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X-RAY EXPOSURE TIMER

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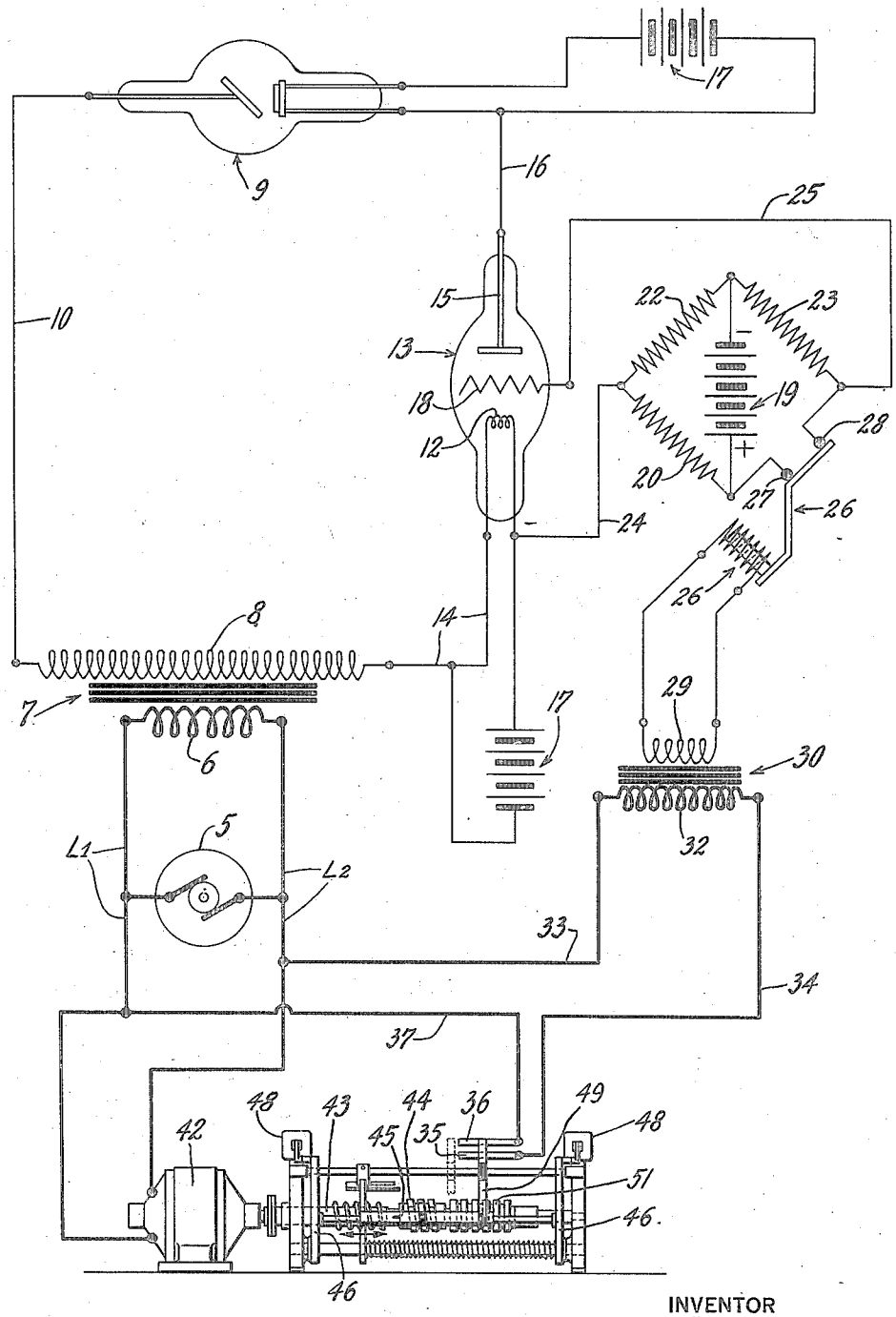

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X-RAY EXPOSURE TIMER

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4 Claims. (Cl. 250—34)

My invention relates to timing devices adaptable to a variety of usages in the electrical arts and has particular relation to such devices employed for the taking of X-ray photographs. Such devices are well known to the prior art and particularly as applied to the taking of X-ray photographs. The Roentgenologist in radiographing various portions of the human anatomy permits the X-ray tube to become energized for various periods of time, depending upon the particular organ or portion of the anatomy to be radiographed. The reasons for requiring energization of the X-ray tube for various periods of time is due to the necessity for X-rays of longer duration and greater penetrative power upon some occasions than that required upon other occasions.

