

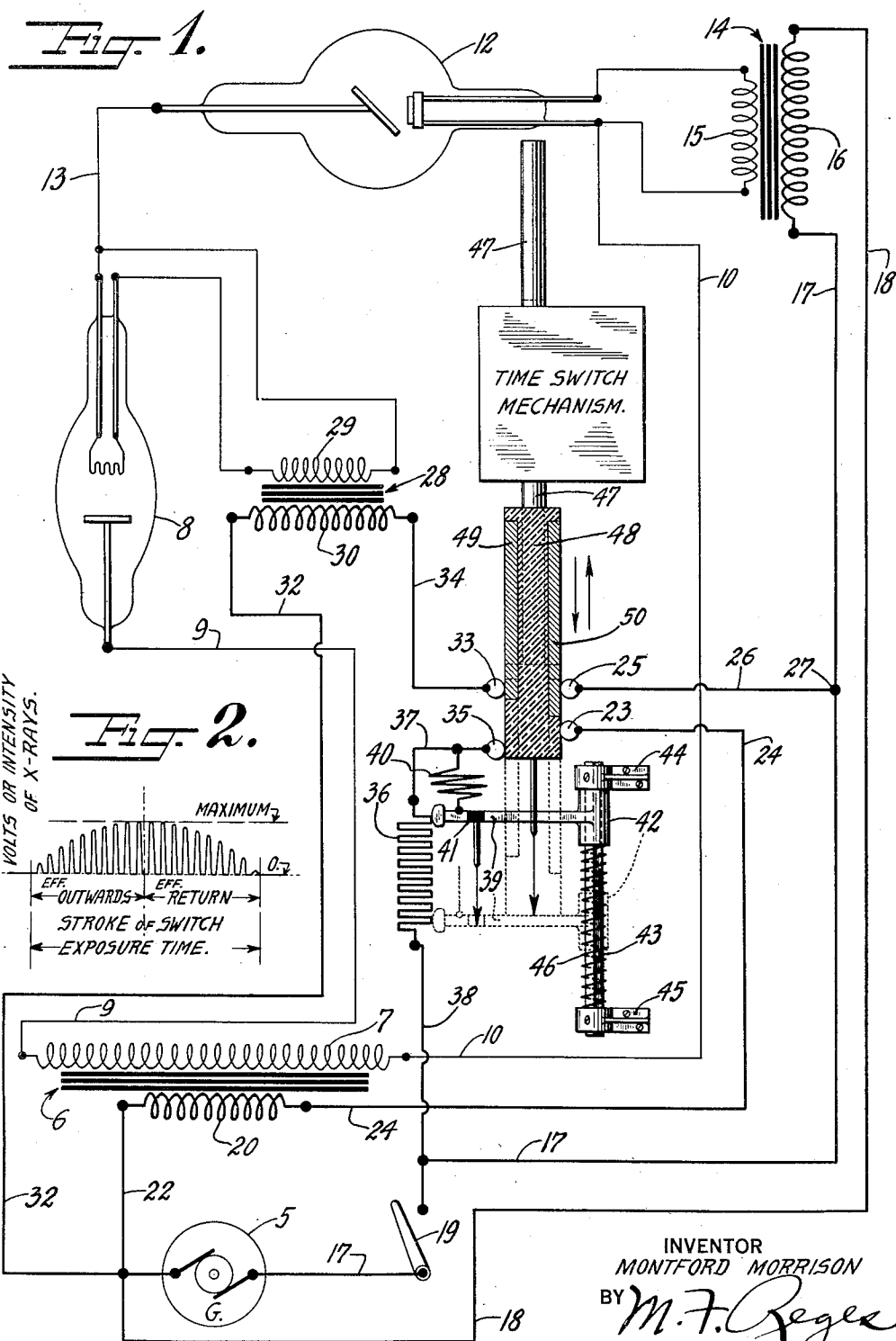
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METHOD AND APPARATUS FOR CONTROLLING X-RAY INTENSITY

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METHOD AND APPARATUS FOR CONTROLLING X-RAY INTENSITY

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My invention relates to X-ray apparatus and has particular relation to an X-ray apparatus wherein the intensity of the X-rays generated or emitted by the X-ray tube are automatically
5 varied during energization thereof.

