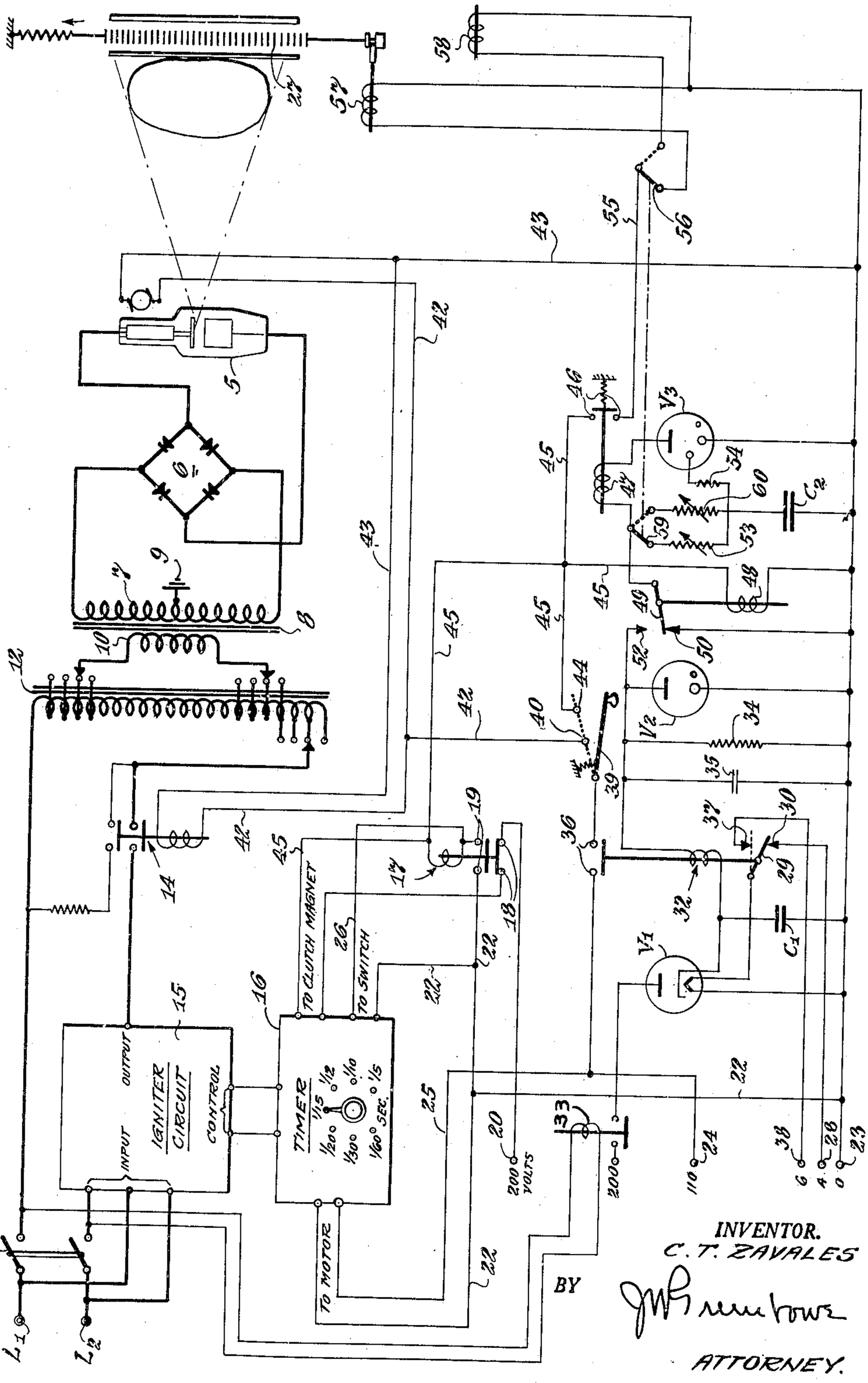
Oct. 25, 1949. C. T. ZAVALES 2,486,089

TIME DELAY CONTROL

Filed Oct. 30, 1946



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Patented Oct. 25, 1949

2,486,089

UNITED STATES PATENT OFFICE

2,486,089

TIME DELAY CONTROL

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Application October 30, 1946, Serial No. 706,594

7 Claims. (Cl. 250—95)

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The present invention relates to X-ray apparatus and particularly to the proper timing of the motion of the Bucky grid as used therewith to prevent fogging and the appearance of grid lines on the resulting radiographic film.

It has long been known in the X-ray art that a Bucky grid will suppress secondary radiation given off by the boney structure of a patient which would otherwise cause fogging of the film. Also, in order to prevent the grid itself from making grid lines on the film, it is essential that such grid be in motion at a uniform rate of speed during the entire preselected period of the X-ray exposure. Inasmuch as the time of exposure is variable by the customary timer employed, to adapt the exposure to the particular part of the anatomy to be radiographed, this means that regardless of the duration of exposure, from the shortest to the longest time range of the timer, the Bucky grid must be uniformly moving.

