Dec. 6, 1927. 1,651,707

F. IRWIG

RADIOGRAPHIC ATTACHMENT FOR X-RAY MACHINES

Filed Feb. 16, 1925 3 Sheets-Sheet 1

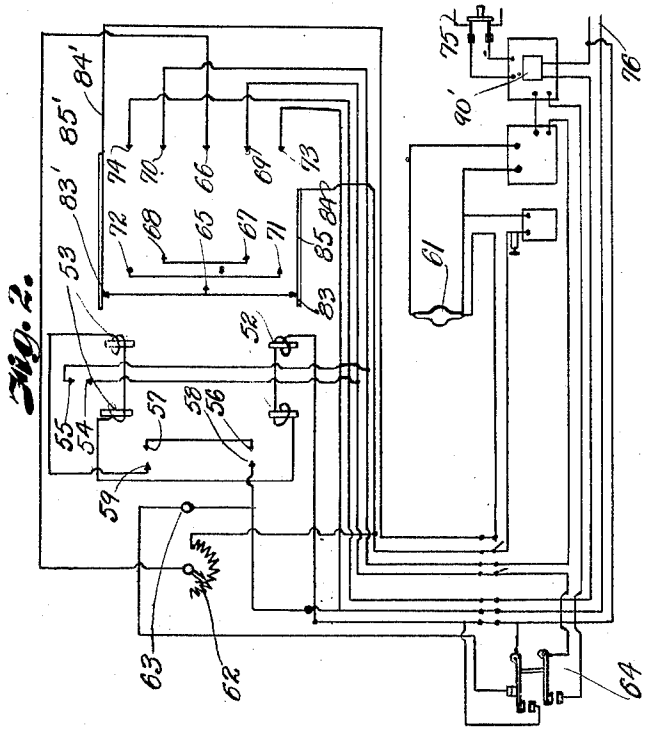


Fig. 2.

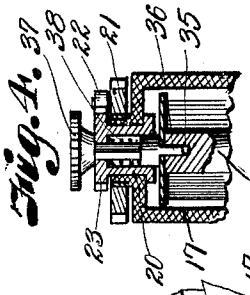


Fig. 4.

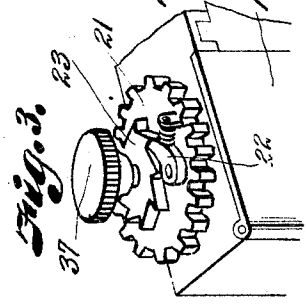


Fig. 3.

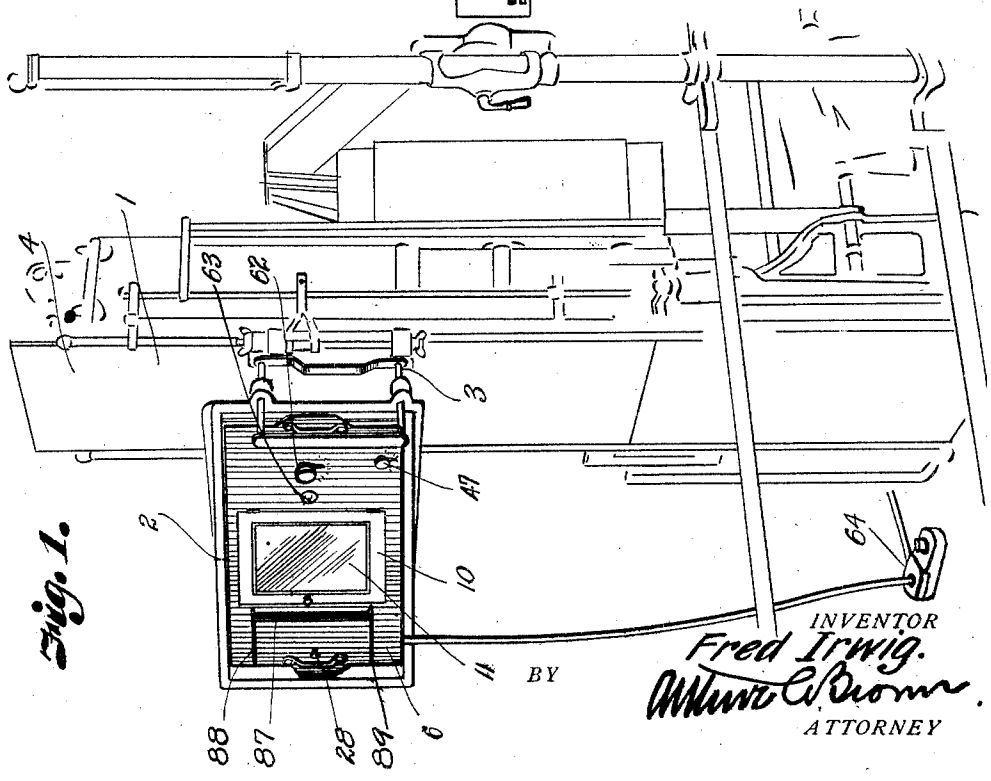


Fig. 1.

