Sept. 25, 1962 E. A. BURRILL 3,056,025

SCANNING IN RADIOGRAPHY

Filed Jan. 16, 1961

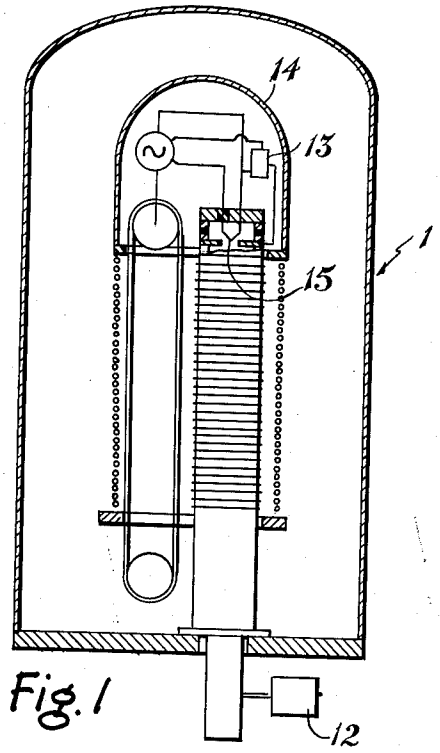


Fig. 1

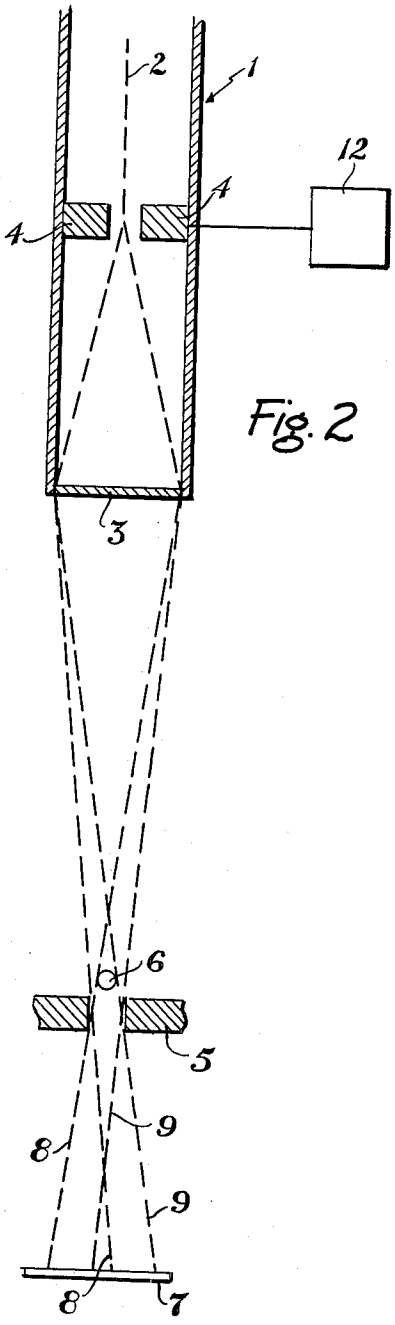


Fig. 2

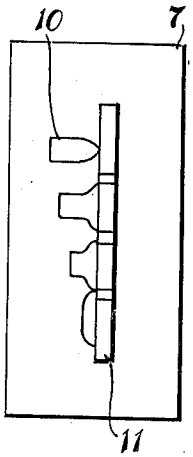


Fig. 3

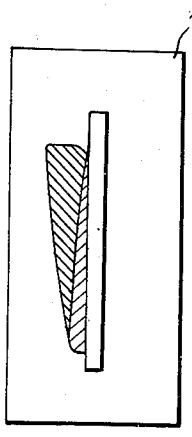


Fig. 4

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SCANNING IN RADIOGRAPHY

Ernest A. Burrill, Weston, Mass., assignor to High Voltage Engineering Corporation, Burlington, Mass., a corporation of Massachusetts

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2 Claims. (Cl. 250—65)

This invention relates to radiographic X-ray machines, and in particular to means for enabling such a device to take a series of flash radiographic exposures of or for continuous recording of motion. In accordance with the invention, this is accomplished by a particular type of scanning device which could either take a series of time-spaced flash exposures or else a continuous recording of motion during the scanning cycle.

The invention may best be understood from the following detailed description thereof, having reference to the accompanying drawings in which:

FIG. 1 is a diagram illustrating a representative radiographic X-ray unit;

FIG. 2 is a somewhat diagrammatic indication of the scanning arrangement of the invention;

FIG. 3 indicates one possible result of a series of exposures;

FIG. 4 indicates one possible result of a continuous exposure.

