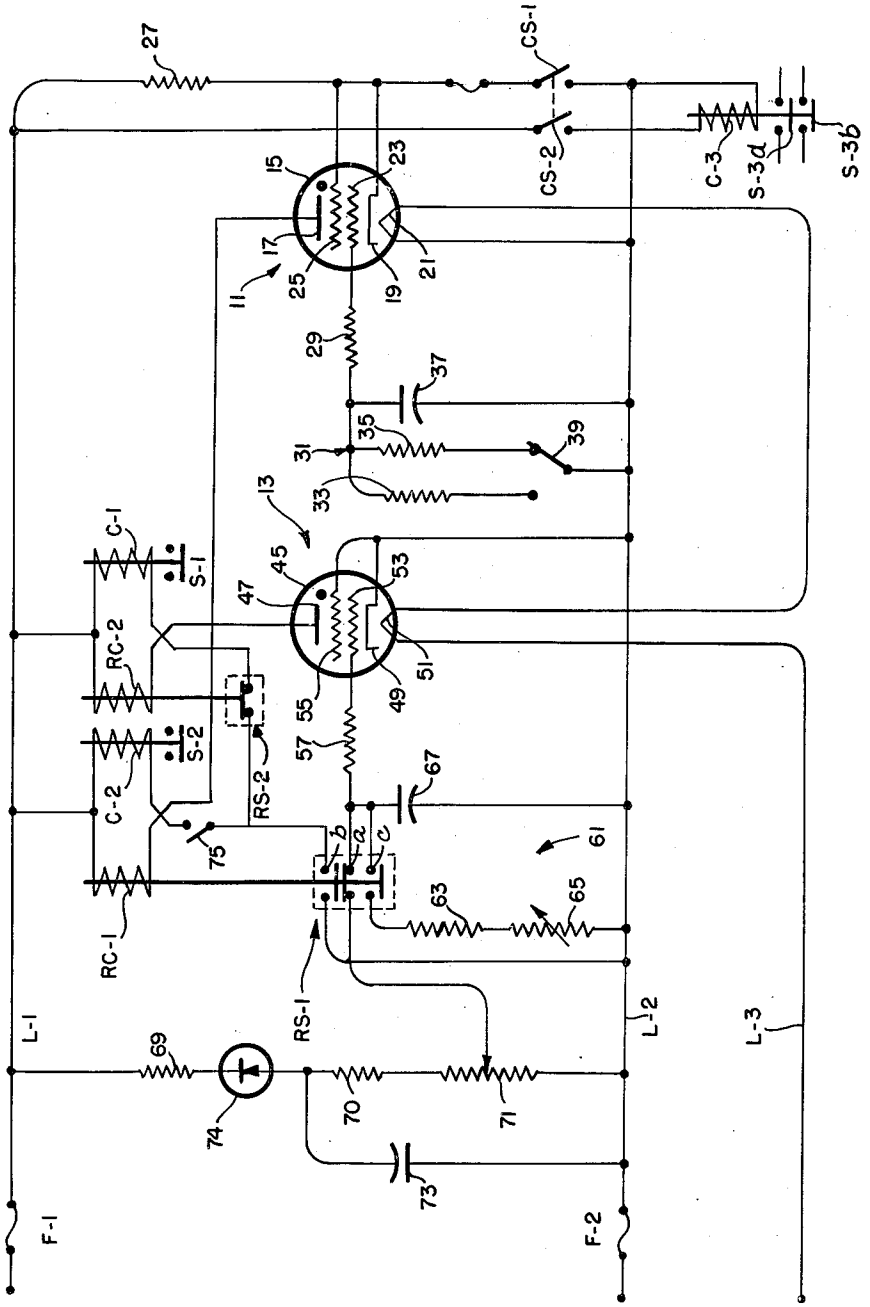
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TIMING APPARATUS

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# TIMING APPARATUS

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The present invention relates in general to interval timing and has more particular reference to electronic timing apparatus, the invention pertaining specifically to an electronic interval timing system especially adapted to control the supply of actuating energy to an electrical load during variable time intervals subsequent to the expiration of a time interval of desired duration following the actuation of a control switch, the same being particularly well suited for use in controlling the operation of X-ray generating tubes for the purpose of obtaining accurately timed X-ray exposures. The present application for U.S. Letters Patent is a continuation of an earlier application, Serial No. 517,966, filed June 27, 1955, now abandoned.