It naturally follows that in taking radiographic pictures of the various portions of the body and also of individuals, depending on the particular case, it is necessary to take exposures of varying time periods due to the difference in thickness of the flesh and tissues. The operator, therefore, determines beforehand the time period for which it is desired to energize the X-ray tube, which is usually accomplished by means of a mechanical timing device, the operation of which automatically follows manual actuation by the operator. Such devices, however, are usually subjected to considerably heavy loads, causing sparking of the terminals of the timing device in making and breaking the circuit, with resulting pitting of these contacts, necessitating frequent renewal of these contact terminals. Moreover, these timing devices are very noisy in their operation and disconcerting to both operator and patient during a radiographic exposure.

Heretofore these devices have usually been connected in the circuit with the primary winding of the high tension transformer, with the opening and closing of this circuit naturally controlling the secondary winding and energization of the X-ray tube. The placing of a timing device at this point in the X-ray system has a further disadvantage in that due to inherent losses within the high tension transformer the timing device, although set for predetermined periods of time, as a matter of fact does not control the energization of the X-ray tube with minute precision, but results in a variance in the time period of energization of the X-ray tube and that of the timing device. This results in the radiographic exposure being of a greater or lesser period of time than that for which the timing device had been preset.

Moreover, in an endeavor to reduce sparking of the contact terminals the timing device operates to close the circuit to the primary winding of the high tension transformer at the zero point of the alternating current wave. Under normal operating conditions with the average commercial potential some degree of success in the reduction of sparking of the contact terminals is obtainable provided the exposure desired is of a duration of 1/120 of a second or greater. However, X-ray exposures of a shorter duration than 1/120 of a second have heretofore been unobtainable due to the limitations of the timing apparatus itself and the alternating current which limits the opening and closing of the circuit at the zero point of the wave to a minimum of 1/120 of a second. This limitation accordingly limits an X-ray exposure to a minimum period of time of 1/120 of a second unless the circuit is opened or closed under load with sparking of the contact terminals.

It is accordingly an object of my invention to provide a timing device for electrical systems which is operable to open and close the circuit at any point on the alternating current wave with an entire absence of sparking.

Another object of my invention is the provision of a timing device for electrical circuits which is operable to energize the circuit for periods of time of less than 1/120 of a second with minute precision and an entire absence of sparking.

Another object of my invention is to provide a timing device which controls the energization of the X-ray tube by being connected directly in the circuit with the latter and therefore subjected to the operating potentials of the X-ray tube.

Another object of my invention is the provision of a timing device which is operable with minute precision and in which the sparking of the contact terminals is entirely obviated.

Another object of my invention is the provision of a timing device directly associated with the high tension circuit and the X-ray tube which is instantaneously operable for various periods of time in response to presetting by the operator.

Still another object of my invention is the provision of a timing device directly associated with the X-ray tube which is operable for energizing the X-ray tube for various predetermined periods of time and in which there is substantially an entire absence of losses in time between the operation of the timing device and energization of the X-ray tube.

Further objects of my invention will become apparent to those skilled in the art by reference

to the accompanying drawing wherein the single figure is a diagrammatical representation of an X-ray system utilizing my novel timing device.

Referring now to the drawing in detail I have shown a suitable source of alternating current of commercial potential, such as a generator 5, which is adapted to supply electrical energy to the primary winding 6 of a high tension transformer 7, by means of conductors L1 and L2. The secondary winding 8 of the high tension transformer 7 has one end connected to a suitable load, such as the anode terminal of an X-ray tube 9, by means of a conductor 10. The other end of the secondary winding 8 is connected to the thermionic cathode 12 of a discharge device 13 by means of a conductor 14. The anode terminal 15 of this discharge device is connected to the cathode terminal of the X-ray tube 9 by means of a conductor 16. The thermionic cathodes of the X-ray tube 9 and the discharge device 13 receive heating currents from a suitable source of low tension energy, such as a low tension transformer or batteries 17.

It can thus be readily appreciated that the secondary winding 8, X-ray tube 9 and discharge device 13 are connected in series with each other and that electrical energy in flowing from the secondary winding 8 to the X-ray tube 9 must of necessity flow between the cathode and anode 12 and 15, respectively, of the discharge device 13.

