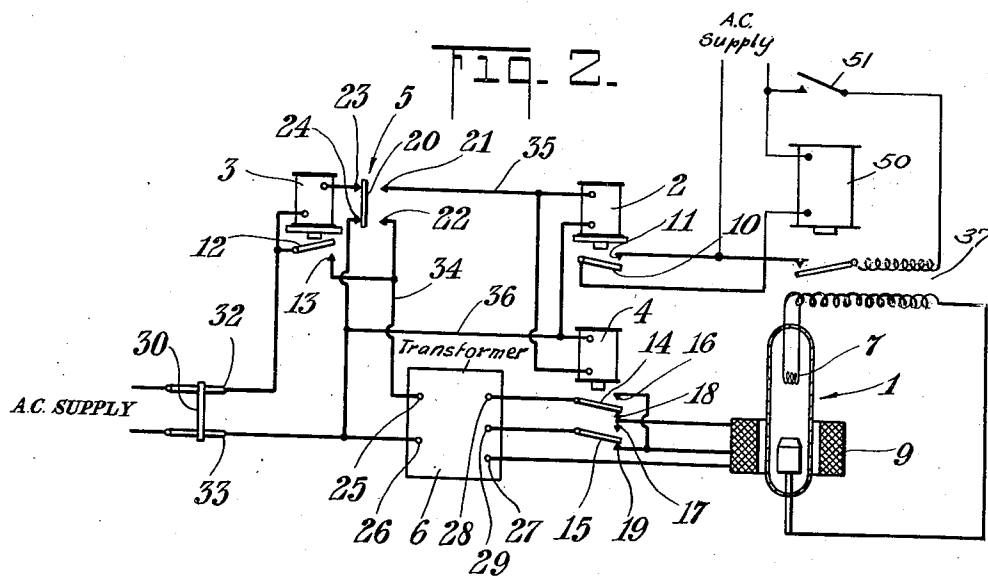


Fig. 2.



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X-RAY APPARATUS

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4 Claims. (Cl. 250-148)

My invention relates to X-ray apparatus, and more particularly to apparatus comprising a rotatable anode X-ray tube.

Such anodes are usually rotated at a high speed, for instance 3600 R. P. M., by an electromagnetic stator, and are supported on suitable bearings of the ball or oilless type. As these bearings are located within the vacuum space of the tube and are subject to considerable heat, they become worn in a relatively short time, and this wear is very objectionable because it may produce vibrations which decrease the life of the tube.

I have found that this wear of the bearings is due to a large extent to the fact that the anode, because of its high inertia, continues to rotate for a considerable time, for instance 8 to 20 minutes, after the stator has been deenergized. In fact the wear due to this free rotation of the anode is considerably greater than the wear produced when the tube is in actual use.

Furthermore, if operating voltage should be applied to such a tube when the anode is stationary or rotating at a subnormal speed, the target may be damaged or destroyed.

The main object of my invention is to overcome the above difficulties and to increase the life of such tubes.

A further object of the invention is to decrease the wear on the anode bearings.

A still further object of my invention is to prevent energization of the X-ray tube when the anode is not rotating at its normal speed.

A further object is to provide a simple control system which accomplishes the above objects.

In accordance with the invention, I provide retarding means to bring the anode to rest quickly after the tube has been placed out of operation. For this purpose, I may reverse the direction of the rotating field which causes rotation of the anode.

Furthermore, I prefer to control the actuating means of the anode by a suitable timing circuit so that the operating voltage cannot be applied to the X-ray tube until a predetermined time after these means are energized, and that these means remain energized until the operating voltage has been removed.

In order that the invention may be clearly understood and readily carried into effect, I shall describe the same in more detail with reference to the accompanying drawing, in which,

Figure 1 is a schematic wiring diagram of an X-ray apparatus embodying the invention, and

Fig. 2 is a schematic wiring diagram of a por-

tion of an X-ray apparatus according to another embodiment of the invention.

The apparatus illustrated in Figure 1 comprises an X-ray tube 1, a time-delay relay 39, a reversing relay 4, a transformer 37, and a three-phase A. C. supply having lines 44, 47 and 48.

