**June 1, 1954** M. S. ABEL **2,680,199**

RADIOGRAPHIC METHOD AND APPARATUS

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*Fig. 1*

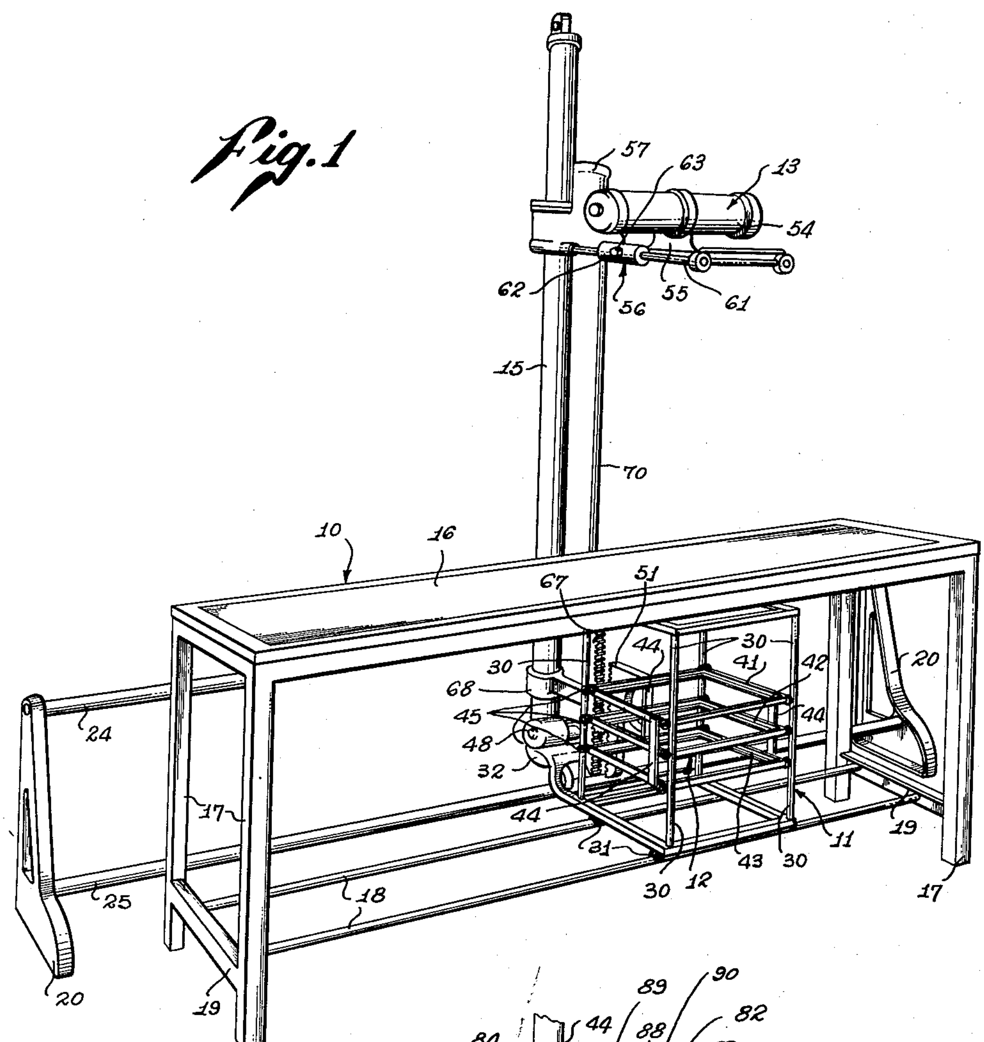


*Fig. 1A*

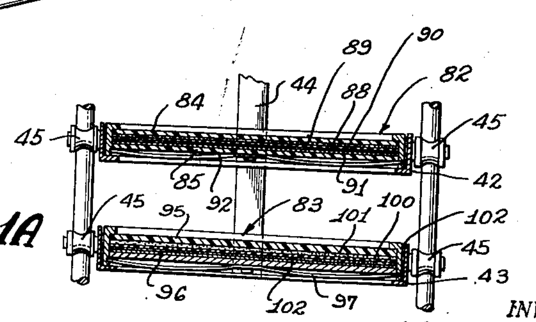


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Fig. 2

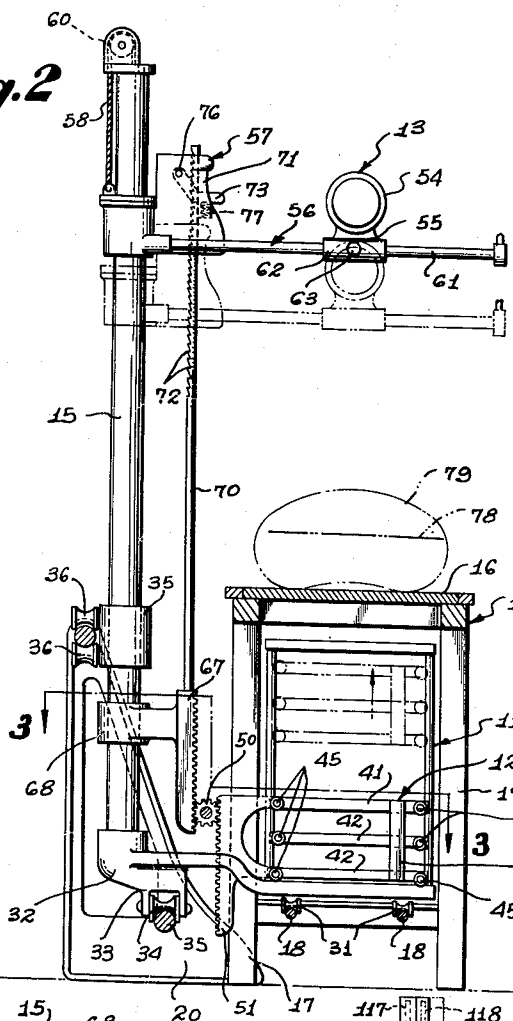


Fig. 5

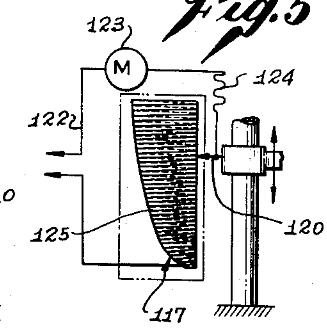


Fig. 3

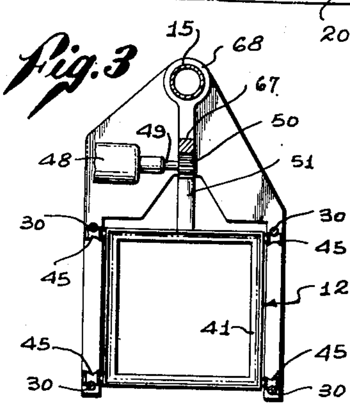


Fig. 4

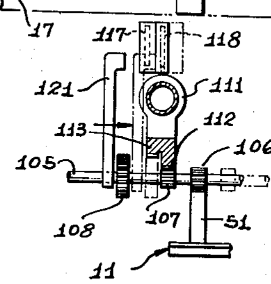


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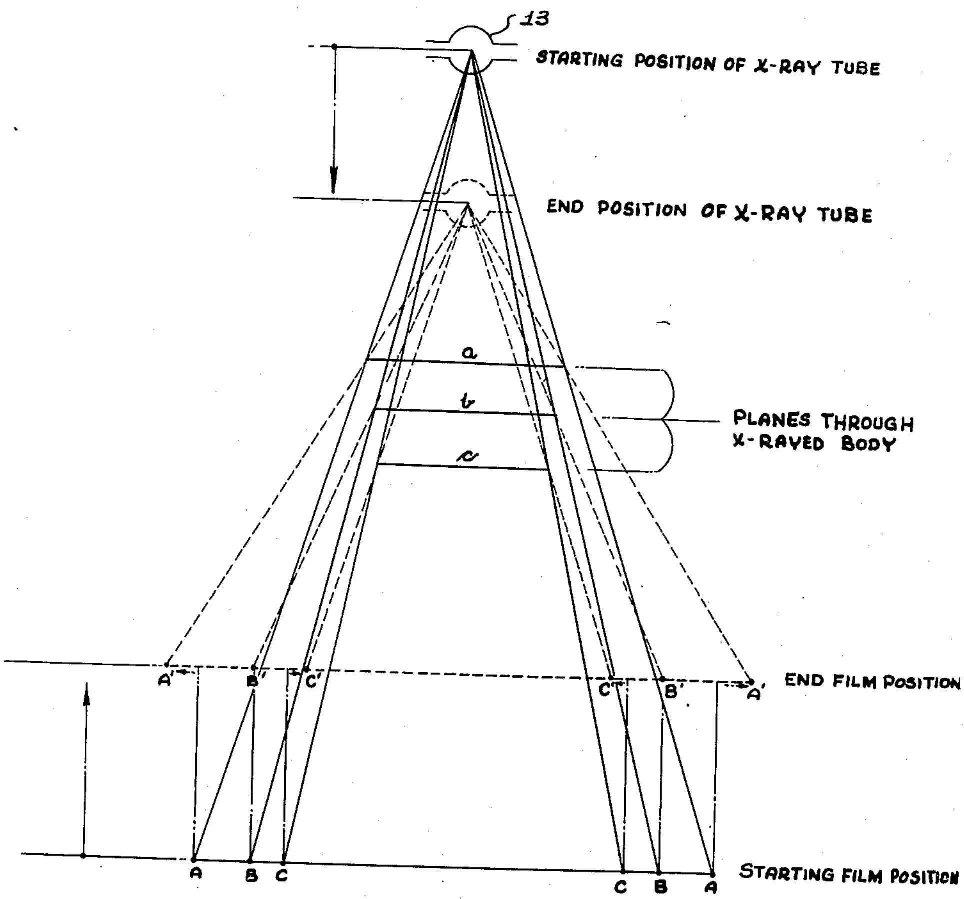
Fig. 6

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# UNITED STATES PATENT OFFICE

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## RADIOGRAPHIC METHOD AND APPARATUS

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Application March 18, 1952, Serial No. 277,253

16 Claims. (Cl. 250—58)

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This invention relates to a method of and an apparatus for making radiographs of body sections. The invention is based on a new technique for securing the virtual focus of X-rays or other radiation and its principles are applicable to fluoroscopic as well as radiographic procedures.

