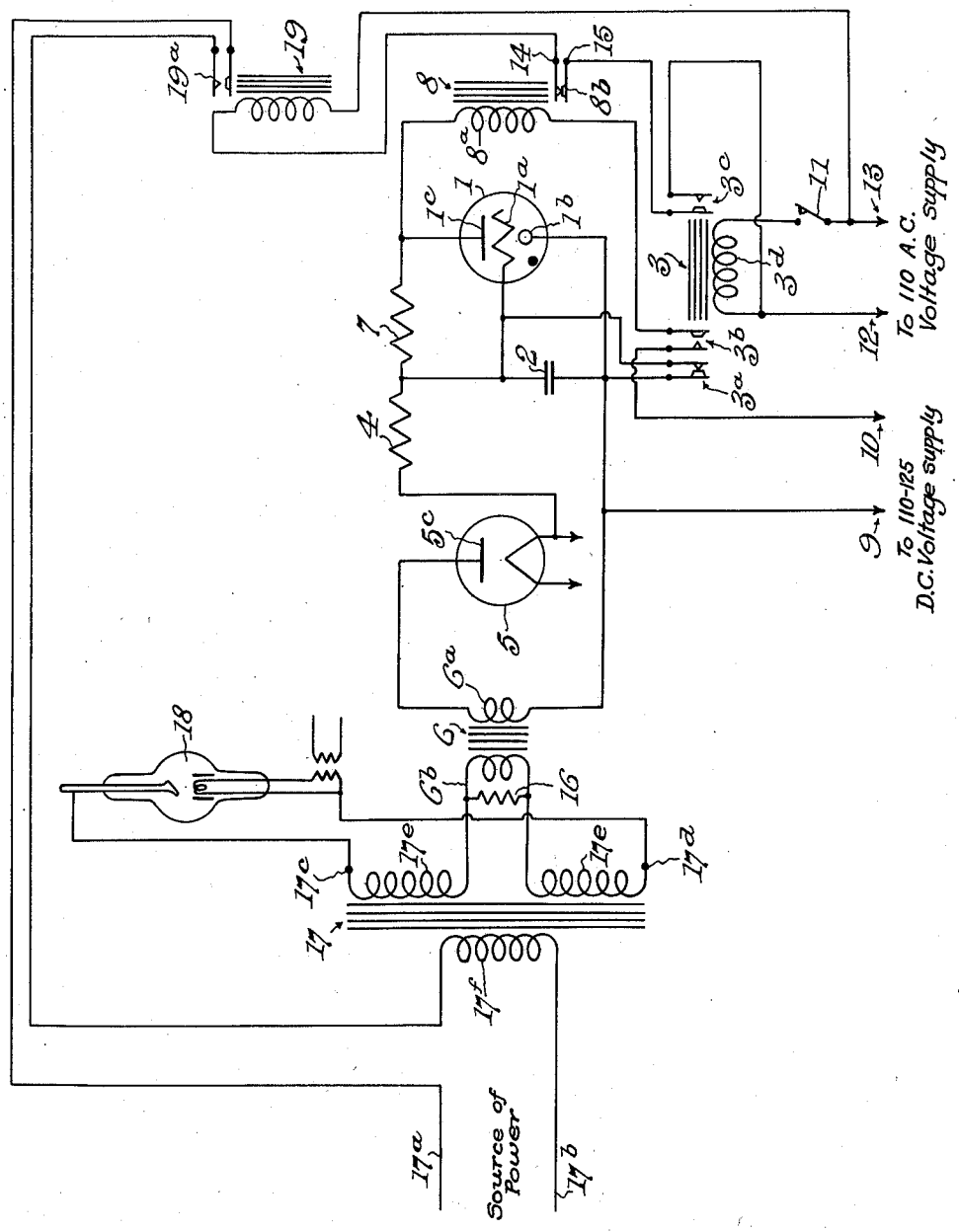
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LIMIT TIMER FOR PROTECTION OF X-RAY TUBES

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LIMIT TIMER FOR PROTECTION OF X-RAY TUBES

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This invention relates generally to a method and means for timing X-ray tubes but more particularly to an apparatus for limiting the exposure time of an X-ray tube, which is automatically set for the voltage used on the tube.

One object of the invention is to provide a method and apparatus for automatically controlling the duration of the flow of current through an X-ray tube to thereby avoid damage and prolong the life of the tube.

Another object of the invention is to provide an apparatus for terminating an X-ray exposure in a predetermined time interval and which is controlled by the voltage impressed on the X-ray tube to vary said time interval.

Another object of the invention is to provide a device adapted to prevent X-ray exposure longer than that permitted by the X-ray tube regardless of the milliamperage going through the said X-ray tube.

In general, the exposure time which may be tolerated by an X-ray tube is a function of the current flowing through the tube; for example: an X-ray tube operated at 200 ma. may tolerate an exposure time of 2 seconds. Longer exposure times under this condition will almost certainly result in damage. On the other hand, if the tube is operated at 30 ma., an exposure time of 15 or more seconds may be tolerated without damage to the tube occurring.