More particularly stated my invention comprises the combination of an X-ray tube of the incandescent cathode type with an incandescent cathode rectifier both of which are connected in series with a suitable source of alternating current, and coordinated switching means are provided which through the operation of a time switch control the main operating current and the cathode heating current of the rectifier tube.
10 The energy passing through the rectifier tube, and consequently through the X-ray tube, is dependent upon the temperature of the thermionic cathode of the rectifier tube and by varying the energy supplied thereto, during predetermined periods of time as controlled by the time switch, the intensity of the X-rays emanating from the X-ray tube during the period of energization thereof will vary in accordance with these variations in cathode heating temperature.

This feature of producing X-rays of varying intensity is particularly useful in the taking of radiographic exposures as it results in a picture in which there is an entire absence of the so-called grid marks and the film appears to have
15 a uniform density over its entire area.

The novel features of my invention will become readily apparent to those skilled in the art by reference to the accompanying drawing wherein

Figure 1 is a diagrammatical representation
20 of an X-ray system in accordance with my invention in which X-rays of varying intensity are generated.

Figure 2 is a graphic representation of the variance in the voltage of the rectifier tube and the variance in the intensity of the X-rays emanating from the tube during a predetermined interval of time.

Referring now to the drawing in detail I have shown a suitable source of alternating current of the usual commercial potential, such as a generator 5. A high tension transformer 6 has one end of its secondary winding 7 connected to the anode terminal of a vacuum valve or rectifier tube 8 by means of a conductor 9. The remaining end of the secondary winding 7 is connected by means of a conductor 10 to the cathode end of an X-ray tube 12 and the anode of this X-ray tube is connected to the cathode end of the rectifier tube through a conductor 13.

A circuit is thus completed from the secondary

winding 7 through the X-ray tube and rectifier tube enabling energy to flow therethrough during each half wave of the alternating current cycle with the remaining half wave suppressed by the well known action of the rectifier tube 8. A low tension transformer 14 has its secondary winding 15 connected to the cathode of the X-ray tube 12 for the purpose of supplying heating currents to the same and the primary winding 16 is connected, by means of a pair of conductors 17 and 18, to the source of supply 5 through a suitable switch 19.

The primary winding 20 of the high tension transformer 6 has one of its ends connected to the source of supply 5, by means of a conductor 22, while the remaining end thereof is connected to a contact terminal or brush 23 through a conductor 24.

A similar contact terminal 25 is connected, by means of a conductor 26, to a junction 27 in the conductor 17 so that when the switch 19 is closed and the contact terminals 23 and 25 are bridged a circuit will be closed to the primary winding 20 from the source 5 as can be readily appreciated from the drawing.

A low tension transformer 28, similar to the transformer 14, has its secondary winding 29 connected to the cathode of rectifier tube 8 for the purpose of supplying heating currents thereto. The primary winding 30 of this transformer has one of its ends connected to the source of supply 5, by means of a conductor 32, while the remaining end of this winding is connected to a contact terminal 33 by means of a conductor 34. Another contact terminal 35 which is disposed adjacent this latter terminal 33 is connected to a resistance or rheostat 36 through a conductor 37.

The remaining end of this rheostat is connected by means of a conductor 38 and the switch 19 to the source of supply 5. When, therefore, the switch 19 is closed and the contact terminals 33 and 35 are bridged a circuit will be completed to the primary winding 30. The cathode of the valve tube 8 will thus be heated to an electron emitting temperature allowing energy to flow in the main circuit comprising the valve and X-ray tubes 8 and 9, respectively, and the secondary winding 7.