It is well known in the art that virtual focusing of X-rays with respect to a selected plane of a body may be accomplished by placing an X-ray source at a position spaced from one side of the body and a radiation-sensitive medium at a position spaced from the other side of the body to receive an image of the body structure projected by the source, and then simultaneously shifting the source and medium laterally in opposite respects in a controlled manner to keep the image of a selected body plane constant on the medium while causing the images of all other body planes to shift laterally across the medium. The result is sharp image definition of body structure in the selected plane and through blurring of images of all other body planes, even planes immediately adjacent the selected plane.

While a radiograph resulting from such a procedure is highly informative with respect to structure in the selected plane, in many instances such exceedingly sharp selectivity is a serious disadvantage.

For example, the object of the body section radiograph may be to disclose information about the position, size and configuration of a possible lesion. If the body plane selected for the radiograph just misses the lesion the radiograph will afford no indication whatsoever of the existence of the lesion and additional exploratory body section radiographs will be necessary. On the other hand, if the selected plane passes through the lesion, the radiograph image will be restricted to two-dimensional information about a three-dimensional condition and a series of additional radiographs will be necessary for adequate visualization of the form of the lesion, especially if the lesion is of substantial size. Thus, the limitation of the usual body section radiograph to data about a single body plane too often results in the necessity for numerous additional radiographs. A series of radiographs is not only expensive but also objectionable as possibly involving over exposure of the patient to radiation.

A further disadvantage inherent in conventional body section techniques is that excessive lateral shifting of images outside the selected plane not only distorts relationships excessively but also introduces factitious artifactual image elements, which are linear or annular according

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to the character of the relative movement of the radiation source and the sensitive medium that is used to achieve the focus effect. These added image elements are often confusing and may lead to serious errors in diagnosis.

The general object of the present invention is to obtain body section radiographs that provide appreciable useful three-dimensional data in the radiograph image. More specifically stated, the broad object of the invention is to achieve a compromise between a non-body section radiograph having very little differentiation with respect to body planes and a conventional body section radiograph restricted substantially to a single plane of the body.

A new technique for obtaining body section radiographs is contemplated that will provide sharply focused detail in a selected body plane and details that are gradually less sharply focused in planes progressively removed from the selected plane in both directions. In other words, the improvement lies in achieving a broad "focus" peak with respect to a series of successive body planes as distinguished from a sharp "focus" peak limited to a single body plane.

In general, this object is attained by placing a point source of radiation on one side of a body at a position on a line perpendicular to a selected plane of the body, positioning a radiation-sensitive medium parallel to said plane at a location on the same line on the other side of the body and then during an exposure period moving both the source and the medium simultaneously along this line in a manner to keep the image of the selected body plane constant on the medium while causing the images of all other body planes to change in magnification. Thus the difference in "focus" effect that distinguishes among the different planes resides in change in magnification as distinguished from extensive lateral shifting of unwanted images. The new difference is difference in degree, not complete obliteration of details in planes other than the selected plane.

The desired result is obtained by initially positioning the point source and the medium with a given ratio between the distance from the radiation source to the selected body plane and the distance from the selected body plane to the medium, and then regulating the movements of the source and the medium, respectively, to maintain this ratio throughout the exposure period thereby to maintain constant magnification of body structure in the selected plane. The simultaneous movement of the source and the medium may be either towards or away from the body.

It will be readily understood that while magnification in the selected plane remains constant, magnification of images in other planes will vary in accordance with the distance of such planes from the selected plane. Thus the images of the other body planes will be less sharply defined in accord with the distance of the planes from the selected plane. As will be explained, if the radiation source and the sensitive medium are moved simultaneously towards the body during the exposure period, images in body planes between the selected plane and the source will, in effect, contract during the exposure period while images in body planes spaced towards the sensitive medium will, in effect, expand.

It is inherent in the new technique that while loss in sharpness by change in magnification is progressive in both directions from the selected plane the loss is less rapid in the direction towards the sensitive medium and this fact may be taken into consideration to advantage. For example, in making an exploratory body section radiograph where there is reason to believe that the suspected lesion is at a certain level, the selected plane for the radiograph may be chosen at a somewhat higher level than the suspected level since a given degree of loss in sharpness caused by change in magnification will extend for a greater distance below the selected plane than above the selected plane.

Since the exposure time required to produce an image of a given intensity on a radiation-sensitive medium such as a film varies inversely as the square of the distance of the sensitive medium from the radiation source, it is apparent that uniform movement of the light source and medium towards each other throughout an exposure period will result in progressively increased intensity of exposure throughout the period. A further object in the preferred practice of the invention, therefore, is to equalize the intensity of exposure throughout the exposure period. This object is accomplished by progressively varying the rate of relative movement between the radiation source and the sensitive medium throughout the exposure period, the purpose being to vary the rate of relative movement in inverse relationship to the distance between the source and the sensitive medium so that the intensity of exposure will be substantially constant throughout the exposure period.