In order to control the flow of energy through the discharge device 13 I have provided a control electrode 18 interposed between the anode 15 and the cathode 12, and a negative potential is impressed from an auxiliary source upon the same to prevent the energization of the X-ray tube 9. When it is desired to energize the X-ray tube or load 9 the potential of this auxiliary source is instantaneously reversed from negative to positive for the predetermined periods of time required under the circumstances. This auxiliary source of potential for controlling the control electrode consists of a source of constant potential of relatively low voltage in comparison with the operating voltages of the X-ray tube, such as a transformer or batteries 19.

The positive terminal of the source of supply 19 is connected to one end of a resistance element 20 and the negative end of this source is connected to the intermediate point between a pair of similar resistance elements 22 and 23. These respective resistance elements 20, 22 and 23 are connected in substantially the form of a Wheatstone bridge and are preferably of equal ohmic resistance. A conductor 24 connects one end of the respective resistance elements 20 and 22 to the cathode terminal 12 of the discharge device 13. A conductor 25 connects one end of the resistance element 23 to the control electrode 18 of the descharge device 13. One end of the resistance element 23 is connected to one end of the resistance element 20 and the positive terminal of the source of potential 19, by means of a relay or solenoid 26, which establishes contact between a pair of contact terminals 27 and 28 connected to the respective elements 20 and 23.

The magnetic winding of the relay 26 receives electrical energy from the secondary winding 29 of an insulating transformer 30. The primary winding 32 of this insulating transformer has one of its ends connected by means of a conductor 33 to the supply conductor L2 extending from the source of alternating commercial potential 5. The opposite end of the primary winding 32 is connected by means of a conductor 34 to a contact terminal 35 and an adjacent contact terminal 36 is connected by means of a conductor 37 to the opposite supply conductor L1.

Connection of the contact terminals 35 and 36 and consequently energization of the primary winding 32 of the insulating transformer 30 is established by means of a timing device, the details of which are shown and described in the copending application of Arthur Mutscheller, Serial No. 473,221 filed August 5, 1930.

Briefly stated this timing device comprises a synchronous motor 42 which is energized by having its terminals connected to the supply conductors L1 and L2. This motor in turn is arranged to drive a worm shaft 43 which has an insulated drum 44 fixed thereto provided with contact segments of varying peripheral lengths. A movable member 45 is carried by a square shaft disposed adjacent the worm shaft and in turn is supported by a pair of rocking brackets 46. The movable member 45 is caused to engage the worm shaft 43 by energization of a pair of solenoids 48 which receive energy from a suitable source, not shown, and are operated through a manual switch by the operator.

In the aforementioned copending application one of the supply conductors utilized for energizing the load, such as the primary winding 32, is connected to the movable member 45 which establishes contact with the peripheral contact segments of the drum 44. These latter contacts are suitably connected to contact rings 51 also carried by the worm shaft and suitable brushes, such as shown at 49, complete establishment of the circuit to the load for the desired period of time. However, as this particular apparatus per se forms no part of my present invention and for the sake of simplicity I have shown the brush contact member 49 alone as performing the operation of automatically completing the circuit to the load in response to operation of the mechanism. For all intents and purposes, therefore, closure of the contact terminals 35 and 36 is established by the brush 49 for the periods of time for which the mechanism is preset by the operator.

Accordingly the primary winding 32 of the insulating transformer 30 will be energized for corresponding periods of time as that selected by the operator with attendant operation of the timing device. Energization, therefore, of the relay 26 follows energization of the transformer 30 for the same predetermined periods of time with closure of the contact terminals 27 and 28.

Although I have shown a timing device similar to that shown and claimed in the copending application above mentioned, any suitable timing device well known to the art may just as readily be utilized in place thereof, which accomplishes the same purpose.

The operation of my timing device is as follows: With the primary winding 6 of the high tension transformer 7 receiving energy from the source 5 the secondary winding 8 thereof will likewise be energized. The thermionic catchodes of the X-ray tube and discharge device 13 receive heating current from the respective low tension sources 17, and in the normal operation of the auxiliary source 19 the control electrode 18 is supplied with a negative potential and the relay 26 is in the open position, i. e., contacts 27 and 28 are not bridged by the latter.

Although the secondary winding 8, discharge

device 13 and the X-ray tube 9 are connected in series with each other energization of the X-ray tube 9 is prevented by the negative potential from the auxiliary source.

