

May 5, 1942.

G. FRANK

2,281,931

X-RAY APPARATUS

Filed June 27, 1939

5 Sheets-Sheet 1.

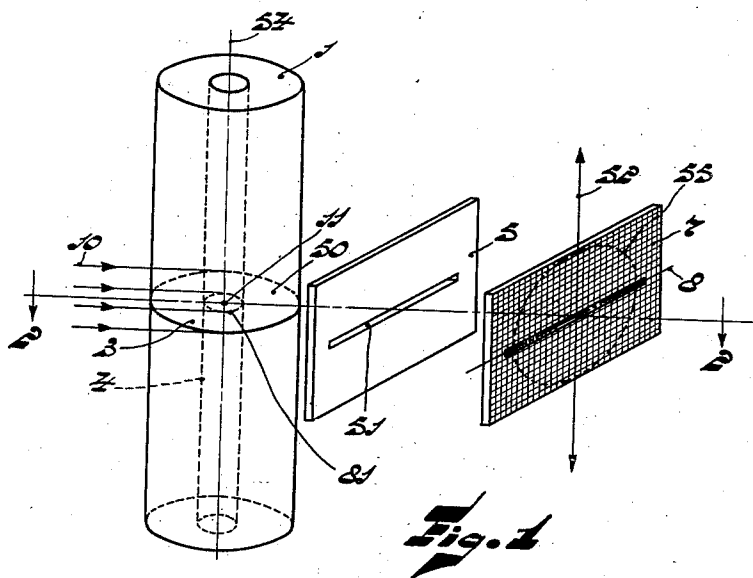


Fig. 1

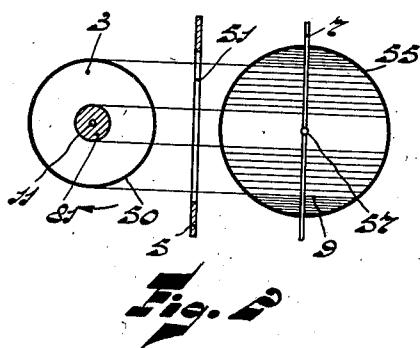


Fig. 2

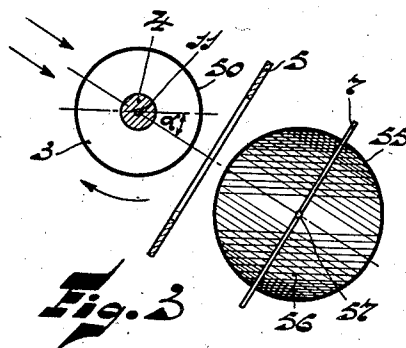


Fig. 3

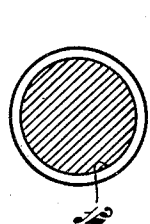


Fig. 4a

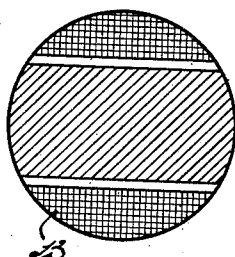


Fig. 4b

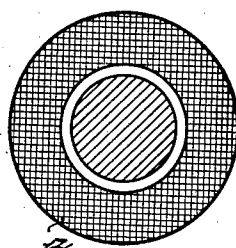


Fig. 4c

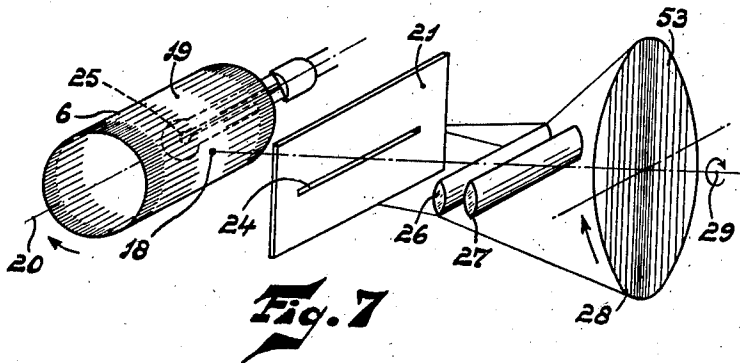
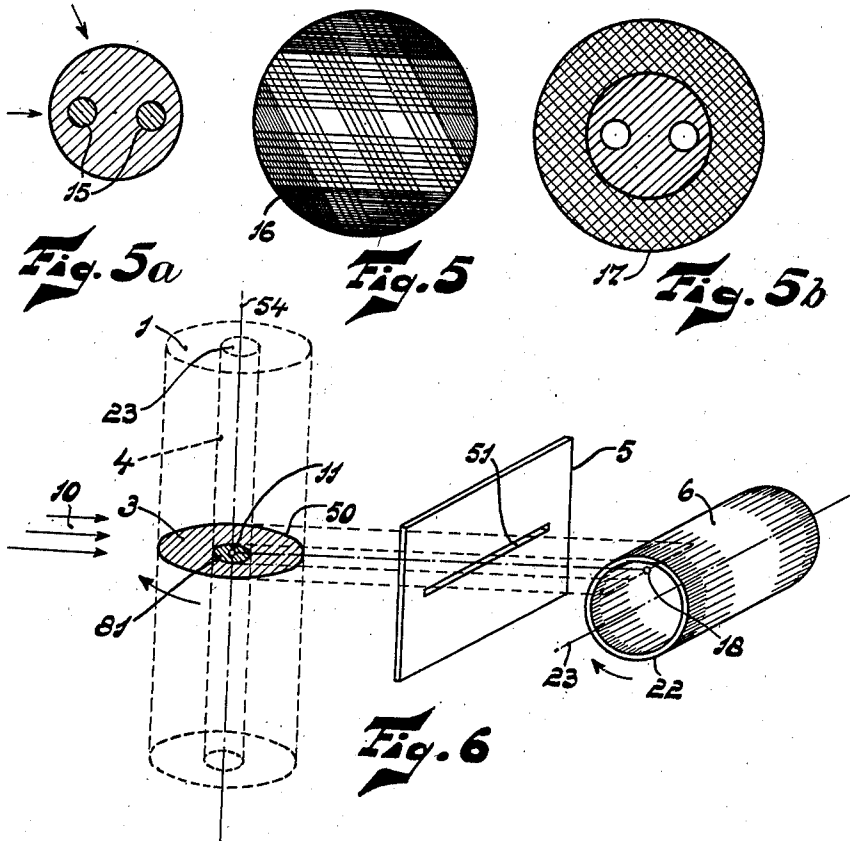
INVENTOR
GABRIEL FRANK
By *Chas. B. Simon*
ATTORNEY.

