

March 12, 1929.

S. KATZMAN
METHOD OF TAKING AND COMPLETING X-RAY PICTURES OF OBJECTS IN
ACTION AND MACHINE FOR TAKING PICTURES ACCORDING THERETO

1,704,974

Filed Jan. 14, 1928

3 Sheets-Sheet 1

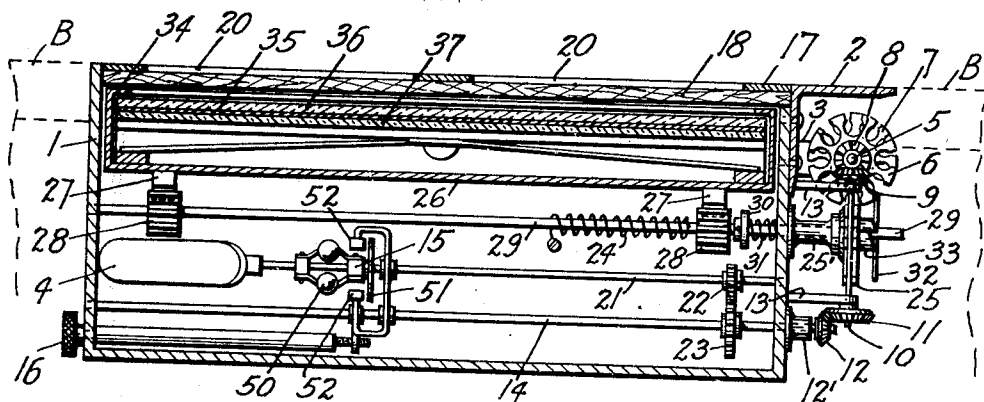
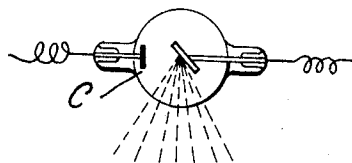


FIG. I.