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Fig. 6.

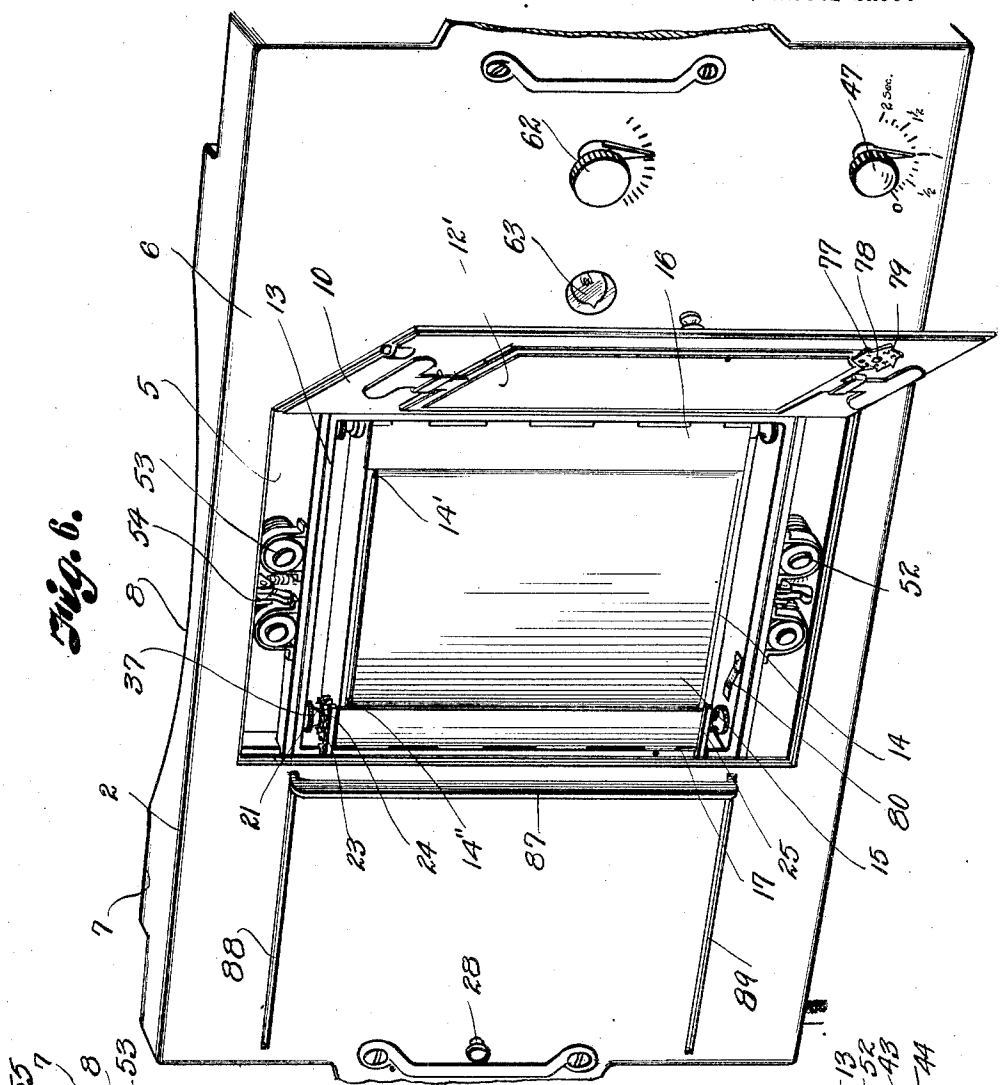
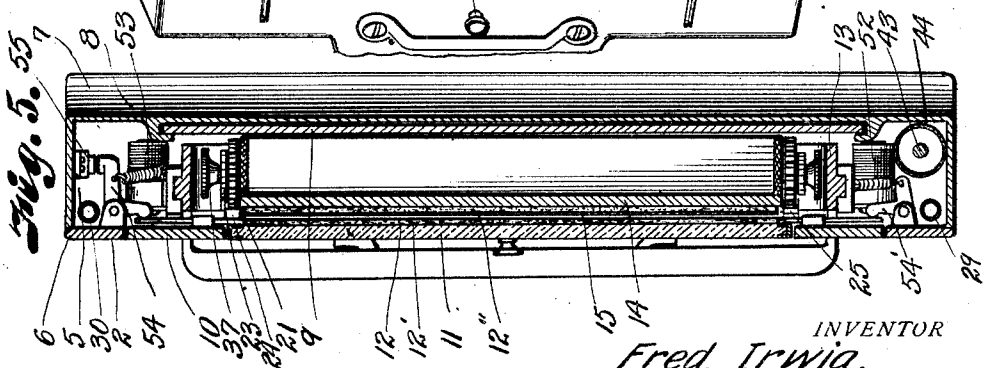


Fig. 5.