May 5, 1942.

G. FRANK
X-RAY APPARATUS
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2,281,931

5 Sheets-Sheet 2



INVENTOR
GABRIEL FRANK
By *Edw. B. Leamon*
ATTORNEY.

May 5, 1942.

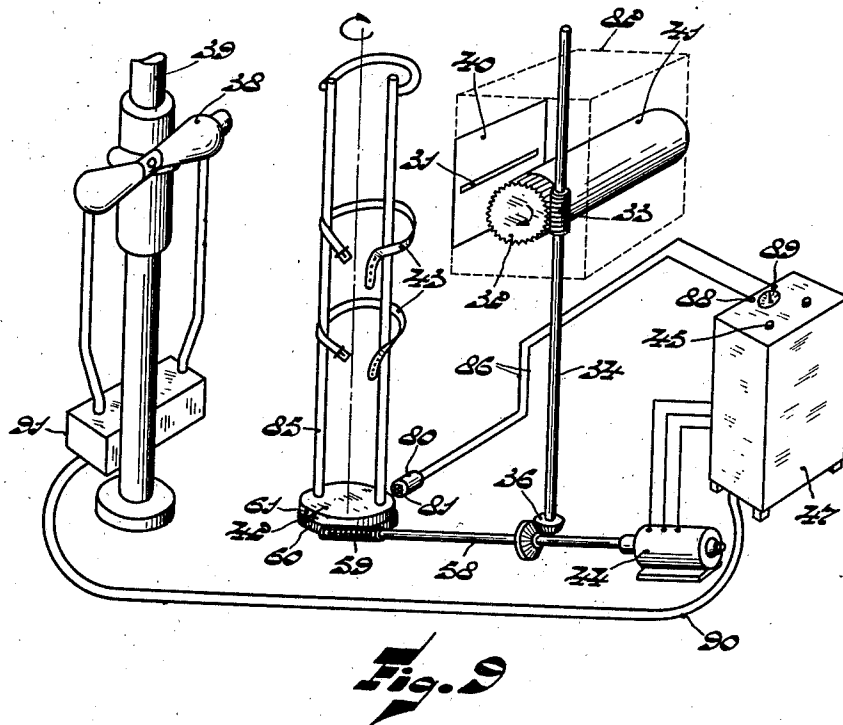
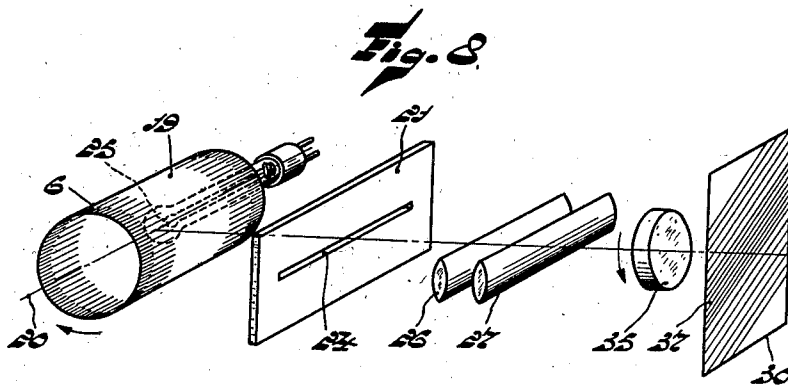
G. FRANK

2,281,931

X-RAY APPARATUS

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5 Sheets-Sheet 3



INVENTOR
GABRIEL FRANK
By *G. H. Blum*
ATTORNEY.

May 5, 1942.