The present invention deals with an automatic electronic timing mechanism by which the exposure time to which an X-ray tube is subjected may be limited to within safe levels, regardless of the milliamperage flowing through the X-ray tube. The invention, although particularly applicable to X-ray machines employing automatic photoelectric exposure control, is equally useful on any X-ray machine.

The device which is shown schematically in the accompanying illustration consists essentially of a three-element thyratron tube 1, between the grid 1*a* and cathode 1*b* of which are connected a condenser 2 and the normally-closed contacts 3*a* of the A. C. relay 3. Between the grid 1*a* and the plate 1*c* of the thyratron 1 is connected a resistor 7. Also connected between the grid 1*a* and the cathode 1*b* of the thyratron is a resistor 4 and a rectifier tube 5, the filament of which is connected to the resistor 4 and the plate of which 5*c* is connected, through winding or coil 6*a*, to a transformer 6. This winding of the transformer will henceforth be called the secondary winding 6*a*. The remaining or primary winding 6*b* of the transformer 6 is connected in parallel with

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a resistor 16 to the center of the secondary winding 17*e* of the conventional high-tension transformer 17 of the X-ray machine. The two outside terminals 17*c* and 17*d* of this transformer 17 lead directly or indirectly, depending upon the type of X-ray machine involved, to the X-ray tube 18. The primary winding 17*f* of the high-tension X-ray transformer 17 is connected to a power source (not shown) through the terminals 17*a* and 17*b* in a manner consistent with that employed in conventional X-ray machine practice.

The plate 1*c* of the thyratron 1 is in series with the field coil 8*a* of a D. C. relay 8 and the normally-opened contacts 3*b* of the relay 3. A 100–125 volt D. C. voltage supply is applied between the terminals 9 and 10. The relay 8 has a pair of normally-closed contacts 8*b* which are in series with a pair of normally-open contacts 3*c* of the relay 3. This double pair of contacts 8*b* and 3*c* constitute a switch connected through terminals 14 and 15 to the main relay 19 which closes the normally-open contacts 19*a* of the power lines 17*a* and 17*b* to primary winding 17*f* of the X-ray transformer to thereby energize the X-ray tube 18. The field coil 3*d* of the relay 3 is connected through a switch 11 to a 110-volt A. C. voltage supply through terminals 12 and 13.

The method of operation of the device is as follows: When the exposure switch 11 is closed, relay 3 is activated closing contacts 3*b* and 3*c* and opening contact 3*a*. Continuous circuit thereby is formed between terminals 14 and 15, and the X-ray machine contactor, to which these terminals are connected, is energized and voltage is thereby applied to the high tension transformer 17 of the X-ray machine (not shown) in the conventional manner; voltage thereby is applied to the X-ray tube 18 and the X-ray exposure begun.

The opening of the contact 3*a* and the closure of the contact 3*b* permits charge to flow to the condenser 2 through the field coil of the relay 8 and the resistor 7.

The collection of this charge produces across the plates of the condenser 2 a voltage which increases as the amount of collected charge accumulates. Eventually a potential develops which is sufficient for the firing of the thyratron 1. Instantaneously this tube becomes conductive, current flowing from cathode 1*b* to plate 1*c*. This current flows through the field coil of the relay 8, thereby opening the contacts 8*b* and causing the breaking of the circuit between terminals 14 and 15. The contactor of the X-ray

machine thereby is deenergized and voltage is removed from the high-tension transformer 17 of the X-ray machine and the X-ray exposure thereby terminated. The value of the resistor 7 is chosen so that the time required for the potentials to develop on condenser 2 is equal to the exposure time which may be tolerated by the X-ray tube for the lowest tube currents which will be used.

Simultaneously with the charging of the condenser 2 through the resistor 7 there will also be a charging effect through the resistor 4 and the rectifier 5 by a voltage developed by the transformer 6 in response to a voltage developed across its primary winding when current which flows through the X-ray tube flows through the secondary winding of the high-tension transformer 17 and the resistor 16. This current develops a potential across the resistor 16 which is impressed upon the transformer 6. The greater the current flowing through the X-ray tube, the greater will be the potential developed across resistor 16 and applied to the transformer 6. Depending on the value of this potential, charge will be placed upon the condenser 2 by the resistor 4. The resistor 4 is adjusted so that the time at which the condenser 2 applies a sufficient voltage to the thyratron 1 for it to become conductive will be the maximum exposure time tolerated by the X-ray tube at the highest X-ray tube currents which are used. The rectifier tube 5 is placed in this circuit so that the current flowing through the resistor 4 is unidirectional; the current developed by the transformer 6 is an alternating current and therefore the rectifier is needed to produce the desired unidirectional effect.