X-ray generating tubes function to produce X-rays in response to the activation of the anode of the tube as an X-ray source by the impingement thereon of electrons emitted by and from the cathode of the tube. The cathode, in turn, comprises an electron emission element, such as a filament, adapted to be excited for electron emission in response to the application thereto of filament exciting electrical energy. By applying an electrical potential between the electron emitting cathode and the anode of the tube, as by connecting the same with a suitable source of operating power, electrons emitted by the filament may be caused to travel thence toward the anode and to impinge thereon a high velocity to thus constitute the anode as an X-ray source.

X-ray generating tubes, accordingly, may be operated for X-ray emission during precisely timed exposure intervals by accurately determining the period during which operating power is applied between the anode and cathode of the tube. It is desirable, also, to provide for the application of energizing power to the cathode in advance of, as well as during, the exposure interval, in order to condition the tube for ray generation, at a desired energy level, immediately upon application of tube operating power between the anode and cathode. Furthermore, where the X-ray generating tube is of the sort having a rotating anode, it is desirable to provide for energizing the anode driving motor in advance of, as well as during, the application of tube operating power between the anode and cathode of the tube, in order that the anode be in rotation at operating speed when tube operating power is applied between the anode and cathode of the tube.

An important object of the present invention is to provide a multiple stage timer wherein one stage is operable, at the start of the operating cycle of the timer, to delimit a preliminary interval of desired duration during which timer controlled apparatus, such as an X-ray tube, may be conditioned for operation, as by energizing its cathode or the driving motor of its rotary anode, or both, another stage of the timer being operable to precisely determine the duration of an apparatus operating interval following the termination of said preliminary interval; a further object being to provide for the adjustment of the timer to vary the duration of either or both of the intervals measured or delimited by the timer.

An object of the invention is to terminate each preliminary timing interval within a predetermined time range, measured on the line voltage wave, so that a relay starting the subsequent apparatus timing interval will



have to be supplied with a minimum of power to operate on the first half wave or wait until a following half wave, thereby assuring that all apparatus timing intervals are started at substantially the same time.

Another important object of the invention is to utilize electron flow valves in connection with electrical timing circuits, said valves being controllingly connected with relay switch means to actuate the same in order to delimit preliminary or equipment conditioning as well as operating intervals of selected duration; a further object being to employ timing circuits embodying capacity reactance means operatively associated with the control grid element of electron flow valves in determining the duration of preliminary or equipment conditioning and subsequent operating intervals.

Briefly stated, in accordance with one aspect of the invention, an operable device such as an X-ray generating tube, having components, such as an electron emission cathode, or a rotating anode, which require preliminary conditioning to ready the same for operation, as by energizing the same, in advance of the actuation of the device, may be controlled by means of an electrical timing system having preoperational timing section embodying an electron flow device, a resistance-capacitance network for controlling the operation of the flow device, and a relay controlled by the flow device to delimit a preliminary apparatus conditioning interval during which a conditional component of the operable apparatus, such as the electron emitting cathode or the rotating anode of an X-ray tube, may be brought to optimum operating condition, as to rate the electron emission and desired rotary speed, respectively, the timing system embodying an additional timing section, which may comprise a relay operable under the control of an electron flow valve, which is, in turn, controlled by a suitable resistance-capacitance network, said additional timing section being adapted to control the operating device whereby to delimit a precisely timed operating interval immediately following the preliminary conditioning or warmup interval controlled by the preoperational timing section.

The foregoing and numerous other important objects, advantages and inherent functions of the invention will be apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

Referring to the drawing:

The single figure of the drawing comprises a circuit diagram illustrating a preferred embodiment of the invention.

To illustrate the invention, the drawing shows an electronic timing system particularly well adapted for use in controlling the operation of X-ray generating tubes, which commonly comprise an anode and a cathode enclosed in a sealed and evacuated envelope, the device functioning to produce X-rays as the result of activation of the anode as an X-ray source in response to impingement thereon of electrons emitted by and from the cathode. The cathode of an electron generating tube conventionally comprises an element of the sort capable of electron emission when excited, as by heating the same above the critical electron emitting temperature of the element, emission elements commonly comprising filaments adapted to be heated for electron emission as by the passage therethrough of filament exciting electrical energy derived from a suitable energy source.

To this end the cathode may be energized for electron emission by delivering electrical current therethrough under the influence of electrical potential applied to the cathode from the source of cathode energizing power, electrons emitted by the cathode being directed toward and caused to impinge upon the anode, at high velocity,

under the influence of electron driving electrical potential applied between the anode and cathode from a suitable source of operating power. In the absence of anode-cathode potential, even though the cathode be energized for electron emission, X-rays will not be generated; nor will rays be generated at the anode until electron driving energy is applied between the anode and the cathode at a potential in excess of a relatively low critical level required to drive electrons at velocities sufficient to generate X-rays in response to electron impingement at the anode. Accordingly, a generating tube may be and is commonly controlled for the production of X-rays at the anode by controlling the application of electron driving potential between the anode and cathode, such control being conventionally accomplished by means of a relay switch interposed in the power delivery circuit connected between the anode and cathode of the tube.