G. FRANK

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X-RAY APPARATUS

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Fig. 10

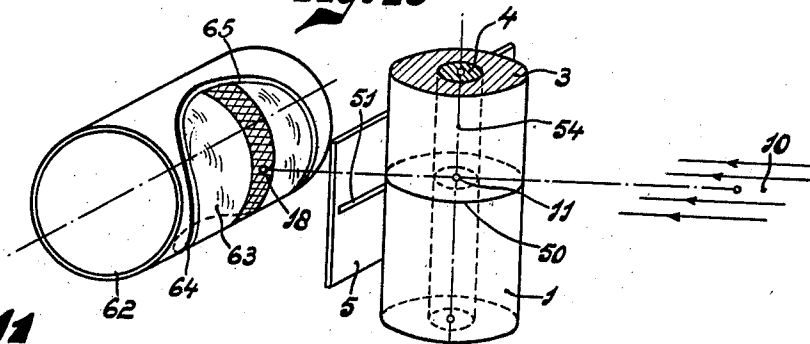


Fig. 11

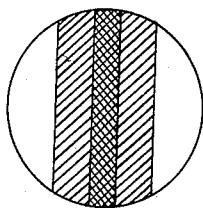


Fig. 12

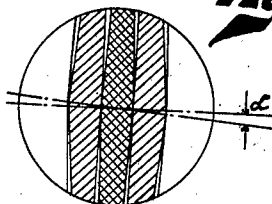


Fig. 18

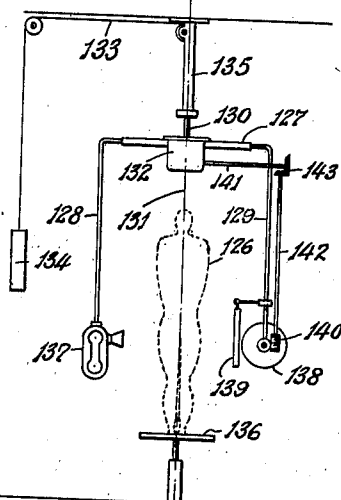


Fig. 13

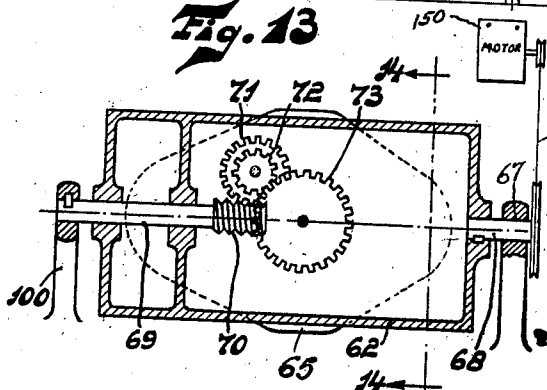
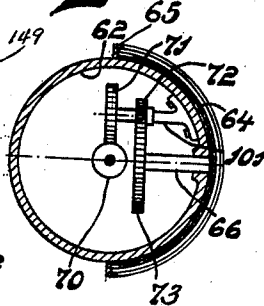


Fig. 14



INVENTOR
GABRIEL FRANK
By *Chas. H. Simon*
ATTORNEY.

May 5, 1942.

G. FRANK
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Fig. 15.

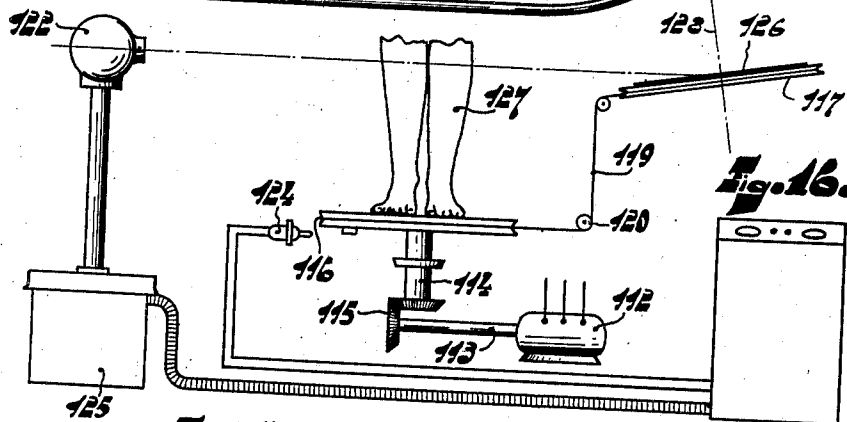
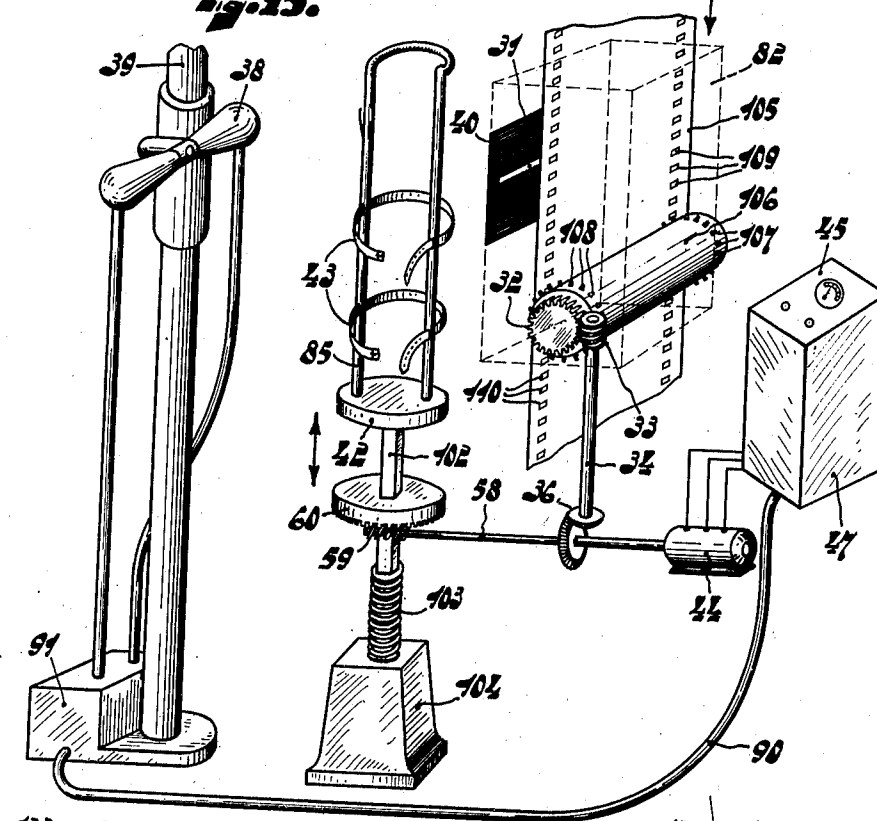
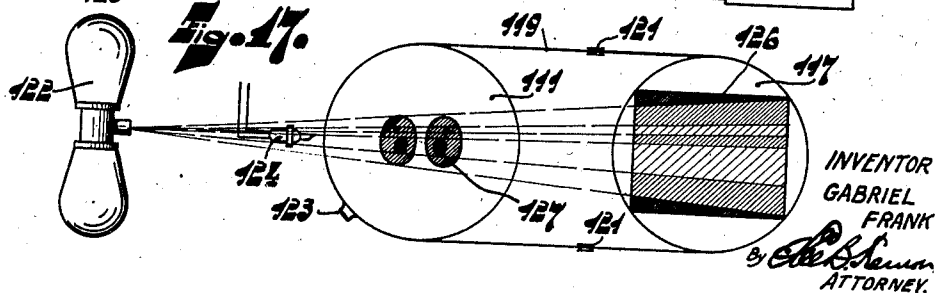