Since there is a time delay period following initiation of an exposure it has been customary to set the apparatus so that the Bucky grid starts its motion in timed relation with the exposure with such time delay taken into consideration. Previous to the present invention this has usually been accomplished by the provision of pneumatic or weighted relays which are supposed to trip the Bucky at the proper moment. The disadvantage of such structure resides in the fact that once set for a given grid the entire mechanism has to be readjusted for any other grid. Aside from this the mechanism itself too readily gets out of adjustment even with a given grid because a pneumatic relay is subject to variations in temperature and a weighted relay to vibrations, which tends to disturb its adjustment.

It is accordingly the object of the present invention to provide a Bucky release time delay control which is accurate and dependable under all conditions of operation.

Another object of the present invention is the provision of a Bucky release time control which assures movement of the grid at a uniform rate of speed before the X-ray exposure can be initiated.

A further object of the present invention is the provision of a Bucky release time control wherein such control is effective electronically.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein the single figure is a schematic illustration of a Bucky release time delay control constructed in accordance with the present invention.

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Referring now to the drawing in detail a rotary anode X-ray tube 5 is shown which receives high potential unidirectional electrical energy through a full-wave rectifying arrangement 6 from the secondary winding 7 of a high voltage transformer 8, with the mid-point of the secondary winding being grounded at 9. The primary winding 10 of this high tension transformer 8 is energized from appropriate taps of an auto-transformer 12, the latter in turn receiving electrical energy from a source of the customary commercial potential L1 and L2, upon closure of a main line switch 13 and an X-ray exposure relay 14, depending on the operation of an igniter control 15 for periods of time as preselected by a timer 16.

Inasmuch as the igniter control 15 per se forms no part of the present invention nor does the timer 16, it is believed unnecessary that the same be herein described in detail. It should suffice to say that they both may be of the type as shown and described in Patent No. 2,316,566, issued April 13, 1943, to J. M. Constable and Roger W. Stamm and assigned to the same assignee as the present invention. It will be noted, however, that since the igniter control 15 is in series with one of the supply conductors L2 for the auto-transformer 12, it controls energization of the latter. Also, inasmuch as the timer 16 controls operation of the igniter control 15 they are associated with the X-ray tube 5 in such manner as to control energization thereof for periods of time as selected by the timer 16.

A relay 17 is provided which has a pair of normally closed contacts 18 and a pair of normally opened contacts 19, with the contacts 18 connecting a terminal 20 (and constituting a tap on a "control" auto-transformer not shown and supplying about 200 volts) to one side of a clutch magnet, indicated by the legend "To clutch magnet," within the timer 16. The timer motor, as indicated by the legend "To motor," is connected by a conductor 22 to an auto-transformer terminal 23 and constituting the grounded or zero tap, while the other side of the motor is connected to a 110 volt auto-transformer terminal 24 by a conductor 25. Accordingly the "Timer motor" runs continuously so long as the control auto-transformer is energized. It will also be noted that conductor 22, extending from the zero tap on the control auto-transformer to one side of the timer motor, branches so as to extend to one of the contacts 19 of relay 17 and to one side of a switch, indicated by the legend "To switch" within the timer 16, and from this timer switch a conductor

26 extends to one end of the winding of relay 17.

The time delay control for the Bucky, shown as a vertical grid 27, comprises an indirectly-heated-cathode type of rectifier tube V1, a voltage regulator type tube V2 and a cold cathode grid glow tube V3. The thermionic cathode of tube V1 receives heating current from a 4 volt tap 28 on the control auto-transformer through a pair of normally closed contacts 29 and 30 of a relay 32. The plate of tube V1 is adapted to be connected by the contacts of a relay 33 to a 200 volt tap on the control auto-transformer, while the cathode of tube V1 is connected through a capacitor C1 to the zero tap 23 of the control auto-transformer.

Upon the cathode of tube V1 reaching proper operating temperature (relay 33 having been energized upon closure of mainline switch 13), tube V1 accordingly becomes conductive and charges capacitor C1. Voltage regulator tube V2 is connected across the output circuit of capacitor C1 through the winding of relay 32 which provides sufficient resistance to limit the current passing through tube V2, and resistor 34 and capacitor 35 are shunted across tube V2 to control the voltage across tube V2. Accordingly, upon capacitor C1 becoming charged, the voltage of the latter is applied across tube V2, causing this tube to become conductive with flow of current through the winding of relay 32. The armature of relay 32 is thus raised which closes a pair of normally open contacts 36 and at the same time opening normally closed contacts 29 and 30. This causes contact 29 to engage a contact 37 connected at a 6 volt tap 38 on the control auto-transformer raising the temperature of the cathode of tube V1 with an attendant increase in current flow through tube V1. The foregoing also functions as a safety feature since it serves as a sufficient time delay which assures the Bucky control being conditioned only for operation even should the operator depress the spring biased exposure switch 39 beforehand, as the latter will have no effect until contacts 36 are closed and this will not occur until tube V1 is conducting and relay 32 is energized. Moreover, such time delay assures the heating of the filaments of all tubes to proper electron emitting temperature before the application of full voltage to the tubes.

