Feb. 28, 1939. C. W. DAUMANN 2,149,164

X-RAY APPARATUS

Filed Dec. 30, 1936

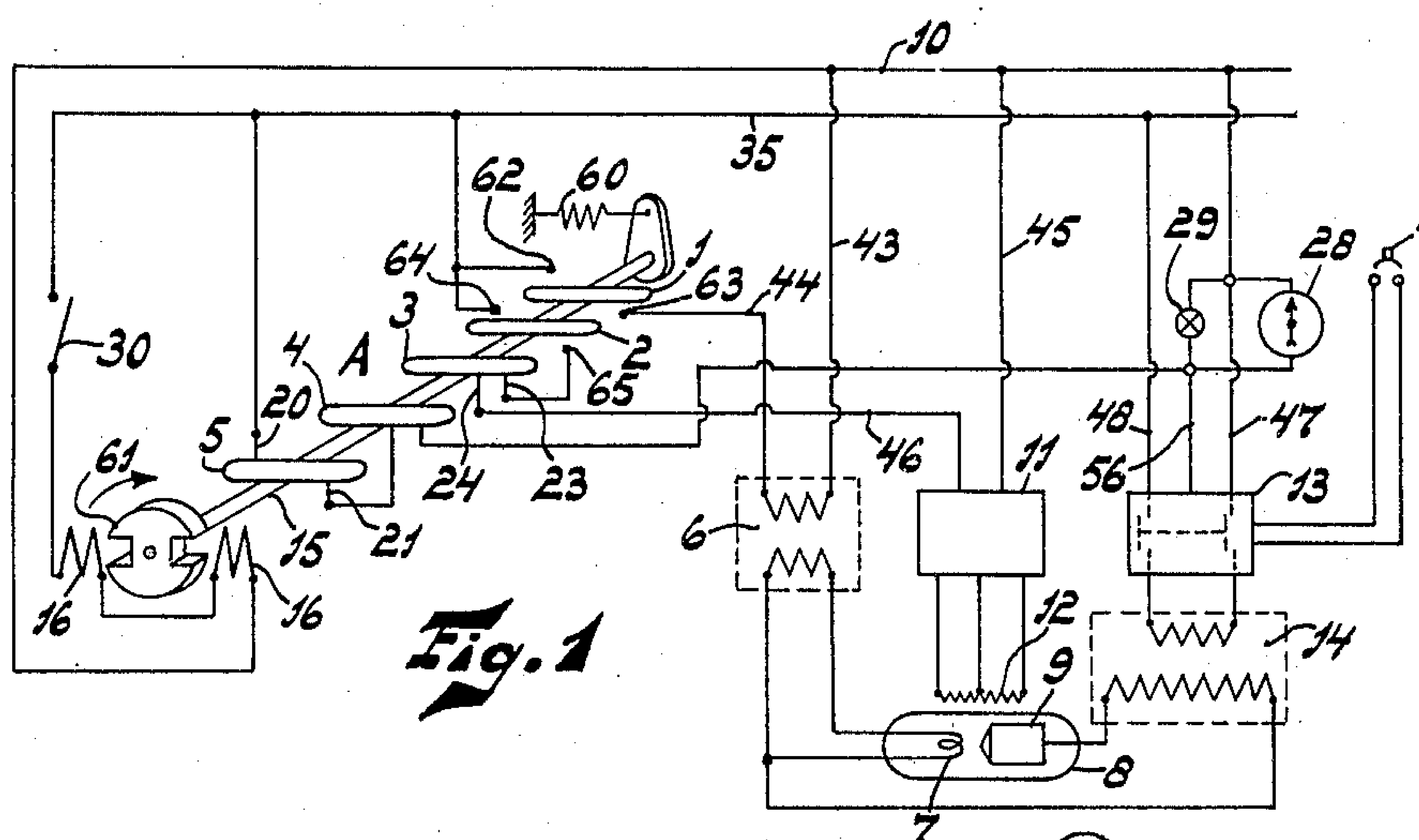

Fig. 1

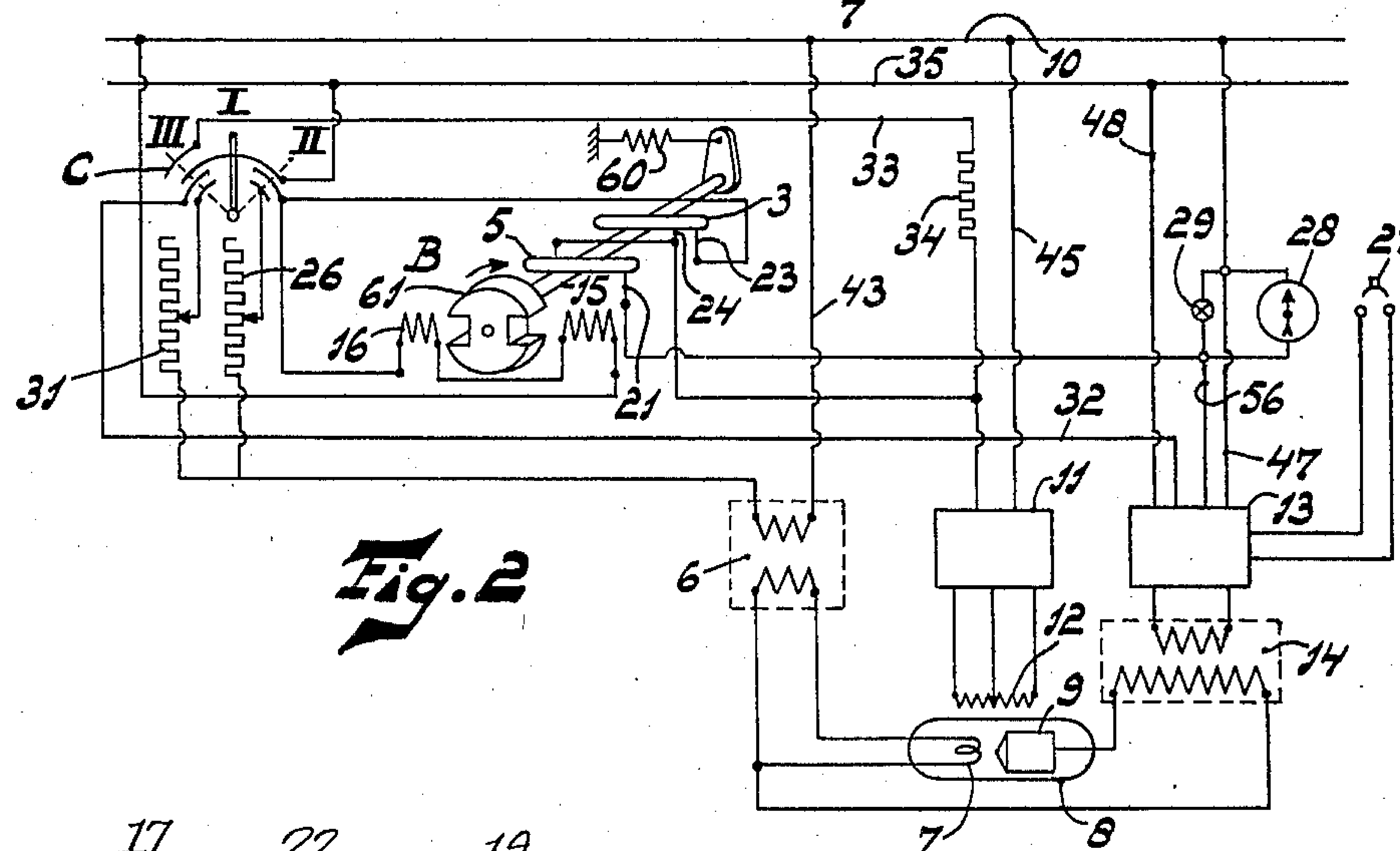