Fig. 17.



INVENTOR
GABRIEL
FRANK
BY *Edw. J. Shuman*
ATTORNEY.

UNITED STATES PATENT OFFICE

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X-RAY APPARATUS

Gabriel Frank, Budapest, Hungary, assignor, by
mesne assignments, to Hartford National Bank
and Trust Company, Hartford, Conn., as trustee

Application June 27, 1939, Serial No. 281,467
In Germany June 27, 1938

15 Claims. (Cl. 250—61.5)

My invention relates to a method and apparatus for representing cross-sections of bodies by means of X-rays.

As is well known, radioscopy or radiography is based on the fact that inside the body subjected to radioscopy many parts have a greater or less absorption for X-rays. As a result a shadow image of the part capable of absorption which is inside the body was obtained. It is, however, also possible that small details are absorbed in the shadow of the part that is in front or at the back of the part and as a result these details become invisible. The X-ray image is simply a large quantity of superposed shadow images and it is often very difficult, even for a professional observer, to properly interpret the same. Several methods have been proposed for taking more exact X-ray pictures in such manner that the desired cross-section of the body to be examined is obtained without its purity being affected by the shadows of the parts located in front or at the back thereof, but in general such methods have numerous disadvantages.

According to one of these methods, an X-ray tube and a light-sensitive member are moved about an axis within the plane of the section desired so that the focus of the tube, the axis of rotation, and a given point of the light sensitive member are always located on a straight line. In this manner it would be possible to ensure that the parts nearer to the axis appear to be more clearly defined, and those parts more distant from the axis are faded. However, such a method only enables one to make pictures of longitudinal section-planes and it is not possible to make pictures of transversely located body-strata of elongated bodies. Furthermore, the faded shadows of the parts located in front of and at the back of the section-plane to be represented interfere with the image.

The main object of my invention is to provide an improved method of taking X-ray pictures of a body-section.

Another object of my invention is to provide an optical system for use in reproducing pictures of body-sections.

A still further object of my invention is to produce a large number of partial X-ray exposures which, when projected one upon the other, form a composite picture of a body-section.

Further objects and advantages of my invention will appear as the description progresses.

My invention is based on the recognition of the fact that all rays emerging from the body and received from a focus located in the plane of

the cross-section and illuminating body from infinitely many sides, jointly determine the cross-section.

In accordance with the invention I take several partial radiographs of the section with a narrow beam of X-rays, enlarge the partial radiographs in a direction perpendicular to the plane of the section, and superpose the enlarged radiographs with mutual angular displacements.

In order that the invention may be clearly understood and readily carried into effect I shall describe the same in more detail with reference to the accompanying drawings in which;

Figure 1 is a diagrammatic perspective view of an arrangement for use in explaining the theory of the invention,

Figure 2 is a sectional view along line 2—2 of Fig. 1,

Figure 3 is a view of a portion of Fig. 2 with several members thereof in different positions,

Figures 4, 4a, 4b, 5, 5a and 5b are plan views of reproductions of various cross-sections,

Figure 6 is a diagrammatic perspective view of a device for recording the line images on a photographic film,

Figures 7 and 8 are diagrammatic perspective views of devices for enlarging and superposing the partial images,

Figure 9 is a side view in perspective of a device embodying the invention,

Figure 10 is a perspective view of a device for carrying out the method according to the invention,

Figures 11 and 12 are plan views of partial images obtained with the device of Fig. 10.

Figure 13 is a sectional side view of a device for moving the light-sensitive member, and

Figure 14 is a sectional view along line 14—14 of Fig. 13.

Figure 15 is a perspective view of a device embodying the invention in which a film band is used for recording the partial pictures.

Figures 16 and 17 show another modification of a device according to the invention.

Figure 18 is a diagrammatic side-view of a device which operates on the same principle as that shown in Fig. 6, but with cinematic reversal of the motion.

In Fig. 1 a body 1, of which a cross section 50 is to be reproduced, comprises an annular portion 3 of semi-transparent material such as muscle tissue of a human leg, and a core portion 4 of a material which is less transparent to X-rays, such as a bone. A beam of parallel X-rays 10

emanating from a remote source (not shown) passes through body 1, and a narrow X-ray beam having a band-shaped cross-section passes through a narrow elongated slot 51 in a diaphragm 5, for example of lead. The directions of the X-rays and the slot 51 determine the plane of the cross-section 50 (indicated by cross-sectioning). The X-ray beam passing through the slot 51 produces a narrow image 8 on a light-sensitive member 7, i. e., an X-ray-sensitive plate, and the density of this image corresponds to the different degrees of absorption of the X-rays by the portions 3 and 81 of the body 1 at section 50. Of course the diaphragm 5 might also be placed between the object and the source of X-rays, but with the situation shown in the drawing a narrower beam of X-rays may be produced.