The quality or intensity of generated X-rays is a function of the rate at which electrons are caused to impinge upon the anode, as well as electron velocity, at the instant of impingement. The rate of electron impingement is, of course, proportional to the rate of electron emission from the cathode, the same, in turn, being a function of cathode excitation, which may be measured either in terms of cathode exciting current or of the potential at which the cathode exciting current is applied. Electron impingement velocity is a function of the electron driving potential applied between the anode and cathode.

When an X-ray generating tube is in operation for the production of X-rays, a considerable amount of heat is produced at the electron receiving surface of the anode as a result of electron impingement thereon. In the interests of optimum performance of the generating tube, it is common to operate the same under load conditions producing temperatures at the anode just short of the softening temperature of the constituent material of the anode. In order to provide for maximum tube loading, it is conventional to constitute the anode as a rotary component driven, as by means of a motor powered from a suitable energy source, preferably for rotation at desired constant speed. As a consequence, each electron receiving portion of the anode may be exposed to electron impingement within a short interval during a complete revolution of the anode and thereafter is disposed outwardly of the electron stream during the remainder of the revolution. Accordingly, each electron receiving portion of the anode is permitted to cool off slightly before being again exposed to heat and X-ray generating electron impingement. As a consequence, a rotating anode tube may be more heavily loaded than a comparable tube containing a stationary anode element.

Where X-rays are applied to a patient being treated or radiographically pictured, it is usually, if not invariably, desirable to precisely delimit the exposure interval and also to assure the application of rays of precisely determined intensity or quality during the exposure interval. In order that a generating tube may produce X-rays at a steady intensity level, it is necessary, inter alia, that electron emission occur at a constant rate at the cathode. Furthermore, where X-rays are generated in a tube having a rotating anode it is desirable, in the interests of uniformity of ray quality, that the anode be in rotation at a uniform rate of speed. Accordingly, prior to the application of X-rays to a patient during an exposure interval, it is desirable to condition the generating tube for optimum performance during the exposure interval. This may be accomplished by applying cathode exciting energy, as well as operating energy, to the anode rotating motor, during a conditioning or warmup interval in advance of the exposure interval, in order that the X-ray generating tube may produce X-rays of desired quality immediately upon actuation of the apparatus for the generation and application of X-rays during an exposure interval.

In order to provide for the conditioning of controlled apparatus during a preliminary or warmup interval in advance of actuation of the apparatus for the performance of its functions during a precisely delimited operating interval, the system of the present invention comprises an electronic timer embodying a pair of timing sections **11** and **13**, the section **11** being adapted to control a predetermined time delay interval within which the controlled apparatus may be conditioned for operation, as by bringing the anode driving motor of a rotary anode X-ray generating tube up to optimum operating speed and by exciting the electron emitting cathode element of the tube to a desired or optimum electron emission level. The other section **13** of the timer is operable to delimit the operation of the controlled apparatus within a precisely measured time interval following the termination of the conditioning interval controlled by the section **11**, the operating interval controlled by the section **13** being variably adjustable.

As shown, the timing section **11** may comprise an electron flow valve **15** having an anode **17**, a cathode **19**, a cathode energizing filament **21**, a control grid **23** and a screen grid **25** connected with the cathode **19**. The anode **17** is connected with a conductor L–1 forming one side of a preferably 110 volt alternating current power supply line, through the operating coil RC–1 of a relay having a normally closed switch RS–1*a* and a pair of normally open switches RS–1*b* and RS–1*c*, the opposite side of said alternating current supply line comprising a conductor L–2 connected, as through a manually operable control switch CS–1, with the cathode **19** and screen grid **25** of the valve **15**, said interconnected cathode and screen grid being also electrically connected with the conductor L–1 through a suitable resistor **27**. The control grid **23** of the valve **15** may be electrically connected through a resistor **29** with one side of a timing network **31** comprising resistors **33** and **35** and a condenser **37** interconnected in relatively parallel relationship between the resistor **29** and the conductor L–2, a switch **39** being provided to interconnect the resistors **33** and **35** alternately with the conductor L–2.