A further important object of one practice of the invention is to produce multiple body section radiographs with a single exposure of the body to radiation. This practice makes it possible to produce two or more simultaneous radiographs centered on two selected parallel body planes. As will be explained, the new technique may be employed to project two images simultaneously on two parallel spaced sensitive mediums with one image projected through one of the mediums onto the other medium. It is a simple matter to maintain constant magnification of both images during relative movement between the radiation source and the two sensitive mediums.

It is a further object of the invention to provide an efficient and highly flexible apparatus for carrying out the described technique. In regard to efficiency, a feature of the preferred embodiment of the apparatus is the utilization of power-actuated means to cause the required relative movements of the radiation source and sensitive medium in a controlled and automatic manner. With reference to flexibility a further object is to make the apparatus adjustable in various respects. It is contemplated that the apparatus will be adjustable with reference to the scale of magnification of images of the selected body plane, adjustable with respect to the selection of body sections, adjustable for the production of multiple simultaneous images, and adjustable with respect to the manner in which the speed of relative movement changes for balanced exposure throughout the exposure period.



The various objects and advantages of the invention will be further understood from the following detailed description considered with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative,

Fig. 1 is a perspective view of the presently preferred embodiment of the invention;

Fig. 1*a* is a fragmentary detail showing in section two spaced cassettes for the simultaneous production of two body section radiographs;

Fig. 2 is a view of the apparatus partly in section and partly in end elevation;

Fig. 3 is a section taken as indicated by the broken line 3—3 of Fig. 2;

Fig. 4 is a fragmentary view similar to Fig. 3 indicating how the preferred embodiment may be modified;

Fig. 5 is a more or less diagrammatic view showing how a special rheostat may be used for speed control to achieve the desired exposure equalization; and

Fig. 6 is a diagram explaining how images of body planes above and below the selected body plane change in magnification in the course of an exposure period.

The principal parts of the embodiment shown in Figs. 1, 2 and 3 include an X-ray table generally designated **10**, a horizontally movable carriage generally designated **11**, a holding means or cassette holder generally designated **12** that is mounted on the carriage for vertical movement, a source of radiation generally designated **13**, and a tubular standard **15** that supports the radiation source above the level of the X-ray table **10**.

The X-ray table **10** on which a person may recline for the purpose of making a radiograph has a horizontal top **16** supported by legs **17** and is provided with a pair of parallel longitudinal rods **18** supported by cross members **19** at each end of the table. The purpose of the two rods **18** is to serve as rails for the horizontally movable carriage **11**. The apparatus also includes an auxiliary support frame in the form of two upright frame members **20** interconnected by upper and lower horizontal rods **24** and **25**, respectively, upon which the upright standard **15** is mounted.

The carriage **11** is in the form of a rectangular or box-like frame that includes four upright corner rods **30**. The bottom of the carriage is provided with suitable rollers **31** with concave peripheries to conform with the circular configuration of the rails **18** on which the rollers rest to support the carriage. Extending rearward from the carriage **11** as a fixed part thereof is a suitable base member to which the tubular standard **15** is attached. This base member **32**, which may be in the form of a casting, includes a downwardly extending bracket **33** in which is mounted a concave roller **34** to ride on the lower rod **25** of the auxiliary frame. To insure stability of the horizontally movable structure on the two rails **18** and the lower rod **25**, the standard **15** is provided with a fixed collar **35** that carries a pair of concave rollers **36** to movably engage the upper rod **24** of the auxiliary frame from opposite sides as shown in Fig. 2. It may be desirable to further insure stability by anchoring the upper end of the standard 15 to a solid wall.

The cassette holder 12 may comprise three open shelves or rectangular frames 41, 42 and 43 fixedly interconnected in vertical alignment by side bars 44. Each of the shelves 41, 42 and 43 is made of angle members and is dimensioned to serve as a seat for a cassette containing a radiation-sensitive medium in the form of X-ray film. For vertical movement in the carriage 11 the multiple-level cassette holder 12 is provided with concave rollers 45 in rotary engagement with the four upright corner rods 30 of the carriage.

Any suitable means may be provided for moving the cassette holder 12 of the radiation source 13 simultaneously in a predetermined manner. In the particular embodiment of the invention shown in the drawings, a suitable motor 48 is provided for this purpose and, as shown in Fig. 3, has a motor shaft 49 on which is mounted a suitable drive pinion 50. The cassette holder 12 is operatively connected with the drive-pinion 50 by a suitable rack member 51 that is fixedly mounted on the rear side of the holder.

The radiation source 13 comprises a focal spot Roentgen-ray tube (not shown) in a tubular housing 54, the focal spot of the tube being on the order of 0.3 mm. which is small enough to approximate a point source of X-radiation. The tubular housing 54 includes a downwardly directed cone 55 through which the radiation is directed and the housing is suitably mounted for horizontal adjustment on a bracket, generally designated 56. The bracket 56 includes a bracket body 57 that slidingly embraces the tubular standard 15 and is connected to a counterweight cable 58. The cable 58 passes over a small sheave 60 at the top of the tubular standard 15 and in a well known manner is connected to a suitable counterweight (not shown) that is movable up and down inside the standard. The bracket 56 includes a pair of spaced horizontal rods 61 mounted in the bracket body 57 and the housing 54 of the X-ray source is slidingly mounted on the two rods 61 by suitable sleeves 62. The sleeves 62 may be provided with suitable screws 63 to releasably immobilize the housing 54 on the two rods 61 at desired positions.