X-ray tube 1 comprises a cathode 7, and an anode 8 which is rotated by the revolving field produced by a three-phase stator 9 located outside the tube. As such tubes are well known in the art and have been described, for instance, in the U. S. Patent #1,893,759 to Albert Bouwers, further description of the same is believed unnecessary.

Relay 39 has two arms 40 and 41 which leave fixed contacts 42 and 43 respectively about 1/2 second after the relay has been deenergized, whereas reversing relay 4 has two arms 14 and 15 which engage fixed contacts 16 and 17 respectively when the relay is energized, and engage fixed contacts 18 and 19 respectively when the relay is deenergized.

Operating voltage is supplied to the X-ray tube by transformer 37 whose secondary winding has its ends connected to cathode 7 and anode 8, and whose primary winding has its ends connected through a single-pole single-throw switch 38 and conductors 45 and 46 to the terminals 32 or 33 of a double-pole single-throw switch 30 which is connected to lines 47 and 48 of the A. C. supply.

The coils of relays 4 and 39 are connected in parallel across conductors 45 and 46, whereas the heels of arms 40 and 41 are connected to lines 47 and 48 respectively, and contacts 42 and 43 are connected to the heels of arms 14 and 15 respectively.

Stator 9, which is a three-phase winding, has one terminal connected to line 48, a second terminal connected to contacts 17 and 18, and a third terminal connected to contacts 16 and 19.

In operating the apparatus, closure of switch 30 energizes relays 39 and 4 whereby stator 9 is energized and anode 8 starts to rotate. Switch 38 is then closed to apply operating voltage to the tube, and after the exposure has been taken is opened. Switch 30 is then opened, which deenergizes relays 4 and 39. Arms 14 and 15 immediately engage contacts 18 and 19 respectively to thereby reverse the direction of rotation of the field produced by stator 9 and retard the rotation of anode 8. After a short time interval, for instance 1/2 second, arms 40 and 41 leave contacts 42 and 43 respectively to thereby deenergize the stator 9 and return the apparatus to the position shown.

The time delay in relay 39 should be such that arms 40 and 41 leave contacts 42 and 43 when the anode has been brought to a slow speed or substantially to rest by the action of the reversed field. In practice I make this time about ½ second, in which case the anode comes substantially to rest within about 3 seconds after switch 30 has been opened.

The apparatus shown in Fig. 2 is somewhat similar to that of Fig. 1, and has the same parts indicated by the same reference numerals.

In Fig. 2 current is supplied from a single-phase A. C. supply through switch 30 to the primary terminals 25 and 26 of a phase transformer 6. The three-phase terminals 28 and 29 are connected to the heels of arms 14 and 15 respectively, whereas the third terminal 27 is connected directly to the third terminal of stator 9.

Relay 39 of Fig. 1 is replaced by a relay 3 having an arm 12 which leaves a fixed contact 13 about ½ second after the energization of the relay. The coil of relay 3 has one end connected to terminal 32 and its other end connected to terminal 33 through contacts 23 and 24 and arm 20 of a two-position switch 5 having a second pair of contacts 21 and 22.

Switch 5 is manually operated, preferably foot operated, and is held in the position shown by a spring (not shown). This switch is preferably of the snap action or toggle type, and as such switches are well known in the art, further description or illustration of the same is believed unnecessary.

To prevent application of operating voltage to the tube while the anode is not rotating at its normal speed, I provide a relay 2 whose coil is connected in parallel with the coil of relay 4. Relay 2 has an arm 10 which engages a fixed contact 11 at a predetermined time, for instance 1 second, after the energization of the relay. Arm 10 and contact 11 are arranged to control the operating circuit of the X-ray tube so that operating voltage can be applied to the tube only when arm 11 is in engagement with contact 10. As indicated in the drawing, arm 11 and contact 10 are connected in the energizing circuit of the main contactor 50 whose armature is in the operating circuit of the X-ray tube 1, which circuit includes a switch 51 which is closed to take an exposure.