The timing section **13** may comprise an electron flow valve **45** having an anode **47**, a cathode **49**, a cathode energizing filament **51**, a control grid **53** and a screen grid **55** connected with the cathode **49** and with the conductor L–2, the anode **47** of the valve being electrically connected with the conductor L–1 through the operating coil RC–2 of a relay having a normally closed switch RS–2. The control grid **53** of the valve **45** may be electrically connected through a resistor **57** with one side of a timing network **61** comprising a resistor **63**, a variable resistance **65** and a condenser **67**, the condenser being interconnected between the resistor **57** and the conductor L–2. The resistor **63** and variable resistance **65** are interconnected in series with the normally open switch RS–1*c* between the resistor **57** and the conductor L–2, whereby said resistor and resistance will be connected in parallel relationship with respect to the condenser **67** whenever and so long as the normally open switch *c* is closed. The network **61** also includes resistors **69** and **70**, a potentiometer **71**, a condenser **73** and a rectifier **74** interconnected between the conductors L–1 and L–2 and with the resistor **57** through the normally closed relay switch RS–1*a*. The resistor **69**, the rectifier **74**, the resistor **70** and the resistance element of the potentiometer may be connected in series between the conductors L–1 and L–2, the condenser **73** being interconnected in parallel with the resistor **70** and potentiometer element between the conductor L–2 and the rectifier **74**, the adjustable element of the potentiometer being electrically connected with the resistor **57** through the normally closed switch RS–1*a*.

The timing system is adapted to perform its function by controlling the supply of actuating energy to a load device or devices, such as the operating coils C–1 and

C–2 of relay switches S–1 and S–2 of any suitable or preferred character. Where the system is applied for the control of an X-ray generating tube for therapeutic or picturing purposes, the relay switch S–1 may be interconnected to control the application of operating power between the anode and cathode of the controlled tube. The switch S–1, accordingly, may serve to control the exposure interval during which X-rays are applied to a patient or other object being exposed to X-rays for therapeutic or picturing purposes. The switch S–2, where provided, may be operable under the control of a disconnecting switch 75 for controlling the operation of auxiliary equipment, such as Bucky Diaphragm equipment, which it may be desired to operate during an exposure interval when applying X-rays for picturing purposes. To this end, the coil C–1 may be interconnected between the conductors L–1 and L–2 in series with the normally open switch RS–1*b* and the normally closed switch RS–2, while the coil C–2 may be interconnected between the conductors L–1 and L–2 in series with the disconnecting switch 75 and the normally open switch RS–1*b*. The coil C–1 and normally closed switch RS–2 are thus in parallel relationship with respect to the coil C–2 and the disconnecting switch 75.

The system may also include a relay device for controlling the supply of energizing power for conditioning the controlled device for operation, such relay device, in the illustrated embodiment, embodying an operating coil C–3 and one or more switches S–3*a* and S–3*b*, the coil C–3 being electrically connected between the conductors L–1 and L–2 in series with a manually operable switch CS–2, which is preferably mechanically connected with the switch CS–1 for operation in unison therewith. The relay switches S–3*a* and S–3*b* may, respectively, be electrically connected to control the supply of energizing power to the cathode and to the anode driving motor of the controlled X-ray generating tube.

The line L–2 may form one side of a preferably 12.5 volt alternating current power supply line for energizing the cathode elements 21 and 51 of the valves 15 and 45, said filaments being electrically connected, preferably in series, between the conductor L–2 and a conductor L–3, forming the opposite side of the power supply line.

So long as switch CS–1 remains open, operating voltage will be applied to the valve 15, which, however, will be prevented from firing by virtue of the connection of line conductor L–1 to the cathode 19 and screen grid 25 through resistor 27. During positive half cycles of energy supplied from the alternating current power source, the cathode and grid of the valve 15 cause it to function as a half wave rectifier, permitting current to flow from conductor L–1, comprising the high voltage side of the supply line, through resistor 27, and from the cathode to the grid of the valve thence through the resistor 29 and the timing network 31 to the conductor L–2, comprising the low or zero voltage side of the line. It will be noted that the resistors 33 and 35 may be connected alternately in the circuit 31 in order to vary the desired preliminary time delay interval. The flow of current allows the condenser 37 to become charged at a relatively high negative voltage value, and the circuit will remain in such condition until closure of the switch CS–1. Upon closure of the switches CS–1 and CS–2, energy for conditioning the controlled device will be applied thereto through the operation of relay switches S–3*a* and S–3*b*. Simultaneously, through closure of the switch CS–1 the potential of the cathode 19 is reduced to that of the low voltage or zero side L–2 of the line. The valve 15, however, cannot immediately fire because of the high negative voltage maintained on its grid 23 by virtue of the charged condition of the condenser 37. Closure of switch CS–1, however, results in discontinuation of any rectifying action between the cathode and grid of the valve, the cathode then being held at zero potential. The negative bias on the grid of the valve, however, will diminish exponentially as determined by the time constant of the network 31, until the grid voltage at which the valve may fire is reached, at which time the valve will become conductive and operable to energize the relay coil RC–1, thereby opening switch RS–1*a* and closing switches RS–1*b* and RS–1*c*. The coil RC–1 will, of course, remain energized after the valve 15 has become conductive for so long as the switch CS–1 remains closed.

