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2,829,272

X-RAY APPARATUS AND METHOD

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2 Sheets-Sheet 1

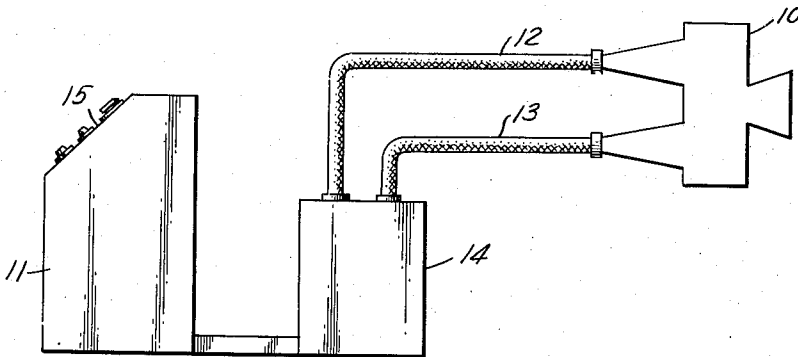


Fig. 1

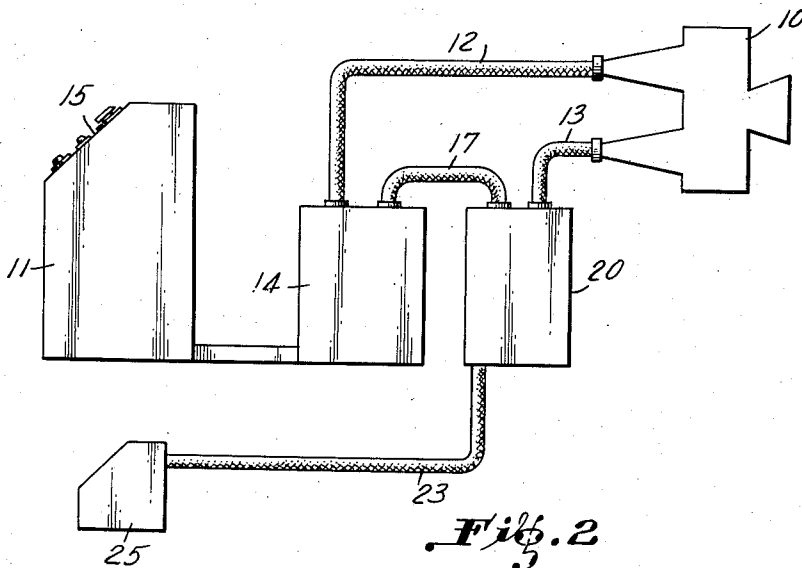


Fig. 2

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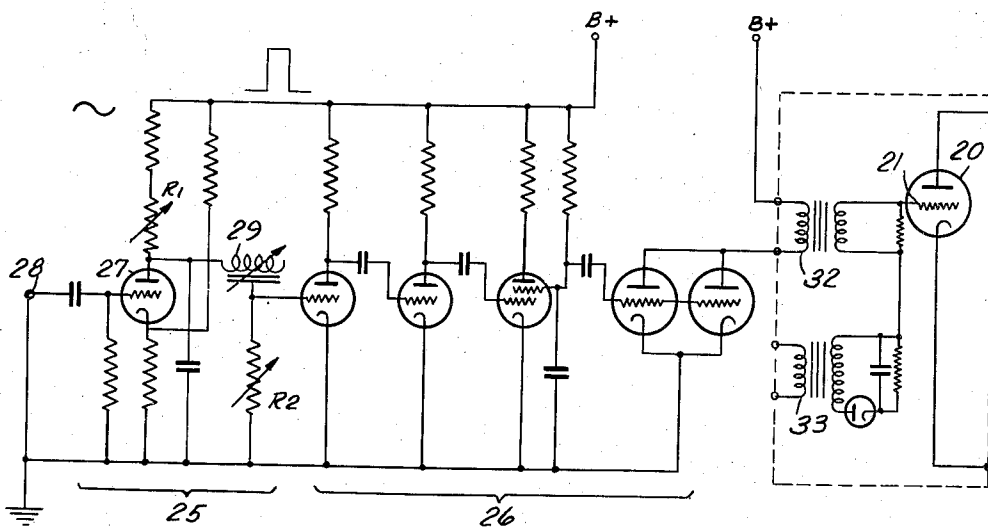
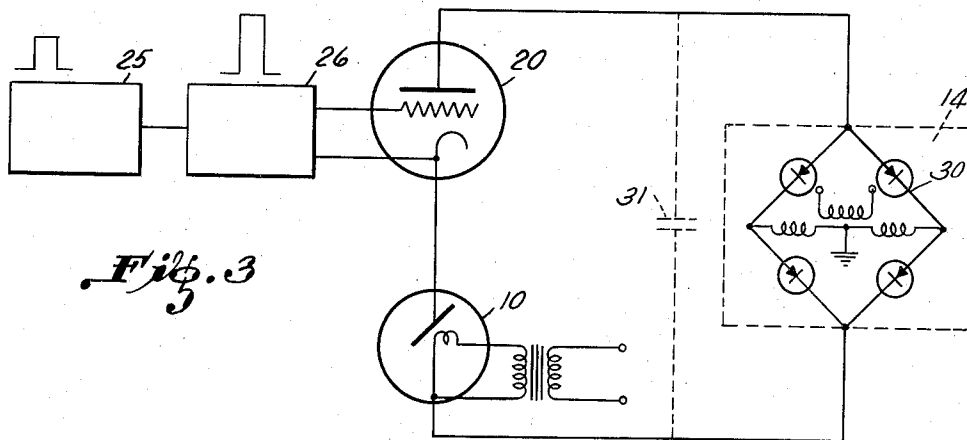
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X-RAY APPARATUS AND METHOD

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3 Claims. (Cl. 250—95)

This invention relates to X-ray apparatus and more particularly, relates to a method and apparatus for controlling an X-ray exposure.

In the art of X-ray examination, certain limitations relating to the subject of the exposure are imposed upon the intensity and duration of the X-ray radiations. For example, in the case of animal or, more particularly, human exposure to X-ray radiations, it is known that a maximum threshold exists on the intensity and the amount of X-ray radiation energy that may be absorbed without detrimental or even fatal results.

The limiting threshold on intensity has been variously defined in the case of humans in terms of the biological reaction of the skin as that quantity of radiation which will produce a mild skin erythema and is identified as the Threshold Erythema Dose (T. E. D.). Thus in the present state of development of X-ray dosimetry, a knowledge of the T. E. D. in Roentgen units for a given subject or class of subjects provides a boundary limit on the quantity of radiation which may be safely applied. The value of the T. E. D. depends on several variable factors, such as the wave length, the area radiated and, to some extent, the subject and, as such, cannot be identified as a physical constant. However, with a knowledge of the factors involved, the magnitude of the T. E. D. for a given application can be practically determined with a reasonable margin of safety.

The subject is of course exposed to the X-ray radiations over some exposure time interval at a given dosage rate so that the energy quantity of X-ray radiation is the energy product of the intensity and duration of the radiation. The exposure time interval is usually determined in relation to the results desired, for example, the degree of luminosity on a fluoroscopic screen or the degree of image amplification for interpretation purposes. Accordingly, for any desired exposure interval it is necessary to keep within safe limits of radiation intensity and overall energy quantity or dosage rate. In conventional X-ray methods and apparatus, this is normally accomplished by maintaining an upper limit on the intensity threshold. This, of course, imposes operating limitations on the application of the radiations and their interpretation. Some significant limitations relate to the degree of screen luminosity and to the image amplification obtainable in conventional X-ray apparatus. This invention relates to the removal or substantial reduction of these limitations by enabling an increase in the threshold of radiation intensity without exceeding the overall energy limit for a given exposure time to safely permit an increase in screen luminosity and image amplification as well as to improve the scanning performance of a conventional fluoroscopic screen.