Fig. 2

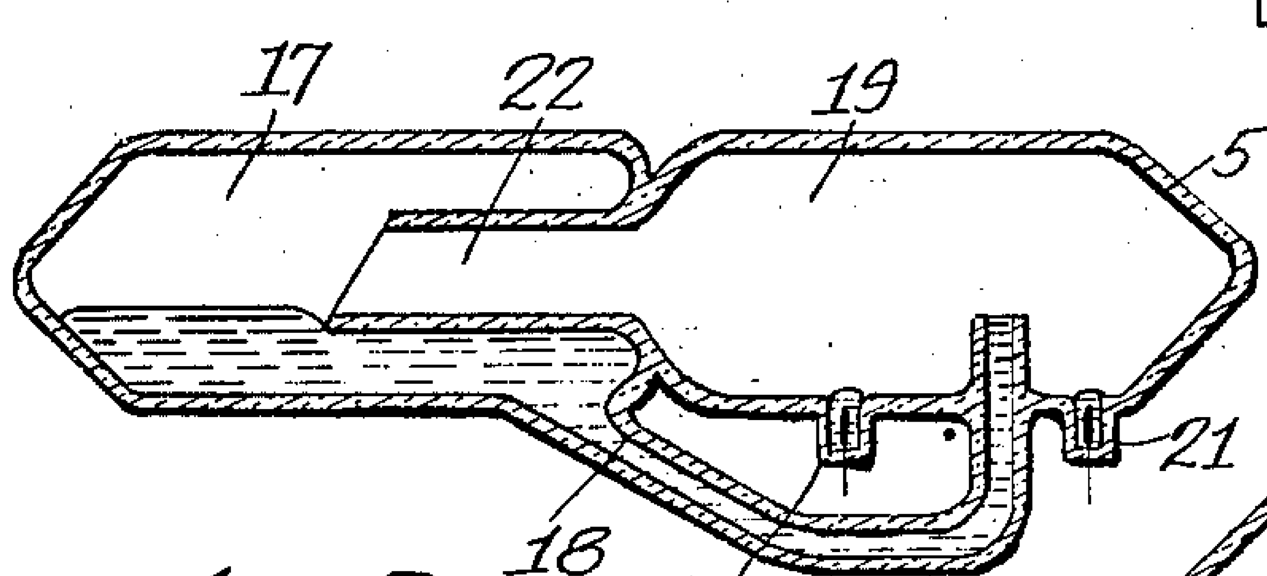

Fig. 3.