Any suitable arrangement may be employed to operatively connect the drive pinion 50 with the bracket 56 for vertical actuation of the radiation source 13. In the particular construction shown in the drawings a vertical rack member 67 in mesh with the drive pinion 50 is mounted for vertical movement by a sleeve 68 that slidingly embraces the tubular standard 15. Extending upwardly from the rack member 67 is an operating rod 70 that is connected to the bracket 56, preferably in an adjustable manner.

In the present construction, the upper end of the operating rod 70 extends through a forward projection 71 of the bracket body 57 and is formed with a series of ratchet teeth 72 for engagement with a latch member 73. The latch member 73, which is pivoted at 76 is normally pressed upward by a concealed spring 77 for normal engagement with a selected ratchet tooth 72. The bracket 56 may be adjusted vertically with respect to its point of connection with the operating rod 70 by depressing the latch member 73 to a release position. Thus the vertical distance between the bracket 56 and the rack member 67 in engagement with the driving pinion 50 may be varied at will.



The mode of operation of the described apparatus may be readily understood from the foregoing description. With a person reclining on the X-ray table for the purpose of making a radiograph it is a simple matter to shift the carriage 11 along with the tubular standard 15 to any desired position longitudinally of the table. A cassette containing an X-ray film is placed on one of the shelves 41, 42 and 43 of the cassette holder and the apparatus is adjusted for a starting position with a given starting ratio between the distance from the source of radiation to the selected horizontal plane of the patient's body and the distance from that plane to the radiation-sensitive film in the cassette below the tabletop. For example, the ratio selected may be 1:1 to provide an image of the X-ray film that doubles the linear dimensions of the body structure in the selected body plane.

The starting positions of the point source of radiation and the cassette holder may be either at their maximum distances or their minimum distances of separation, preferably the former. In Fig. 2 the apparatus is shown adjusted with the radiation source at its upper-limit position and the cassette holder at its lower-limit position. With the cassette mounted on the lower shelf 43, a selected plane 78 in the patient's body 79 is exactly half way between the film in the cassette and the point source of radiation in the housing 54. To make an exposure, the X-ray tube is energized to project an image of the patient's body structure on the film in the cassette and at the same time, or slightly before, the motor 48 is energized to actuate the drive pinion 50 counterclockwise as viewed in Fig. 2. The rotation of the drive pinion lowers the radiation source and simultaneously raises the X-ray film at uniform rate or at variage equal rates throughout the exposure period. The result will be a body section radiograph of the character described.

The manner in which the projected image of the body structure on the radiation-sensitive medium changes in magnification with reference to body planes above and below the selected plane is explained graphically by the diagram in Fig. 6. With the starting position of the point source of radiation at the upper limit position shown in full lines Fig. 6 and with the starting position of the radiation-sensitive film at the lower limit position represented by the lowest horizontal line, the distance from the radiation source to the selected plane represented by the short horizontal line *b* is equal to the distance from the selected plane to the lower limit starting position of the film. The starting image of the short line *b* on the film will be the line B—B. When the radiation source has dropped to the lower limit position indicated in dotted lines and the film has simultaneously moved upward to its upper limit position indicated by the horizontal dotted line, the image of line *b* at the new position of the film is B'—B', the final image line B'—B' having the same length and the same position on the film as the starting image B—B.

The image of a line *a* in a body plane higher than the selected plane expands from the image length A—A at the starting position of the film to the length A'—A' at the final position of the film, the expansion of the line representing change in magnification and being indicated by arrows at the final film position. It is apparent that the arrows represent a penumbra that will be formed around the image A—A in the final radiograph.

The initial image of a line c in a body plane below the selected plane is the line C—C at the starting position of the film, but this line contracts to the length C′—C′ at the final position of the film as indicated by the inwardly directed arrows. The inwardly directed arrows represent the dimension of a penumbra that would be formed around an image C′—C′ in the final radiograph.

The extent to which these penumbras form around images of body structure in planes outside the selected plane is not so great as to detract seriously from their identification. The relative magnitudes of the penumbras may be appreciated by considering typical dimensions. For example, suppose the initial position of the point source is 25 inches from a selected body plane in one direction and the film is 25 inches distant in the other direction and both the source and the medium move 10 inches towards the body in the course of exposure of the film to radiation from the source, the movement of both being uniform during the exposure period.

The dimensional magnification on the film of structure at the selected body plane will be double throughout the exposure period since the ratio of the two distances involved is constant at 1:1 throughout the exposure period. Thus, one inch square of body structure in the selected plane will produce a two-inch square image on the film.

The starting ratio of distances for a body plane five inches above the selected plane will be 2:3 and the final ratio will be 1:2, since the starting distances of the source and film from the upper plane will be 20 inches and 30 inches, respectively, and the final distances will be 10 inches and 20 inches, respectively. Thus the starting image on the film of a 1″ x 1″ square area of body structure in the upper plane will be a 2½″ x 2½″ square and during the exposure period this image will increase in size to a 3″ x 3″ square.