Referring to the drawings, the radiographic unit shown at 1 in FIGS. 1 and 2 may comprise an electrostatic accelerator of the type disclosed in an article entitled "Electrostatic Generators for the Acceleration of Charged Particles," by Van de Graaff, Trump and Buechner, in Reports on Progress in Physics, vol. XI, p. 1, 1948, and in U.S. Patents Nos. 1,991,236 and 2,252,668. However, the invention is not limited to any particular type of electron accelerator. As in any radiographic machine using an electron accelerator, an electron beam 2 comprising electrons which have been accelerated to high energy are allowed to strike a target 3 of high atomic number, such as gold, lead, tungsten, etc., and X-rays are produced at the region of impact. In accordance with the invention the electron beam 2 is deflected by a suitable scanning device, such as the scanning coils shown at 4 in FIG. 2, which imparts a scanning movement to the electron beam before it impinges upon the target 3. The extent of the deflection might be eight degrees, for example, with a target 3 having a length of 15 inches. The scanning coils 4 might provide, for example, a 100-microsecond sweep. A collimating slit 5 of high density material (such as, for example, lead or uranium) is placed, as shown in FIG. 2, between an object 6 being radiographed and the radiographic film intensifying screen combination 7. The extreme rays of the X-ray beam are indicated at 8 and 9, and in a representative device the distance between the target 3 and the lead collimating slit 5 might be twice that of the distance between the lead collimating slit 5 and the film screen combination 7. The object 6 being radiographed might, for example, be 1 inch high and might be placed a distance of $1.75x$ from the target 3, where x is the distance between the lead collimating slit 5 and the film screen combination 7. With the figures and geometries given, the slits must be 1.5 inches wide in which event the image of the slit at the film 7 would be 1.7 inches high. If the distance at the film 7 between the center lines of the extreme beams 8, 9 is 7.5 inches, then the total film length would be 9.2 inches.

The motion of the object 3 shown in FIG. 1 is perpendicular to the plane of the drawing during the exposure interval or intervals. If the electron beam 2 is pulsed, a series of flash radiographic exposures will be

shown by the film 7, as indicated by FIG. 3, which is a shadowgram and hence shows the pictorial result on a film which has recorded a bullet or other projectile 10 striking a barrier 11. If the electron beam 2 is not pulsed, the pictorial result of the event pictured in FIG. 3 would be modified to the form shown in FIG. 4 which illustrates a shadowgram on film similar to that of FIG. 3. In the above example 5.5 flash exposures would be obtainable without overlap. Assuming therefore 5 exposures equally spaced during the 100 microsecond interval of the scanning cycle or sweep, one could have one exposure every 20 microseconds with a total exposure time of 5 microseconds at a flash length of 1 microsecond each. With such an arrangement one would have to modulate the cathode for a 1-to-twenty duty cycle. This could be done by suitable circuitry between the scanning circuit 12 and the grid bias control 13; alternate methods are disclosed in U.S. patent application Serial No. 93,169, filed March 3, 1961, and assigned to the assignee of the present invention.

It is important to consider what charge can be available during this 100 microsecond interval, since the charge during the flash exposure must come from the charge stored in the terminal 14. If the terminal capacitance is assumed to be 50 micro-microfarads and if it is assumed that a terminal voltage drop of 0.5 mev. is permissible, then a total of 25 microcoulombs are available which, divided up into five flashes, is 5 microcoulombs per flash. A $\frac{3}{16}$ of an inch gold target will furnish 1.25 roentgens at 100 centimeters per 250 microcoulombs at 2 mev. Thus each 5 microcoulombs furnishes 25 milliroentgens. The roentgen production can be doubled by going from 2 to 2.5 mev. since the increase in roentgen production varies as the third power of the voltage ratios. Thus at 2.5 mev. you would get 50 milliroentgens for each 5-microcoulomb pulse. Moreover, if the terminal capacitance can be increased by a factor of two, one would get 100 milliroentgens per ten-microcoulomb pulse, the charge having been increased by the increase in the capacitance. It may be assumed that 5 milliroentgens are needed to blacken radiographic film with available fluorescent intensifying screens and if the distance from the target to the film is 8 feet, then the 100 milliroentgen figure mentioned above would furnish 22 milliroentgens at the film, which is four times the amount needed to blacken film. Therefore two half-value-layer thicknesses of absorber can be interposed as the object 6, or roughly 1.6 inches of steel or equivalent.

With 1-microsecond bursts at 10 microcoulombs per burst, one would have ten amperes in the burst. This can be furnished by a heated filament 15. Conventional kinds of grid bias for pulsing 1 microsecond at 20 microsecond intervals are possible. $\frac{1}{20}$ of a microsecond is equal to 50,000 cycles per second. The sweep frequency of the scanner might therefore be 1 per 100 microseconds or 10,000 cycles per second. It is necessary to synchronize the sweep and pulse train with the proper stage in the traverse of the object 6.

Having thus described the principles of the operation together with several illustrative embodiments thereof, it is to be understood that although specific terms are employed, they are used in a generic and descriptive sense and not for purposes of limitation, the scope of the invention being set forth in the following claims.

I claim:

1. A radiographic machine comprising in combination, a target adapted to produce X-rays upon bombardment by high-energy electrons, means for accelerating electrons to high energy and directing them onto the target as an electron beam, X-ray-indicating means spaced from said target, a collimating slit between said target and said X-ray-indicating means, and means for

scanning said electron beam over said target, whereby the X-ray source moves along a line transverse to the line aperture of said slit, whereby said X-ray-indicating means is adapted to indicate the progressive state of an object traveling near said collimating slit along its line aperture.

2. A radiographic machine comprising in combination, a target adapted to produce X-rays upon bombardment by high-energy electrons, means for accelerating electrons to high energy and directing them onto the target as an electron beam, X-ray-indicating means spaced from said target, a collimating slit between said target and said X-ray indicating means, means for scanning said electron beam over said target, whereby the X-ray source moves along a line transverse to the line aperture of said slit, and means for pulsing said electron beam during its motion over said target, whereby said X-ray-indicating means is adapted to indicate a plurality of states, closely time-spaced, of an object traveling near said collimating slit along its line aperture.

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