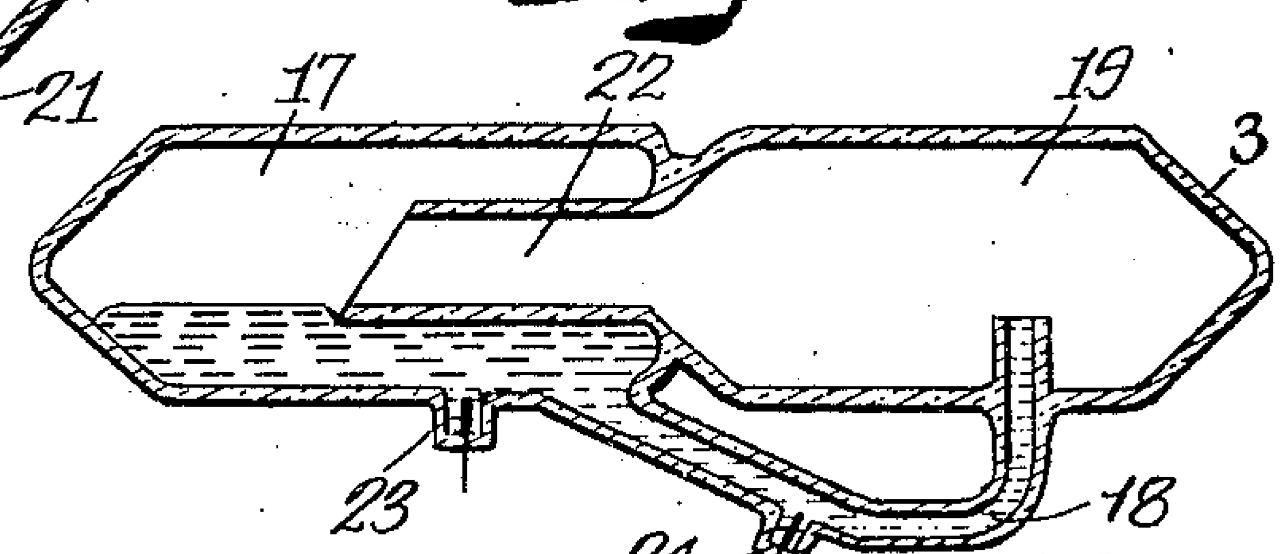

Fig. 4.

INVENTOR

CARL WILHELM DAUMANN

BY [signature]

ATTORNEY.

Patented Feb. 28, 1939

2,149,164

UNITED STATES PATENT OFFICE

2,149,164

X-RAY APPARATUS

Carl Wilhelm Daumann, Eindhoven, Netherlands, assignor to N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands

Application December 30, 1936, Serial No. 118,419
In Germany January 2, 1936

8 Claims. (Cl. 250—95)

My invention relates to X-ray apparatus comprising an X-ray tube having a movable anode, particularly a rotary anode.

The anode of such an X-ray tube is generally rotated by a rotating field set up by an electromagnetic stator mounted on the tube. Such stators, however, increase the size and weight of the movable structure comprising the tube, and it is of great advantage to make them as small as possible. As the anode need notate only during the radiographic exposure, a large reduction in the size of the stator can be effected if it is deenergized immediately after the exposure has been completed to thereby reduce the heating as much as possible.

According to my invention I energize the stator simultaneously with, or a little later than, the energization of the cathode of the tube, and automatically deenergize the stator after a predetermined period of time which is sufficiently long to allow a radiographic exposure to be made with the anode running at its operative speed. Furthermore, to insure that an exposure cannot be made before the anode has attained its operative speed, I prevent the supply of operating current to the X-ray tube until a predetermined time after energization of the stator.

More particularly, I prevent the supply of operating current until shortly after energization of the stator, and—after a predetermined interval during which an exposure may be made—again prevent the supply of operating current prior to, or simultaneous with, deenergization of the stator.

My invention may be carried into effect in various manners. For example, the stator energizing current may be controlled by a time-delay switch having contacts which open at a predetermined time after being closed, whereas a second time-delay switch prevents the supply of operating current to the X-ray tube until a predetermined time, then allows the supply until a predetermined time after which it again prevents the supply. Such switches may be operated by discharge tubes; for example—gas filled triodes. In a simple embodiment of my invention I use mercury time-delay switches, and I shall describe my invention in this connection.

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

Figure 1 is a partly-perspective schematic diagram of an X-ray installation according to the invention;

Fig. 2 is a partly-perspective schematic diagram of an X-ray installation according to another embodiment of the invention;

Figs. 3 and 4 are diagrammatic views of mercury time-delay switches for use in the systems shown in Figs. 1 and 2.

The installation shown in Figure 1 comprises an X-ray tube 8, a step-down cathode-heating transformer 6, a high-tension supply transformer 14, a control device 13, a switching device A, and a phase-converting device 11.

X-ray tube 8 has an incandescible cathode 7 connected across the secondary winding of transformer 6, and a rotary anode 9 connected to one end of the secondary winding of transformer 14, whose other end is connected to cathode 7. The usual valves, such as rectifiers, may be provided between the transformer 14 and the tube 8.

The anode 9 is rotated by a rotary field set up by a three-phase stator 12 supplied with three-phase current by the converting device 11. One side of the input of device 11 is permanently connected through a conductor 45 to a supply lead 10 of a single-phase supply (not shown), whereas its other side is connected through a conductor 46 to the switching device A.