When the valve 15 thus becomes conductive, the apparatus conditioning or warmup period will be concluded as the result of the closure of relay switch RS–1*b*, which initiates the time exposure interval. To this end, closure of switch RS–1*b* will energize the relay coil C–1 through the normally closed relay switch RS–2, thereby applying operating energy to the controlled apparatus, closure of switch BS–1b also energizing the relay coil C–2 in the event that the disconnecting switch 75 be in closed condition.

So long as relay switch RS–1*a* remains closed, valve 45 will be prevented from firing because of the negative bias produced by operation of the network comprising resistors 69 and 70, potentiometer 71, condenser 73 and rectifier 74. When a negative impulse is applied between the conductors L–1 and L–2, current will flow from the low or zero side of the line, comprising the conductor L–2, to the conductor L–1, comprising the high side of the line, the rectifier preventing current flow during half cycles of opposite polarity. The condenser 73 serves as a filter for maintaining a constant negative potential across the resistor 70 and potentiometer 71. Adjustment of the potentiometer permits a variable bias to be applied upon the grid of the valve 45. The resistor 70 functions as a part of the voltage dividing network in order to obtain a desired bias. The resistor 69 serves to limit current flow through the rectifier when the condenser 73 is discharging. The bias voltage from the potentiometer 71 is delivered to the grid of the valve 45 so long as the switch RS–1*a* remains closed. When said switch opens, however, as a result of the firing of the valve 15, the bias applying network is disconnected from the control grid 53, which thereafter is connected with the timing circuit comprising the resistors 63 and 65, in parallel relationship with respect to the condenser 67. Accordingly, the negative bias on the grid 53 will diminish exponentially until the critical voltage is reached at which the valve 45 is permitted to fire, thereby energizing the relay coil RC–2 and causing the switch RS–2 to open to thereby de-energize the coil C–1 in order to discontinue operation of the controlled apparatus and thus end the operating interval.

The function and purpose of the resistors 29 and 57 are to limit the grid current on the valves 15 and 45 to safe values. The cathode energizing elements 21 and 51 are connected in series in order to afford a fail-safe feature in the event that one of the filaments should burn out. If the bias supply to valve 15 should fail, the coil C–1 would be energized during an interval determined by the adjustment of the potentiometer 71. If the bias supply of valve 45 should fail, the relay coil RC–2 would be energized, thereby opening the switch RS–2 and preventing the coil C–1 from being energized. If the bias supply of both valves 15 and 45 should fail, the coils RC–1 and RC–2 would both be energized, but the coil C–1 would not because the switch RS–2, in such event, would be open.

It will be seen from the foregoing that the control system of the present invention provides an interval timer adapted to energize the load device C–1 during a variably adjustable time interval, determined by adjusting the resistance 65, following a time delay of predetermined extent following the actuation of the control switches CS–1 and CS–2, the same being especially well adapted for

use in connection with controlling the operation of X-ray generating tubes and associated apparatus.

An important aspect of the invention resides in the operation of the preliminary or advance timing section 11 which functions to cause termination of its time delay interval always at the same place in the cycle of energizing power delivered in the supply line L–1 and L–2. As a consequence, the main control switch RS–1 is always actuated at the same instant during the energy cycle of power supplied through the conductors L–1 and L–2. This allows for the suppression of inrush current and energy surges in a high tension transformer of the sort which may be connected in the power supply line controlled by the relay switch S–1, which high tension transformer may serve to supply operating energy to an associated X-ray generating tube. Such operation of the timing device leaves said high tension transformer always in the same magnetic condition, which is an important consideration where high tension transformers are switched.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, constructon, and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. The combination, with an X-ray generating tube, of actuating switch means for controlling the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube to condition the same for operation, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence and comprising means forming leading and trailing timer stages, control means operatively associated with the leading stage for starting the same in the performance of its timing cycle and for simultaneously actuating the conditioning switch means to supply energy to the tube to condition the same for operation, said leading stage embodying a control device operable, at the conclusion of an elapsed time interval of selected duration following operation of said control means and determined by performance of the timing cycle of said leading stage, to initiate the trailing stage in the performance of its timing cycle, and means operable with said control device to activate said operating switch means to supply actuating power to said tube, said trailing stage embodying means operable to deactivate said operating switch means and thereby cut off the supply of actuating power to said tube at the conclusion of an elapsed time interval determined by the performance of the operating cycle of said trailing stage.