If we assume that the line-shaped image 8 is enlarged in the direction of the double-headed arrow 52 over an entire circular area 55 we would obtain a picture such as indicated by reference numeral 9 in Fig. 2. It should be noted in Fig. 2 that the image enlarged in the direction of the arrows 52 is shown rotated about the axis 8 of Fig. 1 so as to lie in the plane of Fig. 2.

As will be pointed out hereinafter, this enlargement of the image, which must be at least as long as the length of the line-shaped image of the section projected from a direction normal to the first one, may be obtained by optical means or by a displacement of the image carrier or light-sensitive member itself.

If, as illustrated by Fig. 3, the source of the X-rays is rotated jointly with diaphragm 5 and the X-ray sensitive plate 7 relative to the body 1 through an angle α about the axis 54 of Fig. 1, which axis is normal to the plane of section 50 and intersects this plane at a point 11, a second partial image may be produced. The point of intersection 11 will be referred to as the "point of rotation." Assuming that this second partial image produced on plate 7 is also enlarged in a lateral direction so as to extend over the whole of the circular area 55, a super-position of the two partial pictures is produced, as indicated by reference numeral 56 in Fig. 3, whereby the first and second partial image are assumed to be mutually rotated through the same angle. In Figure 3 the plate 55 is shown rotated into the plane of section 50 and the difference in density of the two partial images 9 and 56 are indicated by cross-sectioning of different spacings.

Several partial pictures may be made in this manner and the enlarged pictures turned over into the plane of section 50 and superposed with mutual rotations about the image-point 57 of the point of rotation 11 equal to the corresponding rotations of the body 1 relatively to the source of X-rays, diaphragm 5 and plate 7. If the several rotations together amount to 180°, the superimposed pictures will represent an exact image of the section 50. The larger the number of partial images, the better will be the total image.

The rotation and exposure may also be made continuously through an angle of 180° so that the total image is a continuous integration and not a step by step superposition.

The cross-section of the core 4, no matter from what side it is exposed, is only slightly transparent to X-rays, and therefore the central part of the X-ray sensitive plate 7 receives only very small quantities of radiation and remains blank. On the other hand a portion of the plate surrounding this blank central portion will be black-

ened to a certain degree, and the portion of the plate surrounding this second portion will be blackened still more intensely.

Figs. 4, 4a, 4b, 5, 5a and 5b show the reproduction of various idealized cross-sections for example, skull and arm bone. In Fig. 4a the reference numeral 12 designates the cross-section to be radiographed, in Fig. 4 reference numeral 13 indicates an extended and turned-down partial picture the blackening being represented by cross hatching, and in Fig. 4b reference numeral 14 the result obtained by superposition or integration of all the partial pictures 13.

In Fig. 5a, reference numeral 15 designates the cross-section to be radiographed, in Fig. 5, reference numeral 16 indicates a superposition of two of the partial pictures and in Fig. 5b reference numeral 17 indicates the result of the superposition of all partial pictures or the integration of blackening.

As only the relative movement between the source of X-rays and the object is of interest, the same result is obtained if the object is rotated, while the source of X-rays, the diaphragm and the ray-sensitive plate are not rotated about the body.

A device in which the object is not rotated is illustrated in Fig. 13 in which an object to be photographed 126, shown as the body of a patient, rests upon a platform 123 which can be raised and lowered by suitable means (not shown) but which cannot be rotated.

Suspended from the ceiling so as to be rotatable in a horizontal plane is a support 127 having two arms 128 and 129. The support 127 is mounted on a rod 130 and can be rotated by an electric motor 132.

The rod 130 can be telescoped within a tubular member 135 fastened to the ceiling. Secured to the end of rod 130 is a rope 133 which passes over two pulleys and carries a counterweight 134. This allows the support 127 to be readily moved up and down.

Arm 128 carries an X-ray generating apparatus 137, whereas arm 129 carries a rotatable drum 138 upon which a ray-sensitive film (not shown) is placed and a split diaphragm 139. The drum 138 is rotated by means of motor 132 and for this purpose the shaft upon which drum 138 is mounted carries a gear engaged by a worm gear 140 mounted on the end of a shaft 142. The other end of shaft 142 carries a gear which engages a gear 143 mounted on the end of a shaft 141 driven by motor 132.

When the motor 132 is placed into operation the support 127 rotates to thereby rotate the source of X-rays 137 as well as the drum 138 and diaphragm 139 about the axis 131. At the same time the drum 138 with the X-ray sensitive film thereon is rotated about the horizontal axis of the drum.

A simple method of recording the line images on a photographic film will be described with reference to Figs. 6, 7 and 8. Referring to Fig. 6, assume that body 1, and consequently also the section 50 thereof, are rotated about an axis 54 normal to the plane of section 50 at the point of rotation 11. A drum 22 consisting of X-ray impervious material or lined with such a material carries an X-ray-sensitive film 6 secured to its peripheral surface and is arranged at the rear of diaphragm 5 with its axis 23 in the plane of section 50 and slot 51. The image point of the point of rotation 11 on the periphery of drum 22 is designated in Fig. 6 by reference numeral 18.

The drum is rotated about axis 23 and body 1 is rotated about axis 54 with the same angular speeds and due to these continuous rotations the partial images of cross-section 50 are recorded side by side on the film 6 to form a composite image, containing every detail of cross-section 15. However, the true form of the cross-section cannot be directly perceived from the record so formed. To obtain this I use an arrangement such as shown in Fig. 7.