Summarizing, the resistor 7 is of such value the thyratron tube 1 will become conductive only after the maximum exposure time which may be tolerated by the X-ray tube at the lowest X-ray tube currents employed and the resistors 4 and 16 adjusted to such values that the thyratron tube 1 will become conductive at the maximum exposure time tolerated by the X-ray tube when operated at the highest X-ray tube currents that are employed. At X-ray tube currents between these extremes the invention will limit the exposure time to values depending on the current flowing through the X-ray tube and at such values as are within those tolerated by the X-ray tube without causing damage.

Manifestly, many changes and modifications in the described automatic time mechanism will be apparent to those skilled in the art. For this reason the description is intended to be illustrative only and the scope of the invention is to be limited only as required by the following claims.

Having thus described our invention what we claim as new and wish to secure by Letters Patent is:

1. An electronic timing mechanism for controlling the exposure time of an X-ray tube comprising in combination a normally open supply circuit, a source of potential connected with said circuit, an X-ray tube including the electrodes thereof, a transformer embodying primary and secondary coils, the primary coil being connected with said supply circuit, the secondary coil with the electrodes of said tube, means for closing said normally open supply circuit and initiating the exposure period of said X-ray tube and additional means in electrical relation with the secondary coil of said transformer for disrupting said supply circuit and terminating the exposure period of said X-ray tube at the expiration of the maximum exposure time tolerated by said tube at the lowest and at the highest tube currents used, said additional means including a control condenser, a pair of uni-directional charging circuits connected with and arranged for simultaneously charging said condenser, one of said circuits being normally open and connected with a source of supply, the other of said charging circuits being connected with the secondary of said transformer, means coupled with said normally open supply circuit for closing the normally open charging circuit and simultaneously inducing current flow in the remaining charging circuit when the exposure period of said X-ray is initiated, each of said charging circuits including resistor means, the value of the resistor means in one of the charging circuits being such that the charging effect of such circuit with respect to said control condenser determines the maximum exposure time tolerated by said X-ray tube at the lowest tube currents used, the value of the resistor means in the other of said charging circuits being such that the charging effect of such circuit with respect to said control condenser determines the maximum exposure period at the highest tube currents used.

2. An electronic timing mechanism for controlling the exposure time of an X-ray tube comprising in combination a normally open supply circuit, a source of potential connected with said circuit, an X-ray tube including the electrodes thereof, a transformer embodying primary and secondary coils, the primary coil being connected with said supply circuit, the secondary coil with the electrodes of said tube, said secondary coil including a resistor, means for closing said normally open supply circuit and initiating the exposure period of said X-ray tube and additional means in electrical relation with the secondary coil of said transformer for disrupting said supply circuit and terminating the exposure period of said X-ray tube at the expiration of the maximum exposure time tolerated by said tube at the highest and at the lowest tube currents used, said additional means including a control condenser, a pair of uni-directional charging circuits connected with and effective for simultaneously charging said condenser, one of said charging circuits being normally open and connected with a source of potential, the remaining charging circuit being inductively coupled with the resistor in the secondary coil of said transformer, means coupled with said normally open supply circuit for automatically closing said normally open charging circuit and simultaneously applying the voltage drop across said last-mentioned resistor to the remaining charging circuit, resistor means in each of said charging circuits, the value of the resistor means in one of said charging circuits being such that the charging effect of said circuit with respect to said control condenser determines the maximum exposure time tolerated by said X-ray tube at the lowest tube currents used, the value of the resistor means in the remaining circuit being such that its charging effect with respect to said control condenser determines the maximum exposure period at the highest tube currents used.

3. An automatic electronic timing mechanism for controlling the exposure time for an X-ray tube comprising in combination a normally open supply circuit including a pair of normally closed contacts, a source of potential connected with

said circuit, an X-ray tube including the electrodes thereof, a transformer embodying primary and secondary coils, the primary coil being connected with said supply circuit, the secondary coil with said X-ray tube, said secondary coil including a resistor, means for closing said normally open supply circuit to initiate the exposure period of said X-ray tube, a thyratron relay system coupled to the secondary coil of said transformer and coacting with the normally closed contacts in the supply circuit, said thyratron relay system operating when said thyratron becomes conductive to open the normally closed contacts in said supply circuit, and control means in electrical relation with said thyratron relay system to render the latter conductive at the expiration of the maximum exposure time tolerated by said tube at the lowest and at the highest tube currents used, said control means including a control condenser, a pair of charging circuits connected with and effective for simultaneously charging said condenser one of said charging circuits being normally open and connected with a source of potential, the other of said charging circuits being inductively coupled with the resistor in the secondary coil of said transformer, means coupled with said normally open supply circuit for closing the normally open circuit and simultaneously applying to the remaining circuit the voltage drop across the resistor in the secondary coil of said transformer, resistor means in each of said charging circuits, the resistor means in one of said charging circuits being such that the time at which said control condenser applies a sufficient voltage to the thyratron for it to become conductive determines the maximum exposure time tolerated by the X-ray tube at the largest X-ray tube currents used, the value of the resistor means connected with the remaining charging circuit being such that the time at which the control condenser applies a sufficient voltage to the thyratron for it to become conductive determines the maximum exposure time tolerated by the X-ray tube at the lowest X-ray currents used.

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