2. The combination, with an X-ray generating tube, of actuating switch means for controlling the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube to condition the same for operation, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence and comprising means forming leading and trailing timer stages, said leading stage embodying an electron flow valve having a control grid and a timing circuit including a condenser connected with the grid, means normally operable to charge said condenser to a level at which it will hold the valve inactive, control means operatively associated with the leading stage for starting the same in the performance of its timing cycle, by causing discharge of the condenser, at the rate determined by the timing circuit, and for simultaneously actuating the conditioning switch means to supply energy to the tube to condition the same for operation, said leading stage embodying a control device operable, at the conclusion of an elapsed time interval of selected duration following operation of said control means and determined by performance of the timing cycle of said leading stage, to initiate the trailing stage in the performance of its timing cycle, and means operable with said control device to activate said operating switch means to supply actuating power to said tube, said trailing stage embodying means operable to deactivate said operating switch means and thereby cut off the supply of actuating power to said tube at the conclusion of an elapsed time interval determined by the performance of the operating cycle of said trailing stage.

3. The combination, with an X-ray generating tube, of actuating switch means for controlling the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube to condition the same for operation, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence and comprising means forming leading and trailing timer stages, said trailing stage embodying an electron flow valve having a control grid and a timing circuit including a condenser connected with the grid, means normally operable to charge said condenser to a level at which it will hold the valve inactive, control means operatively associated with the leading stage for starting the same in the performance of its timing cycle and for simultaneously actuating the conditioning switch means to supply energy to the tube to condition the same for operation, said leading stage embodying a control device operable, at the conclusion of an elapsed time interval of selected duration following operation of said control means and determined by performance of the timing cycle of said leading stage, to initiate the trailing stage in the performance of its timing cycle, by causing discharge of the condenser, at the rate determined by the timing circuit, and means operable with said control device to activate said operating switch means to supply actuating power to said tube, said trailing stage embodying means operable to deactivate said operating switch means and thereby cut off the supply of actuating power to said tube at the conclusion of an elapsed time interval determined by the performance of the operating cycle of said trailing stage.

4. The combination, with an X-ray generating tube, of actuating switch means for controlling the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube to condition the same for operation, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence and comprising means forming leading and trailing timer stages, each of said stages embodying a corresponding electron flow valve having a control grid and a timing circuit including a condenser connected with said grid, and means normally operable to charge said condensers to levels at which each will hold its associated valve inactive, control means operatively associated with the leading stage for starting the same in the performance of its timing cycle, by causing discharge of the condenser of said leading stage, at the rate determined by its associated timing circuit, and for simultaneously actuating the conditioning switch means to supply energy to the tube to condition the same for operation, said leading stage embodying a control device operable, at the conclusion of an elapsed time interval of selected duration following operation of said control means and determined by performance of the timing cycle of said leading stage, to initiate the trailing stage in the performance of its timing cycle, by causing discharge of the condenser of said trailing stage, at the rate determined by its associated timing circuits, and means operable with said control device to activate said operating switch means to supply actuating power to said tube, said trailing stage embodying means operable to deactivate said operating switch means and thereby cut off the supply of actuating power to said tube at the conclusion of an elapsed time interval determined by the performance of the operating cycle of said trailing stage.

5. The combination, with an X-ray generating tube, of actuating switch means for controlling the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube to condition the same for operation, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence and comprising means forming leading and trailing timer stages, said leading stage embodying an electron flow valve having a control grid and a screen grid, a timing circuit including a condenser connected with said control grid, means normally applying alternating electrical potential on said screen grid and cathode to hold the valve inactive and to cause same to charge said condenser, control means operatively associated with the leading stage for starting the same in the performance of its timing cycle, by reducing the potential on the control grid, to thereby condition the valve for operation, and by initiating the discharge of the condenser, at a rate determined by the timing circuit, and for simultaneously actuating the conditioning switch means to supply energy to the tube to condition the same for operation, said leading stage embodying a control device operable, at the conclusion of an elapsed time interval of selected duration following operation of said control means and determined by performance of the timing cycle of said leading stage, to initiate the trailing stage in the performance of its timing cycle, and means operable with said control device to activate said operating switch means to supply actuating power to said tube, said trailing stage embodying means operable to deactivate said operating switch means and thereby cut off the supply of actuating power to said tube at the conclusion of an elapsed time interval determined by the performance of the operating cycle of said trailing stage.