Such having occurred the spring biased exposure switch 39 then becomes effective or is then depressed which engages a contact 40 connected by a conductor 42 to one side of the winding of relay 14 and also to the motor of rotary anode X-ray tube 5. Since the other side of the anode motor, as well as the remaining end of the winding of relay 14, is connected by a branched conductor 43 to the zero tap 23 of the control auto-transformer, both the relay 14 and motor of X-ray tube 5 are accordingly energized, through a circuit extending from auto-transformer tap 24, closed relay contacts 36, closed switch blade 39 and contact 40, through conductor 42 to winding of relay 14 and motor of X-ray tube 5, and thence back to zero tap 23 by means of conductor 43. This accordingly conditions the auto-transformer 12 together with the high voltage net-work ready for operation upon operation of the igniter timing circuit.

At the same time depression of exposure switch 39 also engages a further contact 44 which is connected to a branched conductor 45 extending to one side of the winding of relay 17 and to one side of the clutch magnet, as well as to one of a

pair of normally open contacts 46 of a quick acting D. C. relay 47 and to one end of the winding of a further relay 48. Thus complete depression of exposure switch 39 simultaneously causes energization of the clutch magnet within the timer 16 and relay 48. This energizing circuit accordingly extends from auto-transformer tap 24, through now closed contacts 36, switch blade 39 and contact 44 to conductor 45, one branch of which extends to winding of relay 48 and thence to the zero tap 23 and the other branch of which extends to one end of the winding of relay 17 and then to the clutch magnet, thence from the latter through closed contacts 18 of relay 17 to the 200 volt tap 20.

Energization of the clutch magnet causes engagement of the timing mechanism with the continuously rotating motor within the timer 16. Operation of the timer 16 thus effects control of the igniter timing circuit 15 which, after the aforementioned time delay, initiates energization of auto-transformer 12 together with the high voltage net-work accompanied by the generation of X-rays from the X-ray tube 5. The switch within the timer 16 is provided to prevent re-energization of the clutch magnet so long as the operator maintains switch 39 depressed and to this end the switch within the timer 16 is momentarily closed by the timing mechanism at the end of its cycle to energize the winding of relay 17. This energizing circuit extends from zero tap 23 and conductor 22 to the timer switch, thence to one end of the winding of relay 17 and since the remaining end of this winding is connected to the conductor 45, now carrying current from the 110 volt auto-transformer tap 24 through the switch 39 as previously traced, the winding of relay 17 receives current raising its armature to open contacts 18 (to the clutch magnet) and closing contacts 19 to establish a self-holding circuit to its winding independently of the switch within timer 16.

As previously mentioned there is a slight time delay in the operation of the igniter circuit once it is conditioned for operation by the clutch magnet and the timer 16. However, simultaneously with energization of relay 17 and the "clutch magnet," by engagement of switch 39 with contact 44, the relay 48 is also energized which raises its armature to open normally closed contacts 49—50 and to close contacts 49—52. The output circuit from capacitor C1 is now divided and includes, in addition to tube V2, a variable resistance 53 for regulating the time delay and an additional capacitor C2. When capacitor C2 accordingly becomes charged to the ionizing potential of tube V3 it then discharges through a resistor 54 and across the grid and cathode of tube V3 rendering the latter conductive. The plate circuit of tube V3 includes the winding of relay 47 which now is energized from the auto-transformer tap 200, through switch 33, tube V1, winding of relay 32, contacts 49—52 of relay 48, to the winding of relay 47 and through tube V3 to the zero auto-transformer tap 23.

Relay 47 thus closes its contacts 46 which then completes a circuit from conductor 45 (at the moment carrying a potential of one sign), through a conductor 55 having a normally closed switch 56 interposed therein, to the winding of a Bucky release relay 57 and thence to the zero auto-transformer tap 23. Energization of release relay 57 accordingly starts the previously cocked vertical Bucky grid 27 in motion so that it is moving at a uniform rate of speed by the

time X-rays are generated by the X-ray tube **5** following the time delay caused by the igniter circuit upon depression of the exposure switch **39**.