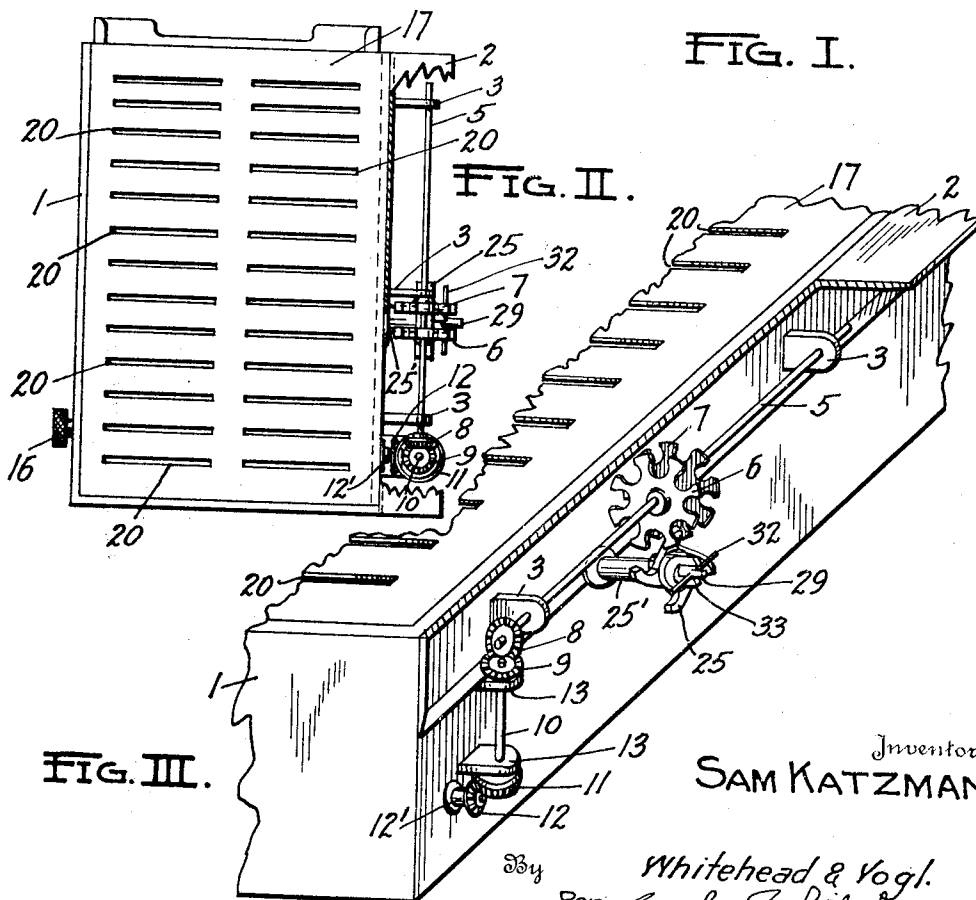


FIG. II.

FIG. III.

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3 Sheets-Sheet 2

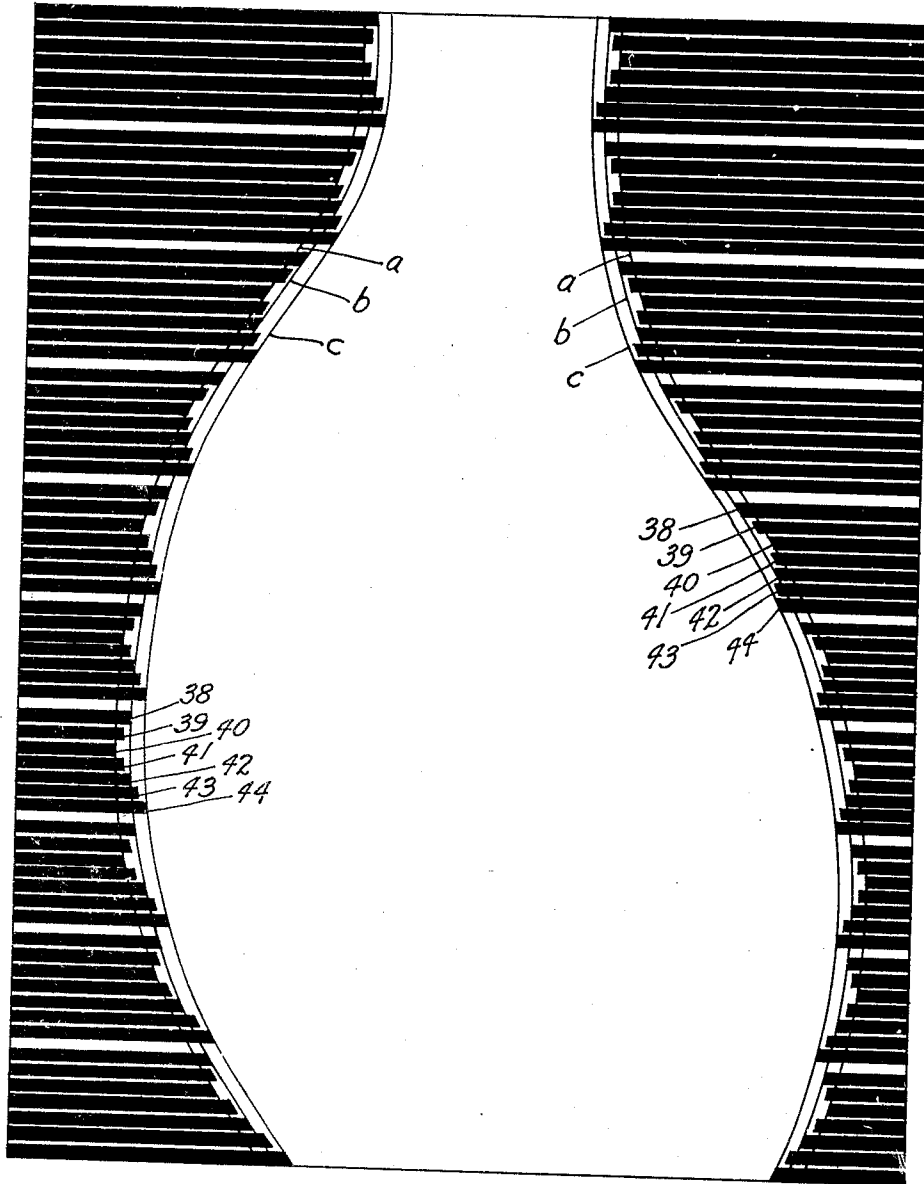


FIG. IV.