The coils of relays 2 and 4 have one end connected through a conductor 35 to contact 21, and their other ends connected through a conductor 36 to terminal 33. Contact 22 is connected to contact 13 and through a conductor 34 to terminal 25 of transformer 6.

As shown, the apparatus is in its normal position with the stator 9 deenergized and with relay 3 energized. If it is desired to take an exposure, switch 5 is moved into its right-hand position, whereby contacts 23 and 24 are disconnected, relay 3 is deenergized, and arm 12 engages contact 13 to thereby energize transformer 6. At the same time arm 20 shunts contacts 21 and 22 to energize relays 2 and 4, whereby arms 14 and 15 immediately engage contacts 16 and 17 respectively to thereby energize stator 9 and cause anode 8 to rotate. However, due to the time delay in relay 2, arm 10 does not engage contact 11 until after about 1 second, and thus the operating voltage can not be applied to the X-ray tube until anode 8 has come up to its normal speed. The exposure can then be taken.

After the exposure has been completed, switch 5 is returned to the position shown whereby re-

lays 2 and 4 are deenergized and arms 10, 14 and 15 immediately assume the positions shown. Opening of contact 10 makes it impossible to apply operating voltage to the tube, whereas arms 14 and 15 engage contacts 18 and 19 respectively to thereby reverse the connections to stator 9 and the direction of rotation of the field produced thereby. This retards the rotation of the anode and brings the same to rest or to a very slow speed within a short time, for instance within 3 seconds.

Due to the time delay in relay 3, arm 12 does not disengage contact 13 until after a predetermined time interval, and thus transformer 6 remains energized until the retarding force exerted by the field produced by stator 9 is sufficient to greatly reduce the speed of anode 8 or to bring the same substantially to rest. In practice I have found that a time delay of about ½ second or slightly less gives very satisfactory results.

While I have described my invention with reference to specific examples, it will be apparent to one skilled in the art that other types of circuits and other types of relays may be used. Furthermore, the several relays may be combined or timing motors may be used. Therefore I do not wish to be limited to the particular constructions described, but desire the appended claims to be construed as broadly as is permissible in view of the prior art.

What I claim is:

1. In an X-ray installation, an X-ray tube having a rotatable anode, means for rotating said anode including an electromagnetic stator for producing a rotating magnetic field, and means to reverse the direction of rotation of said field for a predetermined time sufficient to bring the anode quickly to rest, said latter means being operative only after the X-ray tube has been placed out of operation.

2. In an X-ray installation, an X-ray tube having a cathode and a rotatable anode, means for rotating said anode including an electromagnetic stator, means for energizing said stator in opposite directions including a source of voltage and a reversing relay connected between said source and stator, means to permit the application of operating voltage to the tube including a relay having a contact which closes at a predetermined time after energization, an electromagnetic switch controlling the energization of said two relays and connecting the source to the contacts of said first relay, said electro-magnetic switch opening at a predetermined time after energization, and a two-position manual switch, said latter switch in one position causing energization of said electromagnetic switch and in its other position causing energization of said relays by said electro-magnetic switch.

3. In an X-ray installation, an X-ray tube having a rotatable anode, an electromagnetic stator adapted to produce a rotating field for rotating said anode, means for energizing said stator in two directions comprising an energizing circuit including a reversing relay, means to energize said relay not later than the time at which operating voltage is applied to the X-ray tube and to deenergize the same not sooner than the time at which the operating voltage has been removed, and timing-switching means to interrupt said circuit at a predetermined time after said relay is deenergized.

4. In an X-ray installation, an X-ray tube having a rotatable anode, an electromagnetic stator adapted to produce a rotating field for rotating

said anode, means for energizing said stator in two directions comprising an energizing circuit, a relay having reversing contacts in said circuit, a second relay having a contact adapted to interrupt said circuit at a predetermined time after
5 deenergization of the relay, means for energizing said X-ray tube including an operating circuit

and a voltage supply, and means to simultaneously energize both said relays and connect said voltage supply to said operating circuit and to simultaneously deenergize both said relays and disconnect said voltage supply from said operating circuit.
5

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