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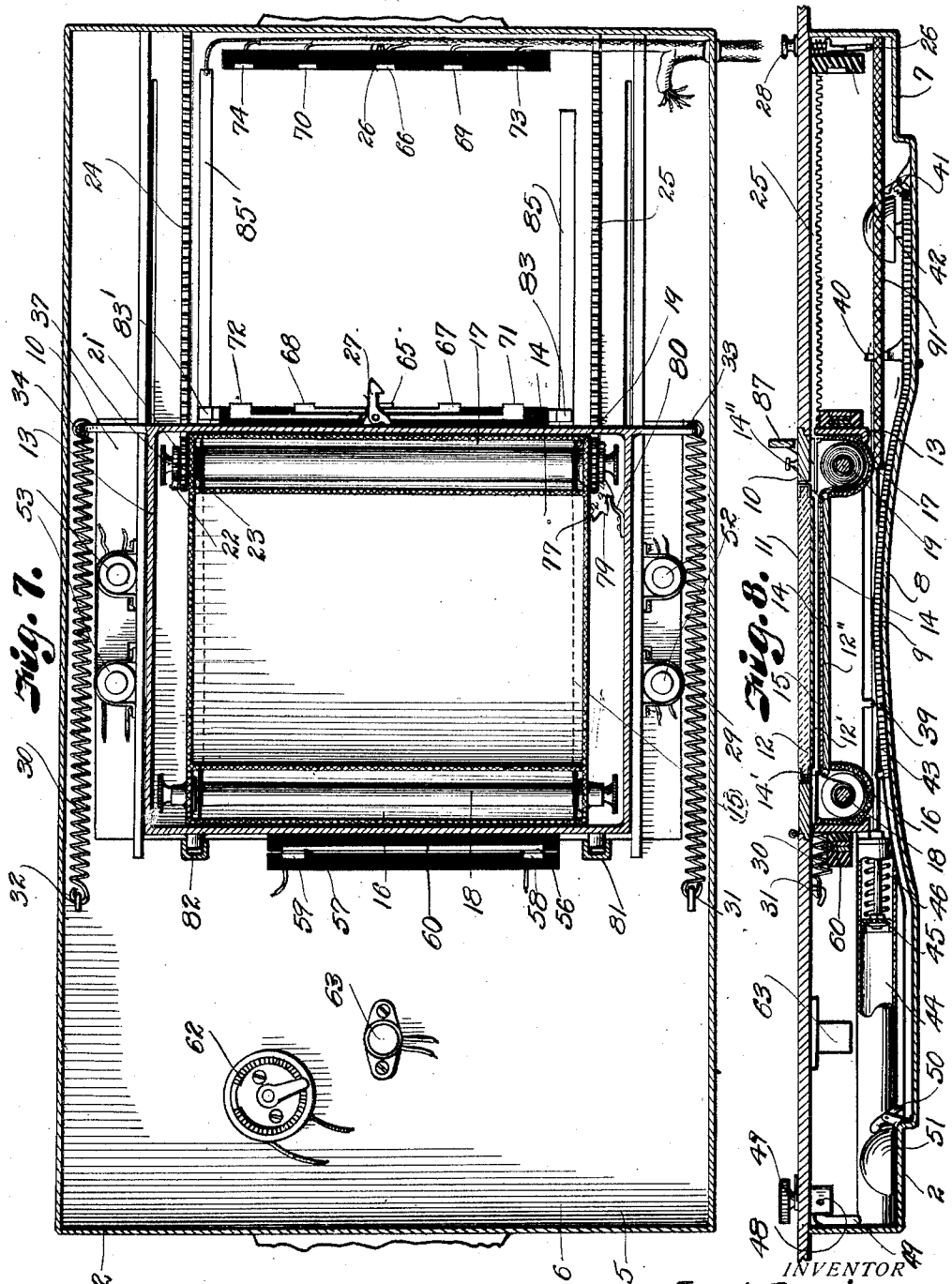


Fig. 7.

Fig. 8.

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UNITED STATES PATENT OFFICE.

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RADIOGRAPHIC ATTACHMENT FOR X-RAY MACHINES.

Application filed February 16, 1925. Serial No. 9,567.

This invention relates to X-ray machines and particularly to that part of the machine which has to do with fluoroscopic examinations and photographic exposures of parts of the human body.

Under the present practice it is comparatively easy to make photographic exposures of parts of the human body which are in reposed condition and also a satisfactory radiographic picture of a heart in action can be made by a momentary exposure, but in this case it is almost meaningless and without any diagnostic value.