In order to vary the energy supplied to the cathode of the valve tube 8 and thereby regulate the energy flowing therethrough and through the X-ray tube, with an attendant variation in the intensity of the X-rays emanating from the latter, I provide the resistance or rheostat 36 with a movable arm 39, to which a flexible conductor 40

is attached in order to connect the arm with the conductor 37 and contact terminal 35.

Movement, therefore, of this arm downwardly over the resistance 36 decreases the total resistance or short circuits the same from the cathode heating circuit and accordingly increases the temperature thereof. An increase of the cathode temperature enables a greater potential to flow through both valve and X-ray tubes with an increase in the intensity of X-ray output due to a change in the wave length of the X-rays.

The arm 39 is insulated by means of a block 41 from other portions thereof and is supported by means of a bearing portion 42 to the square rod or shaft 43 upon which it is arranged to slide during its movement. This shaft 43 is in turn supported in a suitable manner, such as by brackets 44 and 45, and a spring 46 surrounding the shaft 43 tends to retain the arm 39 in the upper extremity of its movement to allow only a minimum of heating energy to be supplied to the cathode of valve tube 8.

In order to actuate the movement of the arm 39 during the period of energization of the X-ray tube and to regulate the time period of operation of both, a timing mechanism of any well known type may be utilized. As this mechanism per se forms no part of my present invention a detail description thereof is believed unnecessary. It is believed sufficient to state that when the mechanism is set for the time period desired a shaft 47, to which is secured an insulating member, such as a drum 48, is caused to move downwardly.

This insulating member 48 is provided with a pair of metallic surfaces 49 and 50 of copper or other well known conducting material which during movement of the shaft 47 bridges the contact terminals 33, 35 and 23, 25 respectively, thus completing the circuits to the primary windings 20 and 30.

It must be noted that the metallic surface 50 is longer than that of the surface 49 and the bridging of the contact terminals 23, 25 takes place therefore before the remaining terminals 33, 35. This allows the primary winding 20 to become energized a short period of time before the heating of the cathode of the valve tube 8 and upon the latter reaching an electron emitting temperature a discharge will follow and X-rays will be generated by the X-ray tube 12.

Further downward movement of the shaft 47 and insulating member 48 causes the same to contact the arm 39 and move the latter downwardly of the resistance 36 and square shaft 43 against the tension of the spring 46. This movement of the arm 39 short circuits the resistance 36 from the cathode heating circuit through the flexible conductor 40 and enables the energy supplied to the cathode of the rectifier tube 8 to increase. This in turn allows a greater amount of energy to flow through the rectifier tube and the series connected X-ray tube and results in an increase in the intensity of the X-ray generated by the latter.

The movement of the shaft 47 and drum 48 being reciprocatory the arm 39 will first completely short circuit the resistance 36 from the cathode heating circuit and then as the shaft moves upwardly the resistance is again cut into the circuit to again reduce the cathode heating energy with its attendant effect upon the main high tension circuit and the intensity of the X-rays generated. The period of time that the respective circuits are closed by the metallic surfaces 49 and 50 and that required for one com-

plete reciprocatory movement of the shaft 47 and drum 48 is dependent upon the setting of the time switch which may be adjusted as desired.

Regardless of whether this time setting be relatively small or large the time switch will cause the complete operation of the associated parts as just described, the only variance being in the rapidity with which the cycle of operation is performed.

Referring now more particularly to Figure 2 I have shown a graphic illustration of the variance in the voltage through the high tension circuit comprising the valve and X-ray tubes and the secondary winding 7 caused by varying the heating energy supplied to the cathode of the valve tube 8 in the manner just described. As the intensity of the X-rays generated by the X-ray tube is dependent upon the voltage impressed thereupon this figure is also representative of the variation in intensity of the X-rays.