In Fig. 7 the reference numeral 19 designates a rotatable drum of transparent material, such as glass, carrying the developed film 6 produced in Fig. 6. The drum 19 has exactly the same outer diameter as drum 22 of Fig. 6 and is rotated about its axis 20. A diaphragm 21 provided with a slot 24 is identical with the diaphragm 5 and is arranged parallel to the axis 20 with the slot 24 in a plane passing through axis 20 perpendicularly to the diaphragm 21.

Arranged within the center of drum 19 is a punctiform light source 25 by which the diaphragm 21 is illuminated through the film 6.

A narrow beam of light passes through slot 24 and is optically analogous to the beam of X-rays emerging from the diaphragm 5 in Fig. 6. This narrow beam of light is enlarged in a direction perpendicular to the plane of axis 20 and slot 24 by being passed through two cylindrical lenses 26 and 27. As a result an enlarged picture 53, similar to the picture 9 of Fig. 2, is projected on a projection screen 28. Screen 28 is in the form of a photographic plate which is caused to rotate with a constant angular speed about an axis 23 passing through the image point 18 of the point of rotation and a slot 24. The plate 28 is rotated with exactly the same angular speed as that of drum 19 by suitable driving means (not shown). The effect of this rotation is geometrically identical with the effect shown in Figs. 3, 4 and 5 and exists in an integration of the blackening effects in each position of the plate 28 and drum 19, so that the desired reproduction of section 50 is obtained on plate 28 after it is developed.

It should be noted that the ratio between the radius of drum 19 and the distance between the record film 6 and plate 28 should not be excessive in order that undue magnification will not occur and films of normal size may be used. For this reason, it may be advantageous to use, instead of a drum with a light source at its center, any other type of film transporting device that permits the light source to be placed at a greater distance from the record film.

It is also possible to dispense with the second photographic film 28 and to make the desired picture of the cross-section 50 directly visible and such an arrangement is schematically illustrated in Fig. 8. In Fig. 8, in which the same reference numerals are used for the parts of Fig. 7, the enlarged image produced by lenses 26 and 27 is not directly projected upon a screen, but is first rotated about the axis of projection by a lens or kaleidoscopic mirror system 35 which is rotated at the same angular speed as drum 19. The beam of light subject to the rotation by the system 35 is thrown on a viewing screen 30, on which an image 37 becomes visible. The speed of rotation is made sufficiently high that the human eye could not perceive the rotation of the image on screen 30, but only an impression of the picture of the cross-section.

The required speed of rotation during the X-ray exposure depends on the intensity and the

hardness respectively of the X-rays, on the sensitivity of the film and on the intensifying screen to be used. In any case, however, the speed of rotation of the object about axis 54 (Fig. 6) and that of the film carrier about axis 20 (Figs. 7 and 8) should be correlated. The devices for effecting these two rotations are preferably coupled in a constrained manner. Also the devices for moving the record film and the picture carrier 28 or the optical image rotating system 35 in Figs. 7 and 8 may be coupled in a constrained manner, i. e., through suitable gearing.

One suitable method of coupling the film drum rotation with the rotation of the object about axis 54 is shown in Fig. 9. In this figure an X-ray tube 38 is secured to a suitable support 39 so that it can be adjusted in a vertical direction. A diaphragm 40 provided with a slot 31 and an X-ray impervious film drum 41 are mounted within a housing 82 so as to be movable in a vertical direction together with the X-ray tube. More particularly the housing 82 may be mechanically interconnected with the X-ray tube 38 so that both these members can be raised or lowered together. The object to be exposed (not shown) is placed on a supporting device 85 comprising a disc 42 adapted to be rotated in a horizontal plane. The disc 42 carries two vertical supports provided with two belts 43 for holding the object. Disc 42 and drum 41 are rotated by an electric motor 44 and are mutually coupled in a constrained manner. More particularly, drum 41 carries a worm-gear 32 driven by a worm 33 mounted on a driving shaft 34 which is driven through a pair of bevel gears 36 from shaft 58 of motor 44. Shaft 58 also carries a worm 59 which drives a worm-wheel 60 secured to disc 42.

Disc 42 has a stud 61, co-operating with a switch device 80. This switch device has a press button 81 and is of the known type that closes a contact when being pushed once and breaks the contact when then being pushed again. By wires 86 the switch device is connected to terminals 88 and 89 of a control apparatus 47. The control apparatus is connected to the transformer 91 of the X-ray tube 38 by a cable 90.

The operation of the arrangement described is as follows. When the current of motor 44 is switched-on by a switch 45 the motor starts and both the disc 42 and the drum 41 begin to rotate. When disc 42 carrying the object to be photographed has moved some time, stud 61 comes into touch with button 81 and pushes the latter. The energizing current for transformer 91 is thereby caused to flow and the exposure is made.

Meantimes disc 42 and drum 41 continue their rotation and when disc 42 has rotated over 360°, notch 61 again pushes button 81 and the current of transformer 91 is switched-off.

In some cases, for example for locating a tumor, it may be desirable that a plurality of cross-sections arranged with small mutual distances should be reproduced in rapid succession. For this purpose an arrangement such as shown in Fig. 9 with slight alterations may be used. More particularly, the rotating cylindrical film drum 41 may be replaced by a continuous film-band. The patient standing on the rotary disc 42 is turned several times while simultaneously the disc is moved upwards or downwards. A slowly rising screw surface is then described by the X-rays relatively to the object. The film-

band is caused to move in front of the diaphragm at a uniform speed.