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3 Sheets-Sheet 3

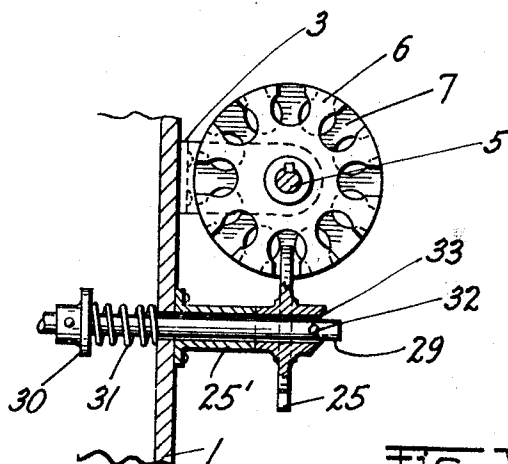


FIG. V.

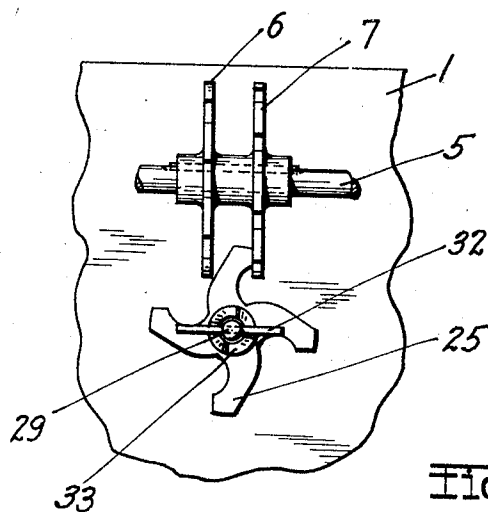


FIG. VI.

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METHOD OF TAKING AND COMPLETING X-RAY PICTURES OF OBJECTS IN ACTION AND MACHINE FOR TAKING PICTURES ACCORDING THERETO.

Application filed January 14, 1928. Serial No. 246,754.

My invention relates to the taking of X-ray pictures and particularly of objects in action, and obtaining a series of such pictures showing a series of progressive stages of such action, and my invention includes an improvement in the process of taking, and also improvements in X-ray machines for taking, such pictures in accordance with said process.

The operation of the process and of the machine can be very simply and graphically described by using as an example the operation in taking a series of pictures of the human heart in action and therefore terminology applicable to such use will be employed hereinafter without in any manner limiting the process or machine, or their objects, uses, or operation to the subject matter here used as an exemplification, the process and machine being both applicable to other subjects as well as to the heart.

An object of my invention is to provide a process and means for obtaining a series of X-ray pictures of the heart showing the outline thereof at each of a series of changes during its cycle, that is, during a complete heart beat.

A further object of my invention is to provide means whereby an X-ray picture showing the changing outline of a heart in action may be taken by separate exposures, or by continuous exposure, of a film during one cycle, that is, during a length of time equal to the period from the start of one heart beat to the start of the next heart beat; or during more than one cycle.

A further object is to provide means whereby at each separate exposure of the film a plurality of X-ray pictures, each of a separate local area of the heart, may be taken.

A further object is to provide means for obtaining a series of X-ray pictures, or a single progressive picture of a plurality of separate local areas of the heart such that by joining the outlines of all local areas taken at the same instant, an outline of the entire heart at that particular instant may be obtained.

A further object is to provide means for obtaining a plurality of outlines of the heart during a cycle, thereby making possible a series of outlines of the heart showing progressively the action of the heart during a

cycle, or making possible a close and exact study of the action of any individual heart's action by observation and measurement of the action of local areas without resorting to the construction of the complete outline.