With respect to a body plane 5 inches below the selected mid-plane, the distance ratio will change from 3:2 to 2:1 in the course of the exposure period since at the start the lower plane will be 30 inches from the source and 20 inches from the film and at the end of the exposure period the lower plane will be 20 inches from the source and only 10 inches from the medium. As a result, a 1″ x 1″ square area of body structure in the lower plane will produce an image 1⅔″ x 1⅔″ square on the film at the beginning of the exposure period and this image will contract to a 1½″ x 1½″ square on each side at the end of the exposure period.

It will be readily understood in the above example that the image of the one-inch square of body structure in the selected plane will be a clear-cut 2″ x 2″ square on the film. The 1″ x 1″ square of body structure in the upper plane will appear as a 2½″ x 2½″ square surrounded by a ¼″ penumbra and the image of the 1″ x 1″ square of body structure in the lower plane will be a 1½″ x 1½″ square surrounded by a $\frac{1}{12}$″ penumbra.

The wide flexibility of the apparatus with respect to the choice of body planes may be appreciated by considering the following specific dimensions that may be employed in a typical embodiment of the invention. It is contemplated that the range of movement of each of the two rack members 51 and 67 will be 12 inches, the radiation source moving downward 12 inches while the cassette holder moves upward 12 inches at the same uniform rate during an exposure period. It is further contemplated that the three open shelves 41, 42 and 43 will be spaced apart two inches vertically and that the upper shelf 41 will position the film thereon exactly 19 inches below the surface of the X-ray table 10 when the cassette holder is at its lower limit position. Thus with reference to the upper surface of the X-ray table the top shelf 41 will be movable between two positions 19 inches and 7 inches, respectively, from the tabletop, the middle shelf 42 will be movable between positions 21 inches and 9 inches, respectively, from the tabletop and the bottom shelf 43 will be movable between positions 23 inches and 11 inches, respectively, from the tabletop. It is further contemplated that the engagement of the latch member 73 with the operating rod 70 will be adjusted to position the point source of radiation at any of the following starting positions as measured upward from the tabletop: 32 inches; 30 inches; 28 inches; 26 inches; and 24 inches.

When the apparatus is constructed with the above dimensional relationships a radiograph may be made for selected body planes ranging from ½ inch above the tabletop to 6½ inches in half-inch steps. When the point source of radiation is adjusted at the upper limit starting position 32 inches above the tabletop and the cassette holder is at its lower limit position, the film positions represented by the three shelves 41, 42 and 43, respectively, "focus" on body planes 6½ inches, 5½ inches, and 4½ inches, respectively, above the surface of the X-ray table. Thus a cassette may be placed on any one of the three shelves to produce a radiogram centered on the corresponding body plane above the tabletop.

If the adjustment of the starting position of the point source of radiation is changed from 32 inches to 30 inches above the tabletop the planes of "focus" corresponding to the three shelves 41, 42 and 43 will be 5½ inches, 4½ inches, and 3½ inches, respectively, above the tabletop. In like manner, a starting position of the radiation source of 28 inches above the tabletop will fix the three selected "focus" planes at 4½ inches, 3½ inches, and 2½ inches, respectively, above the tabletop; starting the light source at 26 inches will determine planes at 3½ inches, 2½ inches, and 1½ inches, respectively; and, finally, lowering the starting point of the radiation source to 24 inches fixes the three planes at 2½ inches, 1½ inches and ½ inch, respectively, above the tabletop.

Fig. 1a indicates how two or more cassettes may be placed on the cassette holder 12 to make a corresponding number of radiographs simultaneously. For example, with the apparatus adjusted with the point source of radiation at the starting upper limit position 32 inches above the tabletop, cassettes 82 and 83 may be placed on shelves 42 and 43, respectively, to make radiographs of body sections 5½ inches and 4½ inches above the tabletop, respectively.

The upper cassette 82 has top and bottom walls 84 and 85, respectively, of a material that will permit radiation to be transmitted therethrough to the lower cassette 83. The material may be any suitable plastic. The radiation-sensitive film 88 in the cassette is sandwiched between an upper intensifying screen 89 and a lower intensifying screen 90. A sheet of aluminum foil 91, or other suitable material, is placed under the lower intensifying screen 90 to stop selectively the soft scattered radiation which is generated at secondary sources and tends to fog the film. The usual leaf-spring members 92 are made of plastic material to avoid interference with the transmission of the radiation to the lower cassette.

Lower cassette 83 is of the same general construction as the upper cassette, being provided with a top wall 95 of plastic material, but has a bottom wall 96 which may be made of métal and the leaf spring members 97 below the bottom wall may also be made of metal. The film 100 in the lower cassette is sandwiched between two intensifying screens 101 and 102. The various intensifying screens in the two cassettes are selected to equalize the response of the two films to the radiation, thus compensating for the different distances of the two films from the radiation source as well as the losses incurred by the radiation in passing through the upper cassette.

It is apparent that when the apparatus is operated in the described manner with the two cassettes 82 and 83 in position the result will be two radiographs centered on body planes spaced one inch apart and since the resulting radiographs will reveal structure both above and below the planes on which they are centered the two radiographs taken together will give specific information about body structure through a considerable range of levels. Thus the two radiographs taken in one exposure period are equivalent in interpretative value to a large number of conventional body-section radiographs which would require a correspondingly large number of successive exposures.