There are situations where photographic exposures, under present practice, must be made in a more or less haphazard and unsatisfactory manner. For example, in intestinal work the operator is never positive that the exposures are made at the time that the muscular wave, which will present the diseased part to the photographic plate, is in that part of the cycle to give a picture of the best diagnostic value.

The stomach is constantly going through a series of muscular movements, expansions and contractions, (perisistalsis) which alternate during digestion and evacuation of the stomach. Certain diseases of the stomach and duodenum are discernible through a fluoroscope and are indicated by the outline of the organ which is always changing through the action of the perisistalsis, alternately presenting and covering the diseased parts.

Anatomic changes are mostly found at the junction of the stomach and duodenum and a picture taken during the expulsion of the stomach content into the duodenum is almost never of any diagnostic value, therefore it is highly important to get that part of the cycle in which a distinct line of separation is visible between the stomach and the duodenum. If, for example, the line which separates the duodenal-cap from the stomach is straight and no other deformations are found or noticed it indicates that the stomach and duodenum are anatomically normal, but if the line appears jagged or broken there are indications of a diseased condition, therefore, during the cycle of muscular expansions and contractions the actual condition of the stomach will be more apparent at one time than at another so it is important to make the exposures when the condition is most apparent.

There are many other possibilities for the use of my invention. There are many conditions where a picture has to be taken at a special angle to give a satisfactory view. Attention is called to the radiographic technic of duodenal pictures; to pictures of the aorta and to that of mediastinum (that means the zone between the heart and the spine) and to the difficulties which may arise in pictures of joints. For example, before my invention the angle which gave the best view had to be determined by a fluoroscopic examination. Then the fluoroscopic screen was replaced by a plate and the picture was taken. In the interim the patient had often changed his or her position, or the plate had moved, and a worthless picture was obtained. Likewise it was necessary to make a number of photographic exposures of the stomach and duodenum in an endeavor to have pictures of each step in the cycle of the muscular movements of the parts being photographed. This was done without any positive assurance that a photographic exposure was made of every step, or every movement, so it will be apparent that in many cases photographs were made without developing the actual condition of the part of the body diseased. With my invention, however, it is possible to obtain a photograph of each step or desired muscular contraction or movement and it is also possible to obtain definitely that angle or that intended position and view of the organ being photographed which will give the best interpretation of existing conditions. This is accomplished by providing a cassette with a fluoroscopic screen which may be placed over part of the body to be examined so that the operator may visually observe the actual condition within the body and at the proper time and position make an instantaneous photograph, upon a photographic film, so that he can be sure that he has obtained the particular step, or if necessary, each step in the cycle of operations of the part of the body examined.

An important feature of my invention is that the operator may actually view the object from the beginning of the fluoroscopic examination until and while the exposure is being made and that it is possible to obtain pictures of a size as much as one foot in vertical diameter. This is satisfactory for any kind of an examination and this size picture may be made with an apparatus not larger than a normal fluoroscopic frame.

Another striking feature of the invention is that on account of the simple arrangement of the fluoroscopic screen and the photographic plate, and the alternating working of the last in a longitudinal direction, a rapidity, perfection, number and size of picture may be obtained as has been impossible heretofore with any machine or apparatus of which I have knowledge. Attention is also called to the important fact that all the pictures are obtained upon one film, one beside the other in a lineal direction. This is for the comparison of the pictures with each other and is of immense diagnostic value.

There are means provided for controlling the milliamperage of the filament of the "Coolidge tube" in accordance with whether a fluoroscopic examination is being made or a radiographic picture is being taken. Obviously when a fluoroscopic examination is being made the intensity of the light source, and therefore the quantity of the Roentgen rays, will be less than when the radiographic picture is being made.

There is a wiring in the cassette which also automatically changes the high tension current from a lower voltage to a higher voltage by a double solenoid arrangement which may be attached to the rheostat which controls the primary transformer current.

An important feature of my invention is that I have provided means for automatically feeding the film by the movement of the carriage which carries the film holder. The film may be put in the holder in daylight, and there are other refinements of the invention which will be specifically described hereinafter, reference being had to the accompanying drawings, in which

Fig. 1 is a perspective view of my invention applied.

Fig. 2 is a wiring diagram for the electric circuits.

Fig. 3 is a detailed, perspective view of the film feeding gear.

Fig. 4 is a sectional view through the end of the film holder supporting the gear.

Fig. 5 is a sectional view through the film holder and carriage.

Fig. 6 is an enlarged, detailed, perspective view of the fluoroscopic cassette, carriage and appertenances.

Fig. 7 is a longitudinal, sectional view through the cassette and carriage from the inside looking toward the operator's side of the fluoroscope, and

Fig. 8 is a vertical, longitudinal, sectional view through the cassette and carriage.