Briefly, in accordance with this invention, there is provided a method and apparatus for enabling an increase in the threshold of radiation intensity beyond an intensity level which is limited to a safe value that will not damage the subject when continuously applied over a

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given predetermined exposure time by applying the X-rays intermittently at such increased intensity during the same exposure time interval in a manner that will not damage the subject. The invention further contemplates a method and apparatus for rendering such intermittent application periodic during such period of time, and in such manner, that the time duration of the X-ray application is less than the time interval between each application. The apparatus embodies an X-ray generator adapted to be energized from a source of high potential electrical energy and normally isolated from such source by an electronically controlled translating device with means for rendering such device periodically ineffective in accordance with the foregoing method.

In the drawings:

Fig. 1 diagrammatically illustrates in block form a conventional X-ray apparatus and system;

Fig. 2 illustrates the conventional system of Fig. 1 as modified in accordance with this invention;

Fig. 3 diagrammatically illustrates in block form the portion of the system of Fig. 2 to which this invention is directed;

Fig. 4 is a schematic circuit diagram of the portion of the system shown in Fig. 3 of the drawings with the exception of the X-ray tube and its high potential source.

Referring now to Fig. 1 of the drawings, there is shown a conventional X-ray generating apparatus, with the individual components diagrammatically shown in block form. The X-ray tube generator 10 is conventional in form and adapted to be energized from a source of high potential electrical energy 11 which is supplied through the connecting cables 12 and 13 from a high potential transformer 14. An X-ray control panel 15 for controlling the operation of the apparatus in accordance with the desired results is shown physically disposed in proximity to the generating apparatus.

As hereinbefore indicated in the introduction, it is conventional practice in the art of X-ray examination to continuously apply X-ray radiations of a predetermined intensity for a predetermined duration of time, and the threshold of such radiation intensity is limited in its continuous application to a predetermined safe value which will prevent a quantity of absorption that may prove detrimental or even fatal to the subject. Such intensity threshold limitation imposes operating limitations on the screen luminosity and image amplification as well as on the scanning performance during examination.

This invention is directed to the removal or substantial modification of these operating limitations and embodies a method and apparatus for increasing or raising the threshold of radiation intensity and intermittently applying such increased intensity of radiations during the same period of time without increasing the total quantity of radiation beyond a predetermined safe limit. In order to enable some measure of control over the intermittent application of such of the X-ray radiations, it is preferred to make their application periodic during the prescribed time period and a system and apparatus has been devised for carrying out the principle of this method.

Thus, as shown in Fig. 2 of the drawings, the conventional X-ray generating system of Fig. 1 may be modified in accordance with this invention by introducing an electron translating device 20 between the high potential source of energy and the X-ray generator tube which device will normally isolate the tube from the source until externally rendered ineffective periodically in accordance with the principle of my method.

The isolating or trigger device 20 shown in Fig. 2 of the drawings is preferably a multi-electrode electronic device such as a high potential triode tube which may

be independently biased in a manner to isolate the X-ray tube 10 from the high potential source. The bias on the high potential triode may be periodically removed or modified in a manner to apply the transformer potential to the X-ray tube.

In the system shown in Fig. 2 of these drawings, the preferred manner of so periodically modifying the triode bias is in the form of a pulse generator 25 which periodically creates an electrical impulse that is electrically coupled at 23 to trigger the triode and apply the high potential from the transformer 14 to the X-ray tube 10.

As best shown in Fig. 3 of the drawings, the high potential from the transformer 14 is rectified and applied through the high potential triode 20 to the X-ray tube. In its preferred form the rectifier is shown as a conventional bridge type rectifier 30 which can also be a half-wave or self rectified generator. There is also shown in Fig. 2 a condenser 31 connected by dotted lines across the output of the high voltage system. The condenser 31 is shown in dotted lines for the reason that it may or may not be used and still accomplishes the desired results. If not used and the source of energy is a 60 cycle source, there will be obtained a pulsed output with a 120 cycle envelope in the system shown while if a self-rectified or half wave generator is used, the alternate 120 cycle pulses will be omitted. Thus, it is apparent that when the condenser 31 is utilized with either a half wave or full wave circuit, the high voltage output will be pulsed at a constant value. The pulse generator 25 and an amplifier 26 are shown diagrammatically in block form coupled to the high potential triode to trigger the system in the manner hereinbefore described.