6. The combination, with an X-ray generating tube, of actuating switch means for controlling the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube to condition the same for operation, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence and comprising means forming leading and trailing timer stages, said trailing stage embodying an electron flow valve having a control grid, a timing circuit including a condenser connected with said control grid, means normally operable to connect a source of electrical potential as a bias on said control grid at a potential level sufficient to hold the valve inactive and simultaneously to charge said condenser at said level, control means operatively associated with the leading stage for starting the same in the performance of its timing cycle and for simultaneously actuating the conditioning switch means to supply energy to the tube to condition the same for operation, said leading stage embodying a control device operable, at the conclusion of an elapsed time interval of selected duration following operation of said control means and determined by performance of the timing cycle of said leading stage, to initiate the trailing stage in the performance of its timing cycle, by disconnecting said source from said grid to thereby condition the valve for operation, and simultaneously to initiate the discharge of said condenser, at a rate determined by the timing circuit, and means operable with said control device to activate said operating switch means to supply actuating power to said tube, said trailing stage embodying means operable to deactivate said operating switch means and thereby cut off the supply of actuating power to said tube at the conclusion of an elapsed time interval determined by the performance of the operating cycle of said trailing stage.

7. The combination, with an X-ray generating tube requiring preliminary warm-up conditioning prior to starting the same in operation, of actuating switch means operable to control the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube for preliminary warm-up purposes, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence, said timing apparatus comprising means forming preliminary and main timing stages, control means operatively associated with the preliminary timing stage for starting the same in the performance of its timing cycle and for simultaneously actuating said conditioning switch means to supply energy to condition the tube for operation, said preliminary timing stage embodying a control device operable, at the conclusion of a preliminary conditioning interval of selected duration, as determined by the performance of the timing cycle of said preliminary timing stage, to initiate the main timing stage in the performance of its timing cycle, and means operable with said control device to operate said actuating switch means to energize the tube for operation, said main timing stage embodying means operable to disable said actuating switch means to thereby stop operation of said tube at the conclusion of an elapsed time interval of duration determined by the performance of the operating cycle of said main stage.

8. The combination, with an X-ray generating tube requiring preliminary warm-up conditioning prior to starting the same in operation, of actuating switch means operable to control the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube for preliminary warm-up purposes, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence, said timing apparatus comprising means forming preliminary and main timing stages, said preliminary stage embodying an electron flow valve having a control grid and a screen grid, a timing circuit including a condenser connected with said control grid, means normally applying alternating electrical potential on said screen grid to hold the valve inactive and to charge the condenser, and a control switch operatively associated with the preliminary timing stage for starting the same in the performance of its timing cycle, by reducing the potential on the screen grid, to thereby condition the valve for operation, and by initiating the discharge of the condenser, at a rate determined by the timing circuit, conditioning switch means being operable with said control switch to supply energy to the tube to condition it for operation, said preliminary timing stage embodying a control device operable at the conclusion of a preliminary conditioning interval, as determined by the performance of the timing cycle of said preliminary timing stage, to initiate the main timing stage in the performance of its timing cycle, said actuating switch means being operable with said control device to start the tube in operation, said main timing stage embodying means operable to disable said actuating switch means to thus discontinue the supply of operating power to said tube at the conclusion of an elapsed time interval of duration determined by the performance of the operating cycle of said main stage.

9. The combination, with an X-ray generating tube requiring preliminary warm-up conditioning prior to starting the same in operation, of actuating switch means operable to control the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube for preliminary warm-up purposes, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence, said timing apparatus comprising means forming preliminary and main timing stages, said main timing stage embodying an electron flow valve having a control grid, a timing circuit including a condenser connected with said control grid, means normally operable to connect a source of electrical potential as a bias on said control grid at a potential level sufficient to hold the valve inactive and to charge the condenser at said level, and control means operatively

associated with the preliminary timing stage for starting the same in the performance of its timing cycle and for simultaneously actuating said conditioning switch means to energize the tube to condition it for operation, said preliminary timing stage embodying a control device operable at the conclusion of a preliminary conditioning interval, as determined by the performance of the timing cycle of said preliminary timing stage, to disconnect said source from said grid to thereby condition the valve for operation, and simultaneously to initiate the discharge of said condenser, at a rate determined by the timing circuit, to thereby start the main timing stage in the performance of its timing cycle, said actuating switch means being operable with said control device to start the tube in operation, said main timing stage embodying means operable to disable said actuating switch means to discontinue the supply of operating power to said tube at the conclusion of an elapsed time interval of duration determined by the performance of the operating cycle of said main stage.