I have shown the cassette supported from a frame of an X-ray machine 1 in a vertical position but it may, with equal facility, be supported upon an X-ray machine in a horizontal position dependent upon the desires of the user. It is important to make X-ray pictures of the stomach while the patient is in an upright position, which shows the real relation or position of the stomach in the body, although it is better to take duodenal pictures while the patient is in a reclining position, so it is to be here understood that the position of the X-ray machine proper will not affect the efficiency of my invention. The cassette may also be mounted in a standing frame, especially made for this apparatus, and any X-ray tube may be put behind it and deliver the Roentgen rays.

The cassette 2 is supported on a bracket 3 which may have a swinging movement with respect to the machine and the cassette may be adjusted toward and away from the panel 4 of the X-ray machine 1. The cassette 2 is in the form of a hollow casing having a receptacle portion 5 with a cover plate 6. The middle portion of the bottom 7 of the receptacle 5 has a curvature or concavity 8 adapted to receive the torso, and on the reverse side of the concave wall, that is over the convexity, is a Bucky diaphragm comprising a plurality of alternately laminated lead and wood strips flexibly connected together so that the diaphragm may flex as it moves back and forth over the bottom of the receptacle 5. The diaphragm is designated by the reference numeral 9 and its construction is well known to those skilled in the art. The top or cover 6 is provided with a swinging door 10 carrying a lead glass panel 11. Behind this panel a fluoroscopic screen 12 is placed to exhibit the Roentgen rays coming from the tube and behind the fluoroscopic screen an intensifying screen 12′ is pressed to strengthen and intensify the rays to be thrown on the plate. The fluoroscopic screen 12 is opposite and in line with the concavo-convex portion 8 of the cassette so that the operator may view the subject through the fluoroscope.

Longitudinally movable within the cassette is a film carriage 13 in which is mounted the film holder having a table or back plate 14, covered with another intensifying screen 12″, over which the film 15 moves, the plate 14 being approximately the size of the exposed portion of the film, each time a photograph is to be made, and at this time it should be stated that the table or plate 14 is approximately co-extensive with the fluoroscopic screen. On both vertical edges of the table are two slender rollers 14′ and 14″ over which the film takes its way.

The film holder has two approximately cylindrical lead lined pockets 16 and 17 in one of which is a film roll 18 and the other a spool or reel 19 upon which the film may be wound as the film is paid off. In the ends of the pocket 17 are bushings 20, one at each end, although only one is shown in detail in Figs. 3 and 4. Each bushing supports a rotatable gear 21 carrying a spring pressed

pawl or dog 22 which is adapted to engage with the teeth of a ratchet 23 rigid on the bushing 20 so that when the gears 21 are rotated in one direction the dogs or pawls 22 will, by engagement with the teeth of the ratchet, rotate the spool or reel to wind off a determined amount of film from the film roll 18, but when the gears 21 are rotated in an opposite direction the pawl or dog 22 will ride over the teeth of the ratchet 23 without imparting any rotative movement to the spool or reel 19. The gears are rotated when the carriage is shifted from the operator's right to the left (Fig. 1, or from left to right, Fig. 7) this being due to the fact that the teeth of the gears 21 mesh with the teeth of the rack bars 24 and 25 longitudinally disposed within the casing and secured to the cover 6. Therefore, when the carriage is moved from operator's right to left a new exposed portion of the film will be reeled off the roll 18 and when the carriage reaches the limit of its movement from the operator's right, out of register with the fluoroscopic screen, it will be held in this position temporarily by a latch 26 adapted to engage a hook 27 on the end of the carriage. In this position the film is protected against the X-rays by a lead panel 91. The particular construction of the latch mechanism, however, is unimportant since any device will suffice which will permit release by a button 28 or its equivalent. When the carriage is moved from operator's right to left out of line with the fluoroscope it loads two tension springs 29 and 30, anchored to the cassette at 31 and 32 and to the carriage at 33 and 34, consequently when the carriage is released by pressing the button 28 the springs will retract the carriage back to the original position shown in Fig. 6 and Fig. 7, so that it will be in line, both with the fluoroscope and the concavity 8. These springs, therefore, consist of pieces of wire, the scales of the springs being that which is necessary to perform the work of returning the carriage.

The reel or spool 19 is provided at its ends with slits 35 to receive the blades 36 of the spring pressed bolts 37, the spring 38 urging the blades into engagement with the slits so that when the bushings are rotated the spool will be rotated.