Upon expiration of the exposure as determined by the presetting of the timer **16** which automatically interrupts the igniter circuit **15**, the operator then releases the exposure switch **39** thus deenergizing all the relays **14**, **17**, **47** and **48**. Relay **48** accordingly drops its armature opening contacts **49—52** to deenergize relay **47** and again closing contacts **49—50**. This extinguishes the discharge in tube V3 and allows any residual charge on capacitor C2 to leak off through variable resistance **53**. Upon opening of main line switch **13** relay **33** opens its contacts thereby deenergizing relay **32** which opens its contacts **36** and causing contact **29** to disengage contact **37** and again engage contact **30** to lower the filament voltage of tube V1, with the entire apparatus then being in condition for another exposure or a further exposure utilizing a horizontal Bucky grid (not shown).

In the event the latter is desired the operator merely opens switch **56** in conductor **55**, which interrupts the circuit to vertical Bucky release relay **57**, and closes the switch **56** to substitute a horizontal Bucky release relay **58** which operates in the identical manner as described respecting relay **57**. It will also be noted that switch **56** is tied to a further double through switch **59** which simultaneously opens the circuit through variable resistance **53** and closes a circuit through another variable resistance **60** whereby the latter is effective for operation with operation of the horizontal Bucky grid in the same manner that variable resistance **53** is operable with operation of the vertical Bucky grid **27**.

From the foregoing it will become obvious to those skilled in the art that a Bucky release time delay is herein provided which assures that the Bucky grid is in motion at a uniform rate of speed prior to the emanation of any X-rays from the X-ray tube. Moreover, the time delay normally required for operation of the various elements of the apparatus is fully compensated for regardless of the range of such time delay merely by the proper adjustment of the variable resistance **53** or **60** as the case may be and the selection of the size of the capacitor C2 to charge to the ionization potential of tube V3. By utilizing a quick action D. C. relay energizable from a constant voltage source regulation of the time delay period is exceedingly accurate and precise so that the resulting radiographic film is invariably free of grid lines, which would otherwise occur in the absence of the time delay herein provided by insuring movement of the grid at a uniform rate of speed during the entire period of the X-ray exposure.

Although one specific embodiment of the present invention is herein provided it is to be understood that other modifications thereof may be made without departing from the spirit and scope of the appended claims.

I claim:

1. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable to cause energization of said X-ray tube for a preselected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and for a period of time corresponding to the time

delay in the operation of the latter before actual energization of said X-ray tube including a source of electrical energy having a voltage regulator tube connected thereto for maintaining the application of a constant voltage to said compensating means, and means operable by said compensating means at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

2. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable to cause energization of said X-ray tube for a preselected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and for a period of time corresponding to the time delay in the operation of the latter before actual energization of said X-ray tube including a source of electrical energy together with a rectifier tube connected to said source for producing unidirectional current flow to said compensating means, and means operable by said compensating means at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

3. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable to cause energization of said X-ray tube for a pre-selected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and for a period of time corresponding to the time delay in the operation of the latter before actual energization of said X-ray tube including a source of electrical energy together with a rectifier tube for producing unidirectional current flow and a voltage regulator tube for maintaining the application of a constant voltage unidirectional current from said source to said compensating means, and means operable by said compensating means at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

4. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable to cause energization of said X-ray tube for a preselected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and including an energy storage means together with a variable resistance adjustable to cause operation for a period of time corresponding to the time delay in the operation of said X-ray tube energizing means before actual energization of said X-ray tube, and means operable by said compensating means at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

5. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable

to cause energization of said X-ray tube for a preselected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and including a variable resistance and a capacitor adapted to be charged according to the setting of said variable resistance to cause operation of said compensating means for a period of time corresponding to the time delay in the operation of said X-ray tube energizing means before actual energization of said X-ray tube, and means operable by said compensating means at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

6. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable to cause energization of said X-ray tube for a preselected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and including a variable resistance and a capacitor adapted to be charged according to the setting of said variable resistance to cause operation of said compensating means for a period of time corresponding to the time delay in the operation of said X-ray tube energizing means before actual energization of said X-ray tube and said compensating means also including a rectifier tube for producing unidirectional current flow and a voltage regulator tube for maintaining the application of a constant voltage unidirectional current to said compensating means; and means operable by said compensating means at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

7. A Bucky release time delay control comprising a Bucky grid movable through the field of exposure of a sensitized film to a beam of radiations from an X-ray tube, means operable to cause energization of said X-ray tube for a preselected period of time and subject to an inherent time delay prior to actual energization of said X-ray tube, compensating means operable simultaneously with said X-ray tube energizing means and for a period of time corresponding to the time delay in the operation of the latter before actual energization of said X-ray tube including a source of electrical energy and a tube having a critical voltage breakdown characteristic connected to said source and operable after the lapse of the time delay to cause current flow from said source and through said tube, and means operable by breakdown of said tube and the flow of current therethrough at a preselected moment to cause movement of said Bucky grid at a uniform rate of speed during the entire time of actual energization of said X-ray tube.

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