The modification of the invention indicated by Figs. 4 and 5 includes the substitution of a motor shaft 105 for the previously mentioned motor shaft 49. The motor shaft 105 is longitudinally movable and carries three pinions 106, 107 and 108, the two pinions 106 and 107 being identical with the previously mentioned drive pinion 50 and the pinion 108 being of larger diameter. The previously mentioned sleeve 68 that is slidingly mounted on the tubular standard 15 is replaced by a sleeve 111 which is unitary both with a rack member 112 adapted to releasably mesh with the pinion 107 and a second rack member 113 that is dimensioned to releasably mesh with the larger pinion 108.

The purpose of this modified arrangement is to permit a predetermined change in the speed of movement of the radiation source relative to the speed of movement of the cassette holder to afford a choice of two degrees of image magnification of the body structure in the selected plane. Thus if the starting distance of the radiation source from the selected plane is greater than the starting distance of the radiation-sensitive film from the selected plane it will be necessary to lower the radiation source at a faster rate than the upward speed of the film to maintain the starting ratio throughout the period of exposure.

In the longitudinal position of the motor drive shaft 105 shown in full lines in Fig. 4 pinion 106 is in mesh with the rack member 51 that controls the vertical movement of the cassette holder 12 and the pinion 107 of the same size is in mesh with the rack member 112 to control the downward movement of the radiation source. It is apparent that this adjustment of the drive shaft 105 will cause movement of the light source and film at equal rates and therefore will be used when the starting distance from the radiation source to the selected body section is equal to the starting distance from the selected body section to the film. If the starting distance from the radiation source to the selected body section is greater than the starting distance from the selected body section to the film it will be necessary to lower the radiation source at a higher speed to maintain the starting ratio. For this purpose the drive shaft 105 will be shifted longitudinally to the dotted line position of Fig. 4 thereby to shift pinion 107 into mesh with rack 51 and simultaneously shift the larger pinion 108 into engagement with the rack member 113. It is apparent that in this new position rotation of the shaft 105 will cause the radiation source to move downward at a faster rate than the upward movement of the cassette holder.



A further modification of the invention indicated by Figs. 4 and 5 is the use of a variably wound rheostat to vary the speed of operation of the motor shaft 105 in inverse relationship to the square of the changing distance between the radiation source and the film. As indicated in Fig. 4, it is contemplated that two such rheostats 117 and 118 will be mounted adjacent to the movable sleeve 111 for cooperation alternately with a movable contact 120 (Fig. 5) on the sleeve. It is further contemplated that the two rheostats 117 and 118 will be mounted side by side in a yielding manner with rheostat 118 in vertical alignment with the movable contact 120 as shown in Fig. 4. When the drive shaft 105 is shifted from its full line position in Fig. 4 to its dotted line position a suitable finger 121 moves with the shaft and impinges against the two yieldingly mounted rheostats 117 and 118 to shift the rheostat 118 to the dotted position shown in Fig. 4 thereby shifting the rheostat 117 into position for electrical cooperation with the movable contact 120.

As indicated diagrammatically in Fig. 5 one lead 122 is connected to one side of a variable speed motor 123 and a second lead 124 connects the other side of the motor with a movable contact 120 to place the winding 125 of the rheostat 117 in series with the motor. It is apparent from an inspection of Fig. 5 that downward movement of contact 120 synchronous with downward movement of the radiation source progressively reduces the portion of the rheostat winding 125 that is in the motor circuit with consequent acceleration of the motor. It is contemplated that the successive turns of the winding 125 that are traversed in the downward movement of the contact 120 will progressively diminish in length in accord with a curve conforming to the law of inverse squares so that the acceleration of the motor will cause the film to be exposed at a substantially uniform rate notwithstanding the fact that the distance between the radiation source and the film decreases in the course of the exposure.

It is apparent that the two rheostats 117 and 118 with different windings are required for alternate use since a different rate of acceleration will be required when the larger pinion 108 is substituted for the smaller pinion 107 for causing the downward movement of the radiation source.

From the foregoing description of various practices of the invention, the following advantages over prior methods of body-section radiography may be readily appreciated:

1. The resulting radiograph is an image of a body section of substantial thickness, there being adequate sharpness of the images of body structure on both sides of the selected plane.

2. Because of the thickness of the section that is imaged it is not necessary to predetermine accurately the level of a suspected lesion to obtain a radiograph that will afford adequate visualization of the lesion. In other words, "focusing" is not critical since any radiograph at the approximate level will reveal the lesion.

3. Because of the thickness of the section depicted by the radiograph, a lesion of more than pinpoint size extending up and down through several levels can be completely visualized as to its configuration and relative size on a single film.

4. The three-dimensional information afforded by the radiograph will reveal the relationship of a lesion to the surrounding body structure in planes both above and below the lesion.

5. No confusing factitious shadows are introduced by the method of exposing the film.

6. The new technique makes it possible to produce multiple radiographs of multiple body sections in one exposure with each radiograph of the same quality and interpretative value.