A further object is to provide means including an apertured plate and a film, movable parallel with respect to each other, to obtain a series of X-ray pictures or to obtain a single progressive picture of a plurality of separate local areas of the heart, such that after the film is developed it may be placed adjacent a properly apertured plate and relative movement provided between the plate and the film to simulate a moving picture of the heart in action.

I accomplish the above objects by providing, in an X-ray picture machine, a sensitized film between two intensifying plates or fluorescent screens, adapted to be moved stepwise at high speed with predetermined time intervals between movements, or adapted to be moved continuously.

A plate practically impervious to X-rays is placed adjacent the film and intensifying plates, this impervious plate being provided with a series of slits so positioned as to make separate pictures of the desired local areas of the heart.

These slits are far enough separated on the impervious plates as to permit a series of the required number of exposures to be registered on the film under each slit, such that the last exposure under a given slit will not overlap the first exposure under the adjoining slit. Thus, each slit will register, say, nine exposures on the film without overlapping any of the nine exposures registered by adjoining slits.

To determine the exact form of the heart at the instant of any one of the nine exposures, the outlines of the pictures taken under all the slits at that instant are joined by drawing in connecting lines. And to obtain nine pictures of the heart showing progressively its action during one cycle, the corresponding pictures under each slit are joined. That is, in the series of say nine exposures under each slit, all exposures number 1 are joined to show the exact outline of the heart at the instant of the first exposure; all exposures number 2 are joined to show the exact outline of the heart at the instant of the second exposure, and so on.

If the actual outlines are not constructed, the action of the heart at any local point may be studied by observation and measurement of the pictures taken by the different exposures of each local area.

If, instead of a series of movements, a continuous movement of the film is made, the result upon the film will be less clear but will show a single picture for each slit of the plate.

The contour of each of these series of pictures will show progressively the path of travel of the outline of each local area during the time of the exposures, and the action of the heart may be studied by observation and measurement of the different positions in the contour during the series of exposures of each local area.

If outlines of the heart are also required from such pictures they may be obtained by joining the corresponding points of the contours of the different pictures.

The above explains the process by which study of the progressive action of the heart during one or more cycles is made and the outlines, if desired, obtained.

One embodiment of the construction by which this process may be carried out is shown in the accompanying drawings, in which:

Figure I is a vertical section through the entire machine, with the supporting bench indicated by dotted lines.

Figure II is a plan view of the machine without the supporting bench or X-ray tube and with the guard or protecting platform removed.

Figure III is a perspective of the machine without the supporting bench or X-ray tube and showing the escapement or tripping mechanism.

Figure IV is a diagram illustrative of the pictures obtained on a single film and the method of obtaining therefrom the outlines of the object pictured.

Figures V and VI are detailed views of the escapement mechanism.

The box or enclosure 1, the guard or protecting platform 2, the shaft supports 3, 3, 13, 13, and the plate supports 18, constitute the framework of the machine, the upper surface of which is flush with the supporting bench B, indicated by dotted lines in Figure I.

The X-ray tube C, properly supported and served, is adapted to be positioned as desired above the machine.

In the shaft supports 3, 3, turns the shaft 5, carrying the two timer wheels 6 and 7 and a bevel gear 8, securely attached to the shaft 5.

In mesh with the bevel gear 8 is a bevel gear 9 which is securely attached to the shaft 10.

The bevel gears 8 and 9 are properly sup-

ported and held in mesh by the shaft supports 3 and 13.

To the shaft 10, which rotates in the shaft supports 13, 13, is securely attached the bevel gear 11 which is in mesh with the bevel gear 12. The bevel gear 12 is securely attached to the shaft 14 which is rotated by the motor 4, through the medium of the shaft 21, and the gears 22 and 23.

The bevel gears 11 and 12 are properly supported and held in mesh by the shaft supports 13 and 12'.

Secured to the shaft 21 is a fly ball governor 15. As the fly balls 50 move toward and away from the shaft 21 they move the brake plate 51 along the shaft 21 away from or toward the brake shoes 52.

Adjustment of the position of the brake shoes, therefore, adjusts the speed of the shaft 21 at which contact between the brake plate 51 and the brake shoes 52 takes place.

This adjustment of the brake shoes toward or away from the brake plate 51 is accomplished by rotation of the screw 16.