In the system shown in Fig. 2 of the drawings, the connections between the high potential transformer 14 and the X-ray tube 10 are made by means of shock proof cables 12, 13 and 17 which can constitute the capacity schematically represented by means of the condenser 31 in Fig. 3 of the drawings since each cable has a capacity to ground giving a total capacity across the high potential transformer. It is readily apparent that the pulsing portion including the pulse generator 25 and the electron control device 20 of this system may be easily connected to a conventional existing X-ray generating system by merely removing one of the cables 13 from the transformer 14 and connecting it to the high potential triode 20 and connecting another cable 17 from the high potential transformer to the other side of the high potential triode which is preferably immersed in an enclosure because of the high potential involved.

Referring now to Fig. 4 of the drawings, there is schematically shown a detailed circuit diagram of the pulse generator system that may be utilized to trigger the high potential triode 20 and apply the high potential source of energy to the X-ray tube 10. The pulse generator embodies a master oscillator indicated generally at 27 which, in the form shown, is provided with a synchronized input 28 so that it may be synchronized with any other external circuit in the system. The output of the oscillator is coupled through a saturable reactor 29 to a multiple stage amplifier 26 and to the grid 21 of the high potential triode 20. The trigger pulse could, of course, be obtained in any well-known manner. However, in the preferred form shown in the drawings, the sine wave output is taken from the master oscillator 27 through the saturable reactor 29 which those skilled in the art will recognize as shaping the sine wave into a series of spaced pulses which are in turn amplified to provide sufficient energy for excitation of the high potential triode 20. The amplifier output of the pulse generator 25 is coupled to the high potential triode trigger tube 20 through a transformer 32 which is insulated against the high potential. There is also provided a fixed negative bias for the triode trigger tube which may be obtained, as shown, from a 60-cycle source by

means of another insulated transformer 33 so that the triode tube will not conduct until it is triggered.

In the preferred embodiment shown, the circuit components and their lumped constants are designed to provide a master oscillator 27 having a frequency range from 500 cycles to approximately 20 kilocycles and the saturable reactor 29 is made variable to assist varying the pulse width over a range of approximately 5 to 50 micro seconds. These variables enable a variation in the duty cycle, that is, the ratio between the time duration of each pulse and the interval of time between successive pulses, from 1 to 15, thereby providing a wide range of operation for controlled variation in accordance with the subject matter and the desired results. The resistance R-1 in the plate circuit of the oscillator is made variable to vary the frequency over the range indicated and the resistance R-2 in the output circuit of the oscillator is also made variable to assist the variable saturable reactor in varying the pulse width in accordance with the desired range.

Thus, there has been provided a method and apparatus for exposing a subject to a predetermined safe quantity of X-ray radiation energy over a predetermined exposure time interval by intermittent application of X-rays at an increased intensity during such exposure time interval which enables an increased screen luminosity and image amplification as well as an improved scanning performance on a fluoroscopic screen.

I have shown and described what I consider to be the preferred embodiments of my invention along with suggestions of modified forms, and it will be obvious to those skilled in the art that other changes and modifications, particularly with respect to the detailed performance of the system of this invention, may be made without departing from the scope of my invention as defined by the appended claims.

I claim:

1. An apparatus for periodically connecting an X-ray generator to a source of electrical energy during a predetermined exposure time interval comprising, an electron device having a control electrode, means for operatively connecting said device between the source and the generator, means for biasing said control electrode in a manner to isolate the generator from the source, an oscillator for supplying a periodic control potential, a saturable reactor operatively coupled to the output of said oscillator to shape the periodic control potential into spaced pulses, means for amplifying the pulsed output and coupling it to the control electrode of said electron device in a manner to periodically remove the isolating bias therefrom, thereby periodically energizing the X-ray generator during the predetermined exposure time interval.

2. The apparatus of claim 1 including means for varying the shaping action of said saturable reactor to vary the ratio of the time duration of the pulse to the time interval between pulses from a one-to-one ratio to a one-to-fifteen ratio.

3. The apparatus of claim 1 including means for varying the periodic output of the oscillator over a frequency range from 500 cycles to 20 kilocycles and including other means for controlling the shaping action of the saturable reactor to vary the ratio of pulse duration to the interval between pulses over a duty range from a one-to-one ratio to a one-to-fifteen ratio.

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