My description of preferred practices of the invention in specific detail will suggest to those skilled in the art various changes, substitutions and other departures from my disclosure that properly lie within the scope and spirit of the appended claims.

I claim:

1. A method of making a radiograph of a selected section through a body which includes the steps of: positioning a point source of radiation on one side of said body on a line perpendicular to a selected plane in the body section positioning a radiation-sensitive medium substantially parallel to said plane at a location on said line on the other side of said body with a given ratio between the distance of the source from the selected plane and the distance of the medium from the selected plan; exposing said medium to radiation from said source; and during such exposure continually changing the distance between said point source and said medium by moving the point source and medium relative to each other along said line at rates that maintain said given distance ratio whereby the magnified image of the body structure at said plane produced on said medium remains constant during the exposure period and the images corresponding to other planes change in magnification.

2. A method as set forth in claim 1 in which the rates of movement of said source and said medium are varied substantially inversely as the distance between the source and medium thereby to equalize the exposure of the medium for the different distances.

3. A method of making radiographs of a structure at a plurality of selected parallel planes of a body, including the steps of: positioning a point source of radiation on one side of said body on a line perpendicular to said planes; positioning a plurality of radiation-sensitive mediums corresponding to said sections and parallel to said planes at spaced positions along said line at the other side of said body with a given starting ratio for each plane with respect to the distance from the plane to the corresponding medium and the distance from the section to the source; exposing all of said mediums to said source simultaneously with the radiation passing through one medium to another medium; and during such exposure changing the distances between the source and the mediums by moving the source and the mediums simultaneously along said line at relative rates that maintain said starting ratio for each section during the exposure period, whereby the image of the body structure at a plane that is produced on the corresponding medium remains constant in magnification during the exposure period while the images of all other planes produced on the same medium change during the exposure period.

4. A method as set forth in claim 3 which includes the use of intensifying screens of different ratings to equalize the exposures of the mediums by compensating for the differences in distance from the mediums to the radiation source and for loss of intensity by radiation by absorption in passing through a medium.

5. In an apparatus for making radiographs of a body the combination of: a point source of radiation; means to support said source at a position to one side of said body on a line perpendicular to a selected plane of the body; means to hold a radiation-sensitive medium substantially parallel with said plane at a position on said line on the other side of the body with a starting ratio between the distances of said plane from said source and said medium, respectively; and means to vary the distance between said source and said medium during an exposure period by moving said source and medium simultaneously along said line at relative rates that maintain said starting ratio whereby the magnification of images of the body at said plane remains constant during the exposure period and magnification of other planes vary with the distances of the other planes from said selected plane.

6. An apparatus as set forth in claim 5 in which said distance-varying means continually changes the rate of relative movement between said source and medium inversely as the changing distance between the source and the medium to equalize the rate exposure of the source at the various distances.

7. An apparatus as set forth in claim 5 which includes means to vary the rates of relative movement of said source and holding means in accord with different starting ratios.

8. A combination as set forth in claim 5 in which both said supporting means and said holding means are adjustable in their starting distances relative to said body.

9. In an apparatus for making radiographs of a body, the combination of: a point source of radiation; means to support said source at a position to one side of said body on a line perpendicular to a selected plane of the body; means to hold two spaced parallel radiation-sensitive mediums perpendicular to said line at spaced points along said line on the other side of the body, with a saturating ratio between the distances from one selected body plane to said source and to one of said mediums, respectively, and with the same starting ratio between the distances from a second selected body plane to said source and to the other of said mediums, respectively; and means to move both said supporting means and said holding means along said line relative to said body during an exposure period at rates that maintain said ratios thereby to maintain constant magnification of images of said selected planes on the corresponding mediums during the exposure period.

10. An apparatus as set forth in claim 9 in which said distant-varying means is adapted to progressively change the rate of relative movement between said supporting means and said holding means in inverse relation to the changing

distance between the supporting means and the holding means during the exposure period.

11. In an apparatus for making radiographs of a body, the combination: an X-ray table; a holder below the table for a radiation-sensitive medium, said holder being movable up and down; a point source of radiation; a support for said point source above the table, said support being movable up and down; power-actuated means operatively connected with said support and said holder to vary the distances therefrom to said body simultaneously and in the same manner with respect to increase or decrease of the distances and at relative rates to maintain a given starting ratio between the distance from said source to a selected plane of the body and the distance from said selected plane to said medium.

12. A combination as set forth in claim 11 in which said support and said holder are adjustable with respect to their starting distances from said body.

13. A combination as set forth in claim 11 in which said power-actuated means is adapted to vary the rates of movement of said support and said holder in inverse ratio to the changing distance between said source and said medium.



14. A combination as set forth in claim 11 in which said power-actuated means is adjustable with respect to the rates of movement of said support and said holder.

15. An apparatus as set forth in claim 11 in which said power-actuated means is adapted to change the rates of movement of said support and said holder in inverse relationship to the changing distance between the source and the radiation-sensitive medium; and in which said power-actuated means is adjustable both with respect to the starting rates of movement of said holding means and said supporting means and the rates at which said movements change in the course of on exposure period.

16. An apparatus as set forth in claim 11 in which said holder is adapted to hold a plurality of radiation-sensitive mediums in aligned parallel positions.

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