Transformer 14 has its primary winding connected through a suitable regulating and switching device 13 and conductors 47 and 48 to the supply leads 10 and 35. The device 13 contains the commonly used voltage-regulating means to adjust the amount of voltage applied to the primary winding of the transformer, and a time switch to adjust the time this voltage is applied. The time switch may be of the form described in the U. S. Patent No. 2,061,011 to Vingerhoets, and is controlled by a normally-open push button 27, whereas the controlling current is supplied through conductors 56 and 47 in a manner later to be described. As such voltage regulating means are well known in the art, further description of same is believed to be unnecessary.

The primary winding of transformer 6 has one end permanently connected through a conductor 43 to the supply line 10, whereas its other end is connected through a conductor 44 to the switching device A.

The rotary switching device A, which serves to control the energization of transformer 6 and of converting device 11 as well as the supply of controlling current to regulating device 13, comprises a shaft 15 of insulating material held in the position shown by a spring 60 and carrying an armature 61, contact arms 1 and 2, and timing elements 3, 4 and 5. The shaft 15 is rotated in the direction of the arrow by two actuated coils 16 connected in series across lines 10 and 35, through a normally-open hand switch 30.

Contact arm 1 serves to energize transformer 6, and for this purpose connects contact points 62 and 63 upon closure of switch 30 to thereby connect conductor 44 to supply line 35.

Contact arm 2 and timing element 3 serve to control the supply of current to converting device 11, and for this purpose contact arm 2 bridges contacts 64 and 65; contact 65 being connected to a contact 23 of timing element 3 having a second contact 24 connected to conductor 46.

The timing element 3 serves to interrupt the supply of current to device 11 after a predetermined time, thereby limiting the time of rotation of the anode 9, for instance to 20 seconds. For this purpose I prefer to use a mercury time-delay switch such as shown in Fig. 4. However such time delay may be obtained in various manners which are known per se.

The mercury switch shown in Fig. 4 comprises an envelope forming a chamber 17 containing a supply of mercury, and a chamber 19. The chambers 17 and 19 are connected by a tubular portion 22 extending into chamber 17, whereas a small tube 18 allows a slow passage of the mercury from chamber 17 to chamber 19 upon clockwise rotation of the switch. The switch is provided with contacts 23 and 24, which, with the switch in the positions shown in Figs. 1 and 4, are connected by the mercury. When the mercury switch is rotated clockwise, the mercury slowly flows through tube 18 into chamber 19 and interrupts its connection of contacts 23 and 24 after a predetermined time, which time can be regulated by the design of the tube. When the switch is rotated counter clockwise, the mercury immediately flows back into chamber 17 through tubular portion 22 and again connects contacts 23 and 24.

Timing elements 4 and 5, which serve to control the flow of actuating or control current to the regulating device 13, are connected in series between conductor 56 and supply line 35. Timing element 4, which is the same as that shown in Fig. 4, interrupts the supply of controlling current to device 13 at a predetermined time after closure of switch 30, thereby limiting the time within which an exposure can be made by pressing button 27. The timing element 5 serves to prevent actuating of regulating device 13 by push button 27—thus the application of operating current to tube 8—until the anode 9 has attained its operating speed and the cathode 7 has reached its operating temperature. For this purpose timing element 5 comprises a mercury time-delay switch such as shown in Fig. 3, which is of the same construction as that shown in Fig. 4 with the exception that it is provided with contacts 20 and 21 in chamber 19. Thus timing element 5 makes its contacts at a predetermined time after closure of switch 30, which delay is for example about 1 second.

In the operation of the system, switch 30 is first closed, whereby transformer 6 and converting device 11 are energized by closure of arms 1 and 2, contacts 23 and 24 being shunted. Due to the time lag in element 5, conductor 56 is not connected to conductor 35 and energizing voltage is not applied to device 13 until about 1 second after closure of switch 30 and the resulting clockwise movement of device A. At that time conductor 56 is connected to conductor 35 through elements 4 and 5. After about 30 seconds element 4 breaks its contacts and removes the voltage from device 13, and at the same time, or slightly later, the converting device 11 is deenergized by timing element 3.