The ohmic resistance of the respective elements 20 and 22 being equal, with the auxiliary source of potential 19 connected to the opposite end of each of these respective elements, the mid point between these elements to which the cathode 12 is connected, by means of the conductor 24, is at zero potential relative to the auxiliary source 19.

On the other hand the resistance element 23 has one end connected to the negative terminal of the auxiliary source and its opposite end connected by means of conductor 25 to the control electrode 18 and the contact terminals 27 and 28 are at this time not closed by the relay 26. Accordingly there is no voltage drop caused by the ohmic resistance of the element 23 and a negative potential will thus be supplied to the control electrode 18 relative to that supplied through the conductor 24 to the cathode, which as before stated, is zero or positive relative to the control electrode.

This negative potential is of sufficient magnitude to absolutely prevent the flow of electrons from the cathode 12 to the anode 15 of the discharge device 13 regardless of the potential output of the secondary winding 8 and energization of the X-ray tube 9 is therefore prevented.

Assuming now the operator desires to energize the X-ray tube 9 for a predetermined period of time the timing mechanism is set corresponding to this desired period of energization. The operation therefor of the timing device causes closure of the contact terminals 35 and 36 and energization of the insulating transformer 30. Energization of the relay 26 follows energization of the transformer 30 with attendant closure of the contact terminals 27 and 28. This immediately reverses the polarity of the potential impressed by the auxiliary source 19 upon the control electrode 18 without opening the circuit from the auxiliary source to the control electrode which is essential, as hereinafter more fully set forth.

Upon closure of the contact terminals 27 and 28 by the relay 26 the positive terminal of the source 19 is thus directly connected through the conductor 25 to the control electrode 18 and a positive potential is thus impressed thereupon. High potential energy will therefore flow between the cathode 12 and anode 15 of the discharge device 13 enabling the X-ray tube 9 to receive energy from the secondary winding 8 for the desired period of time as controlled by the polarity of the potential impressed upon the control electrode 18.

At this time energy also flows through the series connected resistance elements 20 and 22 in the same manner as previously described when a negative potential was applied to the control electrode 18. However, now that the control electrode 18 is positive relative to the cathode 12 a current will flow between the cathode 12 and control electrode 18. This circuit is equivalent to connecting an ohmic resistance in parallel with the resistance element 20 which operates to lessen the ohmic resistance of the latter and render the same no longer equal to the ohmic resistance of the element 22.

This, therefore, causes a greater voltage drop across the element 23 than across the element 20 resulting in a lesser value in the positive potential impressed upon the control element 18 than when a negative potential was previously impressed thereon. This positive potential now impressed upon the control element need not be of as high a value as the negative value required to prevent the flow of energy from the secondary winding 8 to the X-ray tube 9. The potential at the intermediate point of the resistance elements 20 and 22, to which the cathode 12 is connected, is now no longer zero relative to the auxiliary source 19 and the control electrode 18, but is carrying a potential. This potential, therefore, is impressed upon the cathode 12 but not being as high as that impressed upon the control electrode 18 enables a current to flow through the cathode control element circuit comprising the resistance element 20.

A high potential energy therefore instantaneously flows between the cathode 12 and anode 15 without any variation or gradual rise simultaneously with the reversal of the potential impressed upon the control electrode from negative to positive.

Upon completion of the operation of the timing device connected in series with the primary winding 32 of the insulating transformer 30, for the time period at which the same has been set, the relay 26 becomes de-energized and opens the contact terminals 27 and 28 restoring the auxiliary source to its normal state, namely that of impressing a negative potential upon the control electrode 18 as hereinbefore stated.

It can thus be readily appreciated that energization of the relay 26 instantaneously follows operation of the timing mechanism and that closure of the relay causes instantaneous reversal of the polarity of the potential impressed upon the control electrode with attendant energization of the X-ray tube for a like period of time. I find it necessary to reverse the polarity of the potential impressed upon the control electrode without opening the circuit of the auxiliary source. If this is not accomplished, but the polarity first reduced to zero before reversal of the same, flow of the high tension energy between the cathode and anode of the discharge device 13 will rapidly build a charge upon the control electrode corresponding to the polarity of that previously impressed which will again cause blocking of the flow between the cathode and anode.