It can be appreciated by reference to Figure 2 that at the time of energization of the X-ray tube and the closure of the circuit by the metallic bridging member 50 the intensity of the X-rays starts at the zero line and, as the resistance 36 is short circuited out of the cathode heating circuit by the movement of the arm 39 until the same is completely short circuited, the intensity of the X-rays reaches maximum. When the arm 36, therefore, completes its extremity of movement and starts in the reverse direction through the action of the time switch the resistance is again gradually inserted in the circuit until at the expiration of the predetermined time period the intensity of the X-rays has dropped from maximum to zero.

The rise and fall in peak voltage or intensity is, of course, gradual during the movement of the arm 39 with periodic drop in voltage and intensity caused by the alternating current cycle which causes the voltage and intensity to drop momentarily to the zero line. This can readily be understood by reference to Figure 2 which is representative of the gradual rise and fall of peak voltage and intensity over a period of several alternating current cycles.

It thus becomes readily apparent to those skilled in the art that I have provided an X-ray system in which the intensity of the X-rays generated by an X-ray tube is automatically varied during the predetermined interval of time of operation thereof regardless of the duration of this period of energization. Furthermore, a uniform maximum intensity is always obtained during the period of energization regardless of its duration.

Although I have shown and described several embodiments 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 appended claims:

What is claimed is:

1. The method of obtaining X-rays of varying intensity from an X-ray tube which consists in supplying the X-ray tube with rectified pulsating current, timing the period of energization of the X-ray tube by the rectified pulsating current, and varying the maximum magnitude of each successive pulsation of the rectified pulsating current supplied to the X-ray tube during the period of energization thereof to vary the intensity of the X-ray output of the tube during its operation.

2. The method of obtaining X-rays of varying intensity from an X-ray tube energized from an alternating current source which consists in converting the alternating current to rectified pul-

sating current and energizing the X-ray tube therewith, timing the interval of energization of the X-ray tube by the rectified pulsating current, and regulating the amount of rectified pulsating current supplied to the X-ray tube during the period of energization thereof to cause a variation in the magnitude of each successive pulsation of the current with a corresponding variation in the intensity of the X-rays emanating from the X-ray tube.

3. In an X-ray system for varying the X-ray intensity for a predetermined period of time, the combination with an X-ray tube, of means for supplying direct current to said X-ray tube including a valve tube having a thermionic cathode and a transformer for supplying heating current to said cathode, a time switch electrically associated with said transformer and operable for predetermined periods of time to cause direct current to flow to said X-ray tube, and means connected to said transformer and operable by said time switch for varying the heating current supplied to said cathode.

4. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube during a predetermined period of time, the combination with an X-ray tube, of a source of electrical energy for said X-ray tube including means for rectifying the current supplied to said X-ray tube, means electrically associated with said rectifying means and operable for predetermined periods of time to cause the rectified current to be supplied to said X-ray tube, and means operable by said last mentioned means for automatically varying the amount of current supplied to said X-ray tube whereby the intensity of X-rays emanating from said tube will be varied during the time of operation of said X-ray tube.

5. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination with an X-ray tube, of a source of electrical energy therefor comprising a rectifier tube having a thermionic cathode, means for heating said cathode including a time switch operable to cause said means to heat the cathode of said rectifier tube for a predetermined period of time and render said source effective to energize said X-ray tube, and means electrically associated with said means for heating said cathode and operable by said time switch to vary the heating current supplied to said cathode whereby the current supplied to said X-ray tube is varied to produce X-rays of varying intensity during the period of operation thereof.

6. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination with an X-ray tube of a source of high potential electrical energy for energizing said X-ray tube, a valve tube connected to said X-ray tube and to said source and operable to control the flow of current from said source to said X-ray tube, means electrically connected with said source and operable to cause said source to energize said X-ray tube for a predetermined period of time, and means electrically associated with said valve tube operable to vary the current flowing through the latter and consequently through said X-ray tube to thereby vary the intensity of the X-rays emanating therefrom, said last mentioned means being operable by said first mentioned means.

7. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination

with an X-ray tube, of a source of high potential electrical energy for energizing said X-ray tube, a valve tube connected with said source and said X-ray tube and operable to control the flow of current from said source to said X-ray tube, a time switch electrically associated with said source and operable to cause said source to energize said X-ray tube for a predetermined period of time, and a rheostat electrically associated with said valve tube and operable by said time switch for varying the current flowing through said valve tube and consequently through said X-ray tube to cause a variation in the intensity of the X-rays emanating from said X-ray tube.

8. In an X-ray system for varying the X-ray intensity for a predetermined period of time, comprising the combination with an X-ray tube, of a high tension transformer having a primary and secondary winding, said secondary winding being connected to said X-ray tube, means for making and breaking a connection to said primary winding, a valve tube having a thermionic cathode connected in series with said secondary winding and said X-ray tube, a heating transformer for said cathode, and means operable by said make and break means and connected to said heating transformer for varying the flow of current in said heating transformer.

9. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination with an X-ray tube, of means for energizing said X-ray tube comprising a source of high potential electrical energy, a valve tube having a cathode to be heated connected to said source and said X-ray tube and operable to control the flow of current from said source to said X-ray tube, a source of heating current for the cathode of said valve tube, means operable to cause the cathode of said valve tube to be energized by said source of heating current for a predetermined period of time and render said valve tube operative to cause said high potential source to energize said X-ray tube, and means electrically associated with said source of heating current for the cathode of said valve tube operable to vary the current flowing through said valve tube and consequently through said X-ray tube and engageable by said second mentioned means for actuation thereby.

10. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination with an X-ray tube of a high tension transformer for energizing said X-ray tube and adapted to be connected to a source of electrical energy, a valve tube provided with a cathode to be heated associated with said X-ray tube and said high tension transformer to cause electrical current of one sign only to flow through said X-ray tube, a low tension transformer for supplying heating current to the cathode of said valve tube and adapted to be connected to a source of electrical energy, means associated with said high tension transformer and said low tension transformer for connecting both said transformers to a source of electrical energy for a predetermined period of time, and means associated with said low tension transformer and said valve tube and operable by said first mentioned means to vary the current flowing through said valve tube.

11. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination with an X-ray tube of a high tension transformer

- for energizing said X-ray tube and adapted to be connected to a source of electrical energy, a valve tube provided with a cathode to be heated connected to said X-ray tube and said high tension transformer to cause electrical current of one sign only to flow through said X-ray tube, a low tension transformer for supplying heating current to the cathode of said valve tube and adapted to be connected to a source of electrical energy, a time switch associated with said high tension and low tension transformers for connecting both said transformers to a source of electrical energy for a predetermined period of time, and a rheostat electrically connected with said low tension transformer and the cathode of said valve tube and operable by said time switch for varying the current flowing through said valve tube and consequently through said X-ray tube to cause X-rays of varying intensity to emanate from the latter.
12. In an X-ray system for varying the intensity of the X-rays emanating from an X-ray tube for a predetermined period of time, the combination with an X-ray tube of a high tension transformer for energizing said X-ray tube provided with a primary and secondary winding, a valve tube provided with a cathode to be heated and connected in series with the secondary winding of said high tension transformer and said X-ray tube to cause electrical current of one sign only to flow through said X-ray tube, a low tension transformer provided with primary and secondary windings for supplying heating currents to the cathode of said valve tube, a time switch associated with the primary winding of said high tension and low tension transformers and operable to connect the same to a source of electrical energy for a predetermined period of time, and a rheostat connected in series with the primary winding of said low tension transformer and operable by said time switch to cause a variation in the current flowing through said valve and X-ray tubes to produce a variation in the intensity of the X-rays emanating from said X-ray tube.
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