It is desirable to move the Bucky diaphragm over the concavo-convex portion 8 of the frame while the exposure is being made for the photographic film so as to counter-act the secondary rays, so I have provided means whereby the movement of the flexible diaphragm 9 will take place when the carriage moves from operator's left to right and for returning the Bucky diaphragm to the left side of the cassette when the carriage is moved out of line with the portion 8 or when it is in its retracted position. This is accomplished by providing one or more depending lugs 39 on the carriage which may engage a similar lug or lugs 40 on the diaphragm so that as the carriage is moved from operator's right to left the diaphragm will be moved from right to left and when it reaches its limit of movement from right to left it will strike a bell tappet 41 to ring the bell 42 which will indicate the movement of the diaphragm has taken place and is ready for use. The diaphragm is connected to a rod 43 projecting into a cylinder 44 and carrying on its end a piston 45 between which and the end of the cylinder is an expansion spring 46 put under compression when the diaphragm is moved from left to right (Fig. 8) by the carriage.

It will be apparent that as long as the carriage is in its latched position the spring 46 will be in its compressed position but as soon as the carriage moves away the bell 42 will ring again and the spring 46 will be free to return the diaphragm to the left (Fig. 8). It is desirous that the movement of the diaphragm be of a speed less than the speed of the carriage so as the speed of the carriage is accelerated by its springs 29 and 30 the movement of the diaphragm is retarded by reason of the fact that the cylinder and the piston act as a check or dash pot, the rate of movement of the diaphragm being governed by a valve 47 to vary the effective port area of an opening 48 in a tube 49 connected with one end of the cylinder 44. When the diaphragm reaches the limit of its movement from left to right it will strike against a bell tappet 50 to ring a bell 51 to indicate its movement has been completed.

On the cassette cover 6 is a rheostat 62 which lowers the milliamperes to the Coolidge tube and there is a lamp 63 in circuit with the foot switch 64 so arranged in the circuit that when the operator's foot is off the foot switch 64 the lamp will illuminate, therefore the lamp 63 constitutes a tell-tale signal.

When the carriage has been moved from operator's right to left or left to right as shown in Fig. 7, also the movement of the diaphragm has taken place and the hook 27 has engaged the latch 26, the contacts of the right side of the carriage are on connection with the contacts which are found on the right side of the cassette (Fig. 7). The lamp 63 will be illuminated. The rheostat 62 is cut in the milliamperage line and the filament of the X-ray tube will be energized by the lower milliamperage. Also a higher resistance is cut in the primary current which goes to the transformer by a double solenoid arrangement.

If the foot switch 64 is depressed the lamp 63 goes out, the high tension circuit with the lower voltage is in the line and the cassette is ready for fluoroscopic use. If the button

28 is pressed the hook 27 will be released and the carriage and diaphragm move from right to left (Figs. 7 and 8) to align with the fluoroscopic screen and with the portion 8 of the cassette. The rheostat 62 is not energized, therefore a higher milliamperage goes to the filament. The resistance which was cut in the primary current of the transformer by the solenoid arrangement is not now energized.

When the carriage reaches the limit of its movement from right to left (Fig. 7) the contacts 56 and 57 on the carriage which contact with the contacts 58 and 59 in the insulated bar 60, carried by the cassette, come together.

The sets of magnets 52 and 53 are now energized, which draws down the fluoroscopic screen upon the film to hold the film tight on its table between the two intensifying screens. These magnets are best shown in Figs. 5 and 6. Between each set of magnets is placed an angulated arm, which keeps the fluoroscopic screen with the lead panel away from the film during fluoroscoping. If the magnets are energized the screen is drawn down and the angulated arm 54 in the set 53 contacts with the contact 55 (see Fig. 5) to close the high tension circuit with the higher voltage, which is used for radiographic work. If the foot button is released by elevating the foot, or regulated by a timer, the high tension current is broken and the lamp 63 will be illuminated again. It will be noticed that the arm 54′ in the set 52 does not carry contacts as does the arm 54 in the set 53.

The right side (Fig. 7) of the carriage carries a plurality of contacts, contact 65 for engagement with contact 66; contacts 67 and 68 for engagement with contacts 69 and 70, and contacts 71 and 72 for engagement with contacts 73 and 74. The contacts 65 and 66 cut in the milliamperage rheostat for the tube filament. The contacts 67, 68, 69 and 70 cut in the high tension current with lower voltage for fluoroscopic use. The contacts 71, 72, 73 and 74 cut in the solenoid arrangement of the primary transformer current if the foot button 64 is depressed. The connections for the various parts are illustrated in the wiring diagram, (see Fig. 2).

I prefer to provide means for numbering the exposures of the sensitized film so on the door 10 I provide a disk shaped stencil 77, rotatable about the pivot pin 78, the stencil having cut out portions to provide numbers in consecutive order. The periphery of the stencil is provided with teeth 79 adapted to be energized by a spring 80 on the carriage so that as the carriage moves from the position for making the exposure the spring will strike one of the projections to bring the stencil portion corresponding to the proper number in position to be printed. When the film or sensitized material is photographed and developed the number will appear on the proper portion thereof, as will be well understood. For convenience I prefer to arrange buffers in the form of dash pots 81 and 82 at the left hand portion (Fig. 7) of the cassette to take up the shock of the carriage when the carriage moves into printing position.