An arrangement with which the latter method can be carried out is shown schematically in Fig. 15. The object body (not shown) is positioned on disc 42 and fixed thereto by means of belts 43. Disc 42 is rotated by motor 44 as described with relation to Fig. 9, with the difference, that disc 42 is mounted on a square shaft 102 and that the worm-wheel 60 is not secured to disc 42, but rotatably mounted on a certain support not shown. Disc 42 has a square central aperture in which fits the shaft 102, so that the latter may slide upwards and downwards in the worm-wheel 60, but is caused to rotate if the worm-wheel rotates. The lower end 103 of the shaft has a circular section and is threaded. It is screwed into a base 104. Thus when the worm-wheel 60 is rotated by electromotor 44 the shaft 102 and disc 42 are also rotated but at the same time are screwed upwards or downwards according to the sense of rotation.

Instead of a drum carrying an X-ray sensitive film, laid around the cylindrical surface of the drum as in Fig. 6, there is provided in Fig. 15 a filmband 105, transported by means of a drum 106 provided with sprockets 107 and 108, which engage perforations 109 and 110 of the film 105. The drum 106 is rotated by motor 44 in the same manner as drum 41 in Fig. 9. When the radiograph so obtained is viewed by means of an arrangement as shown in Fig. 8 and the optical system 35 is rotated so quickly that one revolution thereof corresponds to one revolution of the rotary disc, the observer sees a picture of a continuously falling or rising cross-section.

Obviously, the rotation of the rotary disc must be a slow one, a single rotation requiring at least from 4 to 5 seconds.

Instead of first making a record of the line-shaped images 8 (Fig. 1) and afterwards enlarging the same by optical means, the enlarged partial images can also be made directly on the first film and such a method will be described in connection with Figures 10 to 14.

Referring to Fig. 10, a drum 62 impervious to X-rays carries on its peripheral surface an X-ray sensitive film 63. The axis of drum 62 lies in the plane of the section to be reproduced and when the drum 1 is stationary, a line-shaped image is obtained corresponding to the cross-section 50, as shown in Fig. 1. If drum 62 is rotated there will be produced on film 63 after one complete revolution an enlarged image which, after development of the film, would appear as shown in Fig. 11. Assuming that the body 1 is rotated through an angle α about axis 54 and that the film 63 is rotated through the same angle α about an axis normal to the axis of cylinder 62 and passing through the image 18 of the point of rotation 11, there will be produced, after a second complete revolution of the drum 62 a second partial picture superposed on the first picture with a mutual rotative displacement through angle α . The resulting composite image is shown in Fig. 12.

The circular photographic film 63 is carried by a disc 64 of a flexible and elastic material, for instance steel which is retained at the cylindrical surface of drum 62 by a guide 65 so that it can be rotated while preserving its cylindrical form.

By rotating the plate 64 through an angle α after each complete revolution of drum 62 and continuing this stepwise rotation until the film has been rotated through at least 180°, a super-

position of partial images is obtained representing the cross-section 50 to be examined.

The diameter of disc 64 is preferably made only slightly less than that of drum 62 so that the opposite points of the plate nearly reach each other.

It is not necessary that disc 64 moves step by step, but its rotation may be continuous provided that it is in synchronism with the rotation of the object relatively to the X-rays 10 and diaphragm 5. The number of revolutions of drum 62 must be much greater, for example 200 times greater, than that of the synchronous rotation of the disc 64.

A device in which the correlation of the rotation of the plate 64 and the drum 62 is effected is shown in Figs. 13 and 14. As shown in these figures, a shaft 68 is keyed to drum 62 and is rotatably supported on a bearing 67. The shaft 68 is driven by a belt 149 from an electric motor 150 so as to rotate the drum. The other end of drum 62 is rotatably mounted on a stationary shaft 69 which is keyed to a second bearing 100. Fixedly secured to the free end of shaft 69 is a worm 70 which engages a worm-gear 71 which is secured to a gear 72. Gears 71 and 72 are rotatably mounted on a support 101 secured to drum 62. Rotatably supported by drum 62 is a shaft 66 carrying a gear 73 which meshes with gear 72. The disc 64 is fixedly secured at its center 18 to the free end of shaft 66.

When drum 62 is rotated about shaft 69, worm-gear 71 is rotated due to its being in engagement with the worm 70 and as a result the disc 64 is rotated. Thus the rotative motion of drum 62 is, with a certain gear-ratio (for example 1:200), transmitted to disc 64 and to the photographic film 63 carried thereby.

In Figs. 16 and 17 an object person 127 is standing on a rotating table 111 which is rotated by a motor 112 by means of driving shafts 113 and 114, mutually coupled by a pair of bevel gears 115. The top of table 111 is provided with a groove 116. A leaning disc 117 is rotatably mounted about an axis 118. A rope drive system is provided for driving disc 117 from the turn table 111. The rope 119 runs in the groove 116 and over guide idlers 120 and 121 and drives the disc 117. Disc 117 carries an X-ray sensitive film 126. It makes a small angle with the X-rays radiated by the X-ray tube 122. A slot diaphragm is thereby rendered superfluous.

The disc 111 is provided with a stud 123 cooperating with a switch 124 as in the case of Fig. 9 for switching-on and off the energizing current of the high tension supply transformer 125 for X-ray tube 122, so that the object and the photographic film are exposed to the X-rays during one full rotation of the discs 111 and 117.

The invention is not only of importance for medical appliances but may also be used for industrial purposes such as material-testing.

While I have described my invention in connection with specific examples and certain details of construction, I do not desire to be limited thereto as obvious modification will readily present themselves to one skilled in the art.