The machine has two separate and distinct power units; the timer motor 4 and the tractor spring 24.

The function of the motor 4 is to rotate the shaft 5 at the steady predetermined angular velocity set by the adjustment of the screw 16, so that the timer wheels 6 and 7 which are securely attached to the shaft 5 will rotate accordingly and allow the escape wheel 25 and the shaft 29 a definite intermittent rotation.

The function of the tractor spring 24 is to rotate the escape wheel 25 through the shaft 29, the steady rotation of the timer wheels 6 and 7 permitting this rotation of the escape wheel 25 to take place intermittently.

This feature of construction is illustrated in Figure III, where it will be seen that the two timer wheels 6 and 7 allow the escape wheel 25 to rotate between the timer wheel teeth in jumps, that is, the escape wheel 25 is stopped at regular intervals by contact of one of its teeth with one of the teeth of one of the timer wheels. Hence, as the timer wheels rotate steadily the escape wheel must rotate intermittently.

The most accurate adjustment of the time intervals through which the escape wheel operates can be effected in the construction of the timer wheels 6 and 7, for at any given speed of the shaft 21, as set by the governor 15 and the adjusting screw 16, the width of the teeth as well as the width of the spaces between the teeth can be calculated to allow the predetermined time intervals desired after each jump or rotative movement of the escape wheel 25 and the shaft 29.

The intermittent rotation of the shaft 29 provides intermittent rotation for the gears 28 which are securely attached to the shaft 29. The gears 28 mesh with the racks 27

which are securely attached to the cassette carrier 26. Hence, the tractor spring 24, through the steadily moving timer wheels 6 and 7, the escape wheels 25, the shaft 29, the gears 28 and the racks 27, gives the cassette carrier 26 an intermittent movement that is in step with the intermittent movement of the escape wheel 25. That is, the cassette carrier 26 rests for definite intervals of time and jumps to new positions between rests.

Further adjustment or variation of these time intervals may be obtained by constructing the escape wheel 25 with more or with less teeth as desired, and also by variation in the distance between the timer wheels 6 and 7.

The collar 30 on the shaft 29 acts as a shoulder against which the compressed spring 31 bears, the other end of the spring 31 bearing against the framework 1.

This spring pressure tends to keep the shaft 29 in such position that the pawl 32 is resiliently held in the notches of the ratchet wheel 33.

The ratchet wheel 33 is securely attached to the escape wheel 25 and both the escape wheel 25 and the ratchet wheel 33 are free to revolve as a single unit on the shaft 29 except for the co-action of the pawl 32 and the teeth of the ratchet wheel 33.

The escape wheel 25 is held spaced from the framework 1 by the bearing 25'.

The pawl 32 also serves as a handle or key for the purpose of winding up the tractor spring 24 and thereby returning the cassette carrier 26 to the original or starting position. As the pawl 32 is revolved by hand in winding up the spring 24, the shaft 29 is forced endwise against the pressure of the spring 31 as the pawl 32 rides upon the beveled sides of the teeth of the ratchet wheel 33.

The cassette carrier 26 carries a cassette 34, as is shown in Figure I, the sensitized film 35 being between the intensifying or fluorescent screens 36 and 37. The cassette being of the standard type in use requires no further description.

The plate 17 which is substantially opaque to X-rays is attached to the box frame 1, thus forming the top of the machine.

The person whose heart is being pictured is so positioned upon the bench B and upon the plate 17 that the heart or other part being photographed will be over the plate 17.

The plate 17 is supported by the support plate 18, which is constructed of material that is not opaque to the X-rays.

In the plate 17 are a number of slits 20. The dimensions, shapes and relative positions of the slits may be varied as the objects being shadowgraphed and the results sought may require.

If continuous instead of intermittent movement of the cassette carrier and film is desired, the shaft 5 and the timer wheels 6 and 7 may be dispensed with, and the gear 22 may be made to mesh with the gear 28, the governor 15 then being used to control the uninterrupted revolution of the shaft 29 and the resulting uninterrupted movement of the cassette carrier 26.