I have not followed out the circuits in detail because that will be obvious from the diagram in Fig. 2, but attention is called to the fact that the milliamperage rheostat 62 is inserted in the circuit by the contact 65 which meets the contact 66. The bars 85 and 85′ which are of different length are connected to the milliamperage line through usual wires 84 and 84′. Over the bars 85′ slide or rub the contacts 83 and 83′ to make and break the circuit and also connect with contact 65, as is clearly indicated by reference to the diagram in Fig. 2 and in Fig. 7.

There may be many refinements in the actual commercial embodiment of the invention without departing from the generic principle herein involved, so I do not wish to be limited to each specific detail of construction illustrated in the annexed drawings but reserve the right to make such changes as properly come within the scope of the appended claims. It will be apparent, however, that with the construction illustrated the operator can move the carriage manually from his right to left so that the latch members 26 and 27 will engage and hold the carriage away from the fluoroscopic screen while the operator is making his observations.

As heretofore explained the movement of the carriage in one direction, which according to the illustration (see Fig. 7) is from right to left, sets the printing or radiographic mechanism, including the Bucky diaphragm, and the other appertenances ready to make the exposure provided of course that the operator's foot is on the foot switch 64, then at the proper time the button 28 may be depressed to release the carriage allowing it to sweep into position, opening the higher milliamperage and higher voltage circuit, make the exposure which will be terminated as soon as the operator takes his foot off the foot switch, or will be regulated by a timer.

The device may be applied to existing types of X-ray machines without materially altering their construction, it being necessary of course to slightly rearrange some of the circuits to make them conform to my invention, but the changes required will be minimized by the fact that they can be followed out by any skilled electrician.

The cassette may be manufactured in any special individual frame which will permit

the cassette being mounted in a vertical, horizontal or oblique position.

The stationary Bucky diaphragm, which is seen during the fluoroscopic examination, permits a better view to be had than is possible without a diaphragm if the cassette is used in gastro-intestinal work. But for other examinations the use of the Bucky diaphragm may not be desirable, therefore the cassette may be manufactured without a Bucky diaphragm, or with a diaphragm, in such manner that the cassette may be interchangeable.

To operate the cassette automatically a special foot switch may be used on which the contacts of the cassette may be attached easily and practically instantaneously. If the cassette is not in use the same special foot switch may be used for all X-ray work.

To change the primary transformer current a special double solenoid, or similar arrangement, may be used but the current may also be changed by hand.

The lead panels 91 and 11 and the lead pockets 16 and 17 would be sufficient to protect the film and the body of the operator against the Roentgen rays if the X-ray tube has an arrangement as usual to limit the Roentgen rays, if not more lead protection may be applied to the cassette.

Obviously it is comparatively easy to have the cassette made so that the movement of the carriage can be in any direction. If for any special reason it is desired to make a picture larger than could be obtained with the illustrated embodiment of my invention it will be necessary to make the cassette somewhat larger on that side toward which the carriage moves to permit additional travel of the carriage. This will result in reeling off more film each time the carriage is operated in one direction, consequently each exposure will be on a larger film portion than would be the case with the construction illustrated.

The carriage can be moved away from the screen by grasping the handle 87, which has side bars projecting through the slots 88 and 89. The handle may be of any appropriate construction. If desired the carriage can be moved in both directions by a motor arrangement.

Attention is also called to the fact that with my apparatus the length of the film strip is limited only by the capacity of the spools, therefore a relatively large number of exposures may be made one after the other in longitudinal or lineal alignment upon a single strip and inasmuch as the exposures on the film will bear the same relative position, one to the other that the movements in the cycle of operation of the organ photographed bears. The value of this arrangement will be apparent.

What I claim and desire to secure by Letters-Patent is:

1. In a machine of the class described, a cassette, a fluoroscopic screen, a movable carriage on the cassette back of the fluoroscopic screen having means for carrying a sensitized material, and means for mechanically moving the carriage into line with the fluoroscopic screen.

2. In a machine of the class described, a cassette, a fluoroscopic screen, a holder for sensitized material located at the rear of the screen, means for moving the material across the screen in a lineal direction, and means for numbering the exposures consecutively as they are made by passing the material across the screen.

3. In a machine of the class described, a cassette, a fluoroscopic screen, a holder for sensitized material located at the rear of the screen, layers of light intensifying material parallel with the screen between which the sensitized material passes, and means for clamping the sensitized material between the layers of light intensifying material.