To indicate to the operator that the proper conditions exist for making the exposure, an indicating lamp 29 and an electric time indicator 28 are connected in parallel across conductors 56 and 47. Thus when the controlling current is supplied to the device 13 through timing elements 4 and 5, the lamp 29 is illuminated and the time indicator is started. The latter indicates to the operator the amount of time in which the exposure can be made and its hand is at zero when the contacts of either timing element 4 or 5 are open. When the contacts of both these timing elements are closed the time indicator 28 starts and the hand indicates the amount of time passed away or the amount of time still available for making an exposure.

The system shown in Fig. 1 allows radiographs to be made at any desired instant. For example, if timing elements 3 and 4 have time delays of 20 seconds, and timing element 5 has a delay of two seconds, it will be possible to make a radiograph of up to 1 second duration, even 17 seconds after the lamp 29 is illuminated.

If it is not necessary to wait until a suitable moment for making the exposure, the switch 27 may be closed at an earlier time, for example at the same time as switch 30 is closed. In such case the exposure will be made when the contacts of timing element 5 are closed.

The switches 27 and 30 may be combined in a single housing, or a single switch which successively makes two circuits can replace these switches.

The system shown in Figure 2, which is adapted for either fluoroscopy or radiography, is a simplification of the system shown in Figure 1 and has similar parts designated by the same reference numerals. In the system of Figure 2, a three-position manually-operated switch C makes the connection for fluoroscopy or radiography. The system also comprises a switch B which is similar to switch A in Figure 1, with the exception that contact arms 1 and 2, and timing element 4 are omitted.

The switch C has three positions—namely, I, which is an off-position; II, a radiographic position, and III, a fluoroscopic position. In position III, switch C energizes transformer 6 and converting device 11, and also allows the flow of current to the regulating device 13 whereby the operating current of tube 8 may be switched on for any desired length of time by pressing button 27 or by means of a separate hand switch (not shown). An adjustable resistance 31 in the energizing circuit of transformer 6 serves to decrease the heating current of the cathode 7 to a value suitable for fluoroscopy, whereas a resistance 34 serves to decrease the speed of the anode 9 during fluoroscopy. Thus during fluoroscopy the stator 12 is loaded with a smaller amount of current and can be energized for a long period of time without overheating.

With the switch C in position II, transformer 6 is energized through an adjustable resistance 26, which serves to limit the cathode heating current to a value suitable for radiography, whereas converting device 11 is energized through the timing element 3 which, as in Fig. 1, interrupts the supply of current to this device after a predetermined time. The control current for regulating device 13 is supplied through the series-connected timing elements 3 and 5, whereby timing element 5 makes its contact at a predetermined time after switch C is placed in position II, and timing element 3 deenergizes the regulating device 13 simultaneously with converting device 11.

It will be noted that in Figure 2, the timing element 3 serves the same purpose as elements 3 and 4 in Figure 1, whereas switch C serves the purpose of contact arms 1 and 2 and switch 30.

While I have described my invention in connection with specific applications and examples, I do not wish to be limited thereto but desire appended claims to be construed as broadly as permissible in view of the prior art.

What I claim is:

1. An X-ray apparatus comprising an X-ray tube having a cathode and a movable anode, electrical means for moving said anode, said means being adapted for continuous operation for only a short time period, means for supplying operating current to said X-ray tube, and switching means including a timing element for automatically limiting the energization of said electrical means to a predetermined time interval which is considerably shorter than said short time period.

2. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotatable anode, means for rotating said anode including an electromagnetic stator adapted to be continuously energized for only a short time period, means for heating said cathode, means for supplying operating current to said X-ray tube, and switching-timing means for energizing said stator and automatically deenergizing same after a predetermined time interval which is less than said short time period and for preventing the supply of operating current to the X-ray tube prior to the energization of said stator and subsequent to the deenergization thereof.

3. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotary anode, means for rotating said anode including an electromagnetic stator adapted to be continuously energized for only a short time period, means for energizing said cathode, means for supplying operating current to said X-ray tube, and switching-timing means cooperating with said stator cathode-supply means and operating-current supply means for energizing said stator and cathode at substantially the same time and for automatically deenergizing said stator after a predetermined time interval considerably shorter than said short time period, said switching-timing means preventing the supply of operating current to the tube prior to a predetermined time after energization of said stator and subsequent to the deenergizing of said stator.

4. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotary anode, means for rotating said anode including an electromagnetic stator adapted to be continuously energized for only a short time period, means for energizing said cathode, means for supplying operating current to said X-ray tube, and switching-timing means for limiting the energization of said stator to a time interval considerably shorter than said short time period comprising a switch for energizing said stator, a time-delay switch connected in series with said first switch for deenergizing said stator at a predetermined time after closure of said first switch, and a second time switch for preventing the supply of operating current to said X-ray tube prior to the closure of said first switch and subsequent to the opening of said time-delay switch.

5. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotary anode, means for rotating said anode including an electromagnetic stator, means for heating said cathode, means for supplying operating current to said X-ray tube comprising an electrically-actuated time relay having contacts controlling the supply of operating current, and a control circuit of said relay, switching-timing means for energizing said cathode and stator and for deenergizing said stator after a predetermined time, and means for preventing the supply of operating current to the X-ray tube prior to the energization of the stator and subsequent to the deenergization of the stator, said latter means comprising a timing element having normally-open contacts closing at a predetermined time after the element is placed in its on-position, a second timing element having normally-closed contacts opening at a predetermined time after the element has been placed in its off-position, the contacts of said two elements being connected in series in said control circuit, and means to place said first timing element in its on-position and said second element in its off-position when said stator is energized.

6. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotary anode, means for heating said cathode, means for rotating said anode including an electromagnetic stator adapted to be continuously energized for only a short time period, means for supplying operating current to the X-ray tube, and switching-timing means for energizing said stator and cathode and automatically deenergizing the stator after a predetermined time interval considerably shorter than said short time period, and for preventing the supply of operating current to the X-ray tube prior to the energization of said stator and subsequent to the deenergization thereof, said switching-timing means comprising a switch for simultaneously energizing said cathode and stator and for deenergizing said cathode, and a timing element operative with said switch to automatically deenergize said stator at a predetermined time after the energization of said cathode.

7. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotary anode, means for rotating said anode including an electromagnetic stator adapted to be continuously energized for only a short time period, means for heating said cathode, means for supplying operating current to said X-ray tube comprising a regulating device for controlling the time of the exposure, a control circuit for said device, and switching-timing means for energizing said stator and cathode and for automatically deenergizing the stator after a predetermined time interval considerably shorter than said short time period, and for preventing the supply of operating current to the X-ray tube prior to the energization of the stator and subsequent to the deenergization of the stator, said switching-timing means comprising a timing element having normally-closed contacts opening after a predetermined time delay, said contacts controlling said control circuit and the energization of said stator.

8. An X-ray apparatus comprising an X-ray tube having an incandescible cathode and a rotary anode, means for rotating said anode in-

cluding an electromagnetic stator under dimensioned for continuous operation, means for heating said cathode, means for supplying operating current to said X-ray tube, and switching-timing means for energizing said stator and cathode and for automatically deenergizing said stator after a predetermined time interval considerably shorter than the time period required for the stator to reach its maximum allowable temperature, and for preventing the supply of operating current to said X-ray tube prior to the energization of the stator and subsequent to the deenergization of the stator, said switching-timing means comprising a switch having a rotatable shaft, and a plurality of mercury-tube time-delay switches mounted on said shaft.

CARL WILHELM DAUMANN.