In other words with the negative potential supplied to the control electrode and the flow of energy between the cathode and the anode prevented, reduction of the potential of the control electrode to zero would allow the flow of energy from the cathode to the anode. The electrons, however, would in an infinitely short period of time cause a negative charge to accumulate upon the control electrode which would, as before stated, reach a sufficient magnitude to again prevent the flow. It would also naturally follow that instantaneous control or the degree of precision obtainable, as hereinbefore outlined, would be impossible.

In a like manner after the control electrode has been made positive and the X-ray tube energized for the desired period of time, the control electrode is again supplied with a negative potential which instantaneously causes the de-energization of the X-ray tube without opening of the circuit from the auxiliary source to the control electrode.

It can thus be readily seen to those skilled in the art that I have provided a timing device which is operable with minute precision for predetermined periods of time in response to the actuation of mechanism by the operator. Further-

more, there is an entire absence of time lag due to inherent losses in the various electrical elements of the circuit, and as the only contact terminals employed in my timing device are not subjected to heavy currents there is an entire absence of sparking with deleterious results to the same.

Although I have shown and described one specific embodiment of my invention I do not desire to be limited thereto as various other modifications of the same may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In an X-ray system, the combination with an X-ray tube and a source of high potential alternating current electrical energy therefor, of a timing device connected to said high tension source and to said X-ray tube comprising a thermionic discharge device provided with an anode, a cathode, and a control electrode interposed between said anode and cathode normally operative to positively prevent the flow of energy therebetween and consequently from said high potential source to said X-ray tube, an auxiliary source of electrical energy normally operative to impress a negative potential upon said control electrode of a value sufficient to render the latter operative to prevent the flow of energy, and means electrically associated with said auxiliary source and automatically operable for various predetermined periods of time to cause said auxiliary source to impress a positive potential upon said control electrode without disconnection of said auxiliary source from said control electrode and cause the same to assist the flow of energy from said high potential source to said X-ray tube for periods of time corresponding to the operation of said automatic means.

2. In an X-ray system, the combination with an X-ray tube and a source of high potential electrical energy therefor, of a timing device connected to said high tension source and to said X-ray tube for enabling the latter to be energized by said source for various preselected periods of time comprising a thermionic discharge device provided with an anode, a thermionic cathode, and a control electrode, means connected to said control electrode for normally impressing a potential thereupon having a negative voltage characteristic relative to the operating potential of said X-ray tube to positively prevent the flow of current between the anode and cathode of said device and consequently from said high tension source to said X-ray tube, and means associated with said first mentioned means and operable to cause the latter to alternately impress a negative and positive potential upon said control electrode and render said discharge device non-conductive and conductive for various preselected periods of time with attendant energization and deenergization of said X-ray tube for periods of time corresponding to the operation of said last mentioned means.

3. In an X-ray system, the combination with an X-ray tube and a source of high potential electrical energy therefor, of a timing device connected to said high potential source and to said X-ray tube for enabling the latter to be energized for various predetermined periods of time comprising a thermionic discharge device provided with an anode, a cathode, and a control electrode interposed between said anode and cathode, and operable to cause and prevent the flow of current therebetween and consequently from said high tension source to said X-ray tube, an auxiliary source of electrical energy connected to said control electrode to render the same operative, and mechanism associated with said auxiliary source and operable to cause the latter to alternately impress a negative and positive potential upon said control electrode for various preselected periods of time without any interruption in the potential impressed upon said control electrode, for the purpose of rendering said discharge device non-conductive and conductive with attendant deenergization and energization of said X-ray tube for periods of time corresponding to the operation of said mechanism.

4. In an X-ray system, the combination with an X-ray tube and a source of high potential electrical energy therefor, of a timing device connected to said high potential source and to said X-ray tube comprising a thermionic discharge device provided with an anode, a cathode, and a control electrode interposed between said anode and cathode operable to cause and prevent the flow of current therebetween and consequently from said high potential source to said X-ray tube, an auxiliary source of electrical energy connected to said control electrode and operable to alternately impress a negative and positive potential thereupon to cause said discharge device to become conductive and non-conductive with attendant energization and deenergization of said X-ray tube, a switch connected to said auxiliary source and operable to cause the alternate reversal in the polarity of the potential impressed by said auxiliary source upon said control electrode without disconnection of said source from said control electrode, and means connected to said switch and operable for various preselected periods of time to render said switch operative to cause the alternate reversal in the polarity of the potential impressed by said auxiliary source upon said control electrode with attendant energization and deenergization of said X-ray tube for periods of time corresponding to the operation of said last mentioned means.

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