4. In a machine of the class described, a cassette, a fluoroscopic screen, a movable carriage on the cassette located at the rear of the screen and having means for carrying a sensitized material, means for mechanically moving the carriage into line with the fluoroscopic screen, an X-ray tube, and means for energizing and changing the milliamperage and high tension of the X-ray tube.

5. In a machine of the class described, a cassette, a fluoroscopic screen in fixed position on the cassette, a carriage, means for normally urging the carriage in line with the screen, means for latching the carriage in offset position with respect to the screen, means for releasing the carriage, and a sensitized medium carried by the carriage for making radiographs of the object in front of the screen.

6. A cassette, a carriage movable across the cassette, means for normally holding the carriage against movement, means for moving the carriage to align with an object in front of the cassette, a sensitized medium carried by the carriage, two intensifying screen members between which the sensitized medium may pass, electromagnetic means for clamping the sensitized medium between the screen members, a Bucky diaphragm on the cassette, and means controlled by the movement of the carriage for effecting movement of the Bucky diaphragm.

7. A cassette, a carriage movable across the cassette, means for normally holding the carriage against movement, means for moving the carriage to align with an object in front of the cassette, a sensitized medium carried by the carriage, a Bucky diaphragm on the cassette, and means controlled by the

movement of the carriage for effecting movement of the Bucky diaphragm across the carriage.

8. A cassette, a carriage movable across the cassette, means for normally holding the carriage against movement, means for moving the carriage to align with an object in front of the cassette, a sensitized medium carried by the carriage, a Bucky diaphragm on the cassette, means controlled by the movement of the carriage for effecting movement of the Bucky diaphragm across the carriage, and means for causing the Bucky diaphragm to travel at a speed less than the speed of the carriage.

9. A cassette, a carriage movable across the cassette, means for normally holding the carriage against movement, means for moving the carriage to align with an object in front of the cassette, a sensitized medium carried by the carriage, a Bucky diaphragm on the cassette, means controlled by the movement of the carriage for effecting movement of the Bucky diaphragm across the carriage, means for causing the Bucky diaphragm to travel at a speed less than the speed of the carriage, and for controlling the movement of the Bucky diaphragm after the carriage has come to a state of rest.

10. A cassette, a carriage movable across the cassette, means for normally holding the carriage against movement, means for moving the carriage to align with an object in front of the cassette, a sensitized medium carried by the carriage, a Bucky diaphragm on the cassette, means controlled by the movement of the carriage for effecting movement of the Bucky diaphragm across the carriage, and means for causing the Bucky diaphragm to travel at a speed less than the speed of the carriage for continuing the movement of the diaphragm after the carriage has come to a state of rest.

11. In a machine of the class described, a cassette, a radiographic carriage on the cassette, means for traversing the carriage across the cassette, means for stopping the carriage in position to align with an object in front of it, a table carried by the carriage, a film containing roll at one end of the table, a reeling spool at the other end of the table, a rack carried by the cassette, and a gear in mesh with the rack for driving the reeling spool when the carriage moves in one direction.

12. In a machine of the class described, a cassette, a radiographic carriage on the cassette, means for traversing the carriage across the cassette, means for stopping the carriage in position to align with an object in front of it, a table carried by the carriage, a film containing roll at one end of the table, a reeling spool at the other end of the table, a rack carried by the cassette, a gear in mesh with the rack for driving the reeling spool when the carriage moves in one direction, and an escapement for the reeling spool when the carriage moves in opposite direction.

13. In a machine of the class described, a cassette, a carriage movable across the cassette, means for traversing the carriage in one direction, an X-ray tube in line with part of the cassette, a source of electrical energy for the tube filament, means on the carriage for cutting in a low milliamperage and high tension current with low voltage when the carriage is out of line with the X-ray tube, and means controlled by the carriage for cutting in a higher milliamperage and high tension current with higher voltage when the carriage is in line with the X-ray tube.

14. In a machine of the class described, a cassette, a carriage movable across the cassette, means for manually actuating the carriage, a table carried by the carriage, means for feeding film across the table, intensifying screens between which the film passes, a fluoroscopic screen carried by the cassette, and means for automatically causing the carriage to align with the screen.

15. In a machine of the class described, a cassette, a carriage movable across the cassette, means for manually actuating the carriage, a table on the carriage, means for feeding film across the table, a fluoroscopic screen carried by the cassette, means for automatically causing the carriage to align with the screen, an X-ray tube having a high voltage filament in fixed position in line with the screen, and means automatically operable by the carriage for energizing a conductor to the tube filament.

16. In a machine of the class described, a cassette, a fluoroscopic screen carried by the cassette, a sensitized medium for radiographing an object in front of the fluoroscope, and means for bringing the sensitized medium into and out of alignment with the fluoroscope.

In testimony whereof I affix my signature.

FRED IRWIG.