What I claim is:

1. A method of reproducing an X-ray image of a section of a body, comprising the steps of passing X-rays through the body in several different directions from a source of X-rays located at constant distances from a given point of the section and from a ray-sensitive member, confining the

X-rays passing from the body to the ray-sensitive member to a narrow beam lying in the plane of the section to produce narrow partial images on the member, enlarging the partial pictures in a direction perpendicular to the plane of the section, and superposing the enlarging partial pictures with mutual angular displacements corresponding to the angles between the directions of the X-rays striking the body.

2. In producing upon a ray-sensitive member a true X-ray image of a section of a body, the steps of exposing the body to X-rays to cause a narrow beam of X-rays lying on the plane of the section to pass from the body to the member, and rotating the body about an axis perpendicular to the plane of the section while moving the member with the exposed points moving in a plane substantially perpendicular to the plane of the section to thereby produce a plurality of lateral partial images of a disc-shaped portion of said body on said member.

3. A method of producing an image of a section of a body, comprising the steps of passing X-rays through the body in several different directions from a source of X-rays located at constant distances from a given point of the section and from a ray-sensitive member, confining the X-rays passing through the body to the X-ray-sensitive member to a narrow beam lying in the plane of the section, moving the ray-sensitive member to produce a plurality of adjacent linear images thereon, developing the ray-sensitive member, projecting the linear images one after the other while optically enlarging the same, and superposing the projections of the enlarged images with mutual displacements equal to the angles used between the directions of the X-rays to form a true image of the section.

4. In a method of taking an X-ray picture of a section of a body, the steps of making a plurality of line-shaped partial exposures with narrow X-ray beams lying in the section and extending in various directions and with equal focal distances from a given point of the plane of the section, and moving a ray-sensitive member relatively to the X-ray beam to record a plurality of adjacent line-shaped partial pictures.

5. In a method of taking an X-ray picture of a section of a body the steps of making a plurality of line-shaped partial exposures with narrow X-ray beams lying in the section and extending in various directions and with equal focal distances from a given point of the plane of the section, and continuously moving a ray-sensitive member relatively to the X-ray beam to record a plurality of overlapping line-shaped partial pictures.

6. A method of reproducing a cross-section of a body, comprising the steps, subjecting the body to X-rays emanating from a source, passing from the body to an image carrier a narrow beam of X-rays lying in the plane of the section, rotating the source and image carrier relatively to the body around an axis normal to the plane of the section and simultaneously rotating the image carrier about an axis normal to the surface thereof.

7. An apparatus for taking an X-ray picture of a section of a body, comprising a source of X-rays, a ray-sensitive member for receiving the picture, means for rotating said source and member relatively to said body about an axis normal to the section at the point of rotation, and means to move said member in its plane and in de-

pendence on the rotary movement of said source and member.

8. An apparatus for taking an X-ray picture of a section of a body, comprising a source of X-rays, a ray sensitive member for receiving the picture, means for rotating said source and member relatively to said body about an axis normal to the section at the point of rotation, and means to move said member in its plane and in dependence on the rotary movement of said source and member, said latter means comprising a drum mounted on an axis lying in the plane of the section, means to rotate the drum about its axis, a disc of flexible material supporting said ray sensitive member and pivoted on said drum at its center, means for holding said disc to the cylindrical surface of the drum, and means for rotating said disc about its center.

9. An apparatus for taking X-ray pictures of a section of a body, comprising means for producing a narrow beam of X-rays lying in the plane of the section including a source of X-rays, an elongated carrier for receiving images produced by said X-ray beam, means for producing a relative rotation between said body and said source and carrier, and means for moving said carrier perpendicular to the plane of the section.

10. An apparatus for reproducing a series of band-shaped pictures constituted by lateral X-ray images of a disc-shaped portion of a body taken in several directions in the plane of the disc-shaped portion, comprising a projection screen, means for individually projecting the images with a narrow X-ray beam lying in the plane of the section being viewed, means for enlarging each image in a direction normal to its length, and means for producing relative rotation between the projected images relative to the screen.

11. An apparatus for reproducing a series of band-shaped pictures constituted by lateral X-ray images of a disc-shaped portion of a body taken in several directions in the plane of the disc-shaped portion, comprising a projection screen, means for individually projecting said images upon said screen in rapid succession, means for enlarging each image in a direction normal to its length, and optical means for rotating the projected beams of light.

12. In an installation for making an X-ray photograph which is a true representation of a section of a body, a drum rotatable about an axis lying in the plane of the section, a flexible disc carried by the cylindrical surface of the drum and adapted to receive an X-ray-sensitive layer, a guide holding said disc to said surface, a pivot secured to said disc and rotatably supported by said drum, and means for rotating said disc about said pivot.

13. In an installation for making an X-ray photograph which is a true representation of a section of a body, a drum mounted on an axis lying in the plane of the section, means to rotate the drum about its axis, a disc of flexible material pivoted on said drum at its center, means for holding said disc to the cylindrical surface of the drum, and means for rotating said disc about its center.

14. The method of producing a true X-ray image of a section of a body, comprising the steps of making a large number of lateral X-ray images of a plate-shaped portion of the body at various angles by a narrow beam of X-rays lying in the plane of the section being viewed and with

such enlargement as to give each image a width several times the width of the narrow X-ray beam, and superposing said images with the points corresponding to the axis of the X-ray beams coinciding and with mutual angular displacement of the images about said points.

15. The method of producing a true X-ray image of a section of a body, comprising the steps of making a large number of lateral X-ray images of a plate-shaped portion of the body at

various angles by a narrow beam of X-rays lying in the plane of the section being viewed while giving each image a width at least equal to the length of the image produced by an X-ray beam which is normal to the X-ray beam producing the image, and superimposing the images with the points corresponding to the axis of the X-ray beams coinciding and with mutual angular displacement of the images about said points.

GABRIEL FRANK.