10. The combination, with an X-ray generating tube requiring preliminary warm-up conditioning prior to starting the same in operation, of actuating switch means operable to control the supply of actuating power to said tube, conditioning switch means for controlling the supply of energy to said tube for preliminary warm-up purposes, and timing apparatus controllingly connected with said conditioning and actuating switch means to operate the same in timed sequence, said timing apparatus comprising means forming a preliminary timing stage embodying an electron flow device having a control grid and a screen grid, a timing circuit including a circuit condenser connected with said control grid, means normally applying electrical potential on said screen grid and cathode to hold the device inactive and to charge the condenser, a main timing stage embodying an electron flow valve having a control element, a timing network including a network condenser connected with said control element, means normally operable to connect an electrical potential source as a bias on said control element at a potential level sufficient to hold the valve inactive and to charge the network condenser at said level, control switch means for starting the preliminary timing stage in the performance of its timing cycle, by reducing the potential on the control grid, to thereby condition the electron flow device for operation, and by initiating the discharge of the circuit condenser, at a rate determined by the timing circuit, and for operating said conditioning switch means to supply energy to the tube to thereby condition the same for operation, said preliminary timing stage embodying a relay switch operable at the conclusion of a conditioning interval, as determined by said preliminary timing stage, to disconnect said potential source from said control element to thereby condition the valve for operation and simultaneously to initiate the discharge of said network condenser, at a rate determined by the timing network, to thus start the main timing stage in operation, said actuating switch means being operable with said relay switch to start the controlled apparatus in operation, and means operable to disable said actuating switch means to thereby discontinue the supply of operating power to said tube at the conclusion of an elapsed time interval of duration determined by said main stage.

11. The combination, with an X-ray generating tube having an electron emitting cathode, a rotary anode and a motor for driving the same, of actuating switch means operable to control the supply of tube actuating power between said anode and cathode, conditioning switch means for controlling the supply of driving energy to said motor and exciting energy to said cathode, and timing apparatus for controlling the operation of said conditioning and actuating switch means, said timing apparatus comprising leading and trailing timer stages each embodying an electron flow valve having a control and screen grids, a timing circuit including a condenser connected with its control grid, means normally applying alternating electrical potential on the screen grid and cathode of the valve of the leading stage to hold the valve inactive and to charge the connected condenser, means normally operable to bias the control grid of the valve of the trailing stage at a potential to hold the same inactive and to charge the connected condenser, control means operatively associated with the valve of the leading stage for reducing potential on its control grid and for initiating discharge of the connected condenser, at a rate determined by its associated timing circuit, and for simultaneously actuating the conditioning switch means to energize the cathode and the anode motor, a control device operatively connected with said leading stage and actuated thereby, at the conclusion of an elapsed time interval of selected duration, to initiate discharge of the condenser of the trailing stage, at a rate determined by its associated timing circuit, and to start the trailing stage in its timing cycle, and means operable with said control device to activate said operating switch means to energize said tube for operation, said trailing stage embodying means operable to deactivate said operating switch means at the conclusion of an elapsed time interval determined by the timing circuit of the trailing stage.

12. The combination, with an X-ray generating tube having a cathode excitable for electron emission, a rotary anode and a motor for turning the same, of actuating switch means operable to control the supply of actuating power between said anode and cathode, conditioning switch means for controlling the supply of energizing power to said motor and cathode, and timing apparatus connected with said conditioning and actuating switch means to operate the same in timed sequence, said timing apparatus comprising a preliminary timing stage embodying an electron flow device having control and screen grids, a timing circuit including a condenser connected with said control grid, means for normally applying electrical potential on said screen grid to hold the device inactive and to charge the condenser, a main timing stage embodying an electron flow valve having a control element, a timing network including a network condenser connected with said control element, means normally applying a potential bias on said control element to hold the valve inactive and to charge the network condenser, control switch means operable to start the preliminary timing stage in operation by reducing potential on the screen grid and by initiating the charge of the circuit condenser, said control switch means being simultaneously operable to actuate said conditioning switch means to energize the cathode and the anode motor, a relay operable by said electron flow device at the conclusion of the conditioning interval determined by said preliminary timing stage, to remove the potential bias from said control element and simultaneously initiate the discharge of the network condenser to thus start the main timing stage in operation, said actuating switch means being operable with said relay to start the X-ray tube in operation, and relay means operable by said flow valve to stop tube operation at the conclusion of an elapsed time interval of duration determined by said timing network.

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