While the process may be effected by any suitable mechanical arrangement of power units, gears, timer, wheels, governor, or other similar or dissimilar members or construction so long as the desired results of quick movement between positions and in case of intermittent movement, predetermined periods of rest between movements are obtained, the embodiment herein described as efficient, preferable and novel.

Figure IV is a diagram of a film upon which has been taken a series of seven exposures. Numerals 38 to 44, both inclusive, are attached to several of the series of shadows as taken through one aperture of the plate, each shadow terminating at the outline of the local area of the heart as it was at the instant of the exposure producing such shadow.

To obtain the outline of the heart at any given instant, the termini of the shadows taken at that instant through each of the apertures of the plate are joined. That is, joining the termini of the third shadow in each series produces the outlines *a*. In other words, the outline of the object at the instant of the number three exposure is obtained by drawing a line connecting the termini of all number 40 shadows on the film.

Outline *b* is obtained by a line joining the termini of all number 42 shadows and outline *c* is formed by joining the termini of all number 44 shadows. Thus, the actual outlines of the object at the time of each of the exposures may be obtained.

A plate, such as plate 17, with its apertures 20 placed over a picture of the heart taken according to this process and as illustrated diagrammatically at Figure IV and moved over the picture by successive disclosures through the apertures of the plate of the series of shadows, will give in effect a moving picture of the heart during the cycle of action included within the exposures.

Many modifications of and changes in construction of the machine and in detail of the process may be made within the spirit and scope of the invention and the appended claims.

What I claim as new and desire to protect by Letters Patent is as follows:

1. The process comprising taking X-ray pictures, simultaneously upon a single film,

of separated local areas of an object and drawing lines, connecting corresponding points in the pictures for forming an outline of the object.

5 2. The process comprising taking X-ray pictures of an active object in a series during a given cycle of its action, each picture in the series being upon a single film but being in a plurality of sections, each of which
10 covers only a separated local area of said object, and drawing lines connecting corresponding points in the various sections of each picture for forming an outline of the object in its condition at the time of the taking
15 of said picture, whereby to obtain outlines of said object at each of such series of stages of its cycle of action.

3. The process of picturing progressive changes in an active object during a given
20 cycle of its action, comprising taking a series of exposures during said cycle, each exposure taking X-ray pictures of separated local areas of said object but upon a single film, and drawing lines connecting corresponding
25 points in the local-area-sections of the pictures formed by each exposure.

4. The process of taking a series of X-ray pictures of an active object, each picture being of a plurality of separated local areas
30 of said object but upon a single film.

5. The process comprising taking a series of X-ray pictures, simultaneously upon a single film, of local areas of an active object, such local areas being sufficiently spaced
35 apart for the taking of the series of pictures without overlapping thereof.

6. The process of taking a series of X-ray pictures of an active object, each picture being of a plurality of separated local areas
40 of said object but upon a single film, comprising the interposition between the object and the film of a plate having apertures therein and impervious to X-rays, except for said apertures, and in fixed relation to the object
45 and the provision of movement relatively between the film and the object during said cycle of action.

7. The process of obtaining a moving X-ray picture of an active object comprising
50 taking X-ray pictures of said object in a series during a given cycle of its action, each picture in the series being of a plurality of separated local areas of said object but upon a single film, placing an apertured plate adjacent the developed film and providing
55 relative movement between the film and the plate.

8. In an X-ray machine, means for producing X-rays, a plate therebelow substantially impervious to the X-rays and having
60 a plurality of separated apertures, means for maintaining the plate and the object to be pictured in relatively fixed relation, a sensitized film mounted adjacent and below
65 said plate, and means for causing relative

movement between the plate and the film.

9. In an X-ray machine, means for producing X-rays, a plate therebelow substantially impervious to the X-rays and having
70 a plurality of separated apertures, means for maintaining the plate and the object to be pictured in relatively fixed relation, a sensitized film mounted adjacent and below said plate, and means for causing relative intermittent movement between the plate and the
75 film.

10. In an X-ray machine, means for producing X-rays, a plate therebelow substantially impervious to the X-rays and having a plurality of apertures, means for maintaining
80 the plate and the object to be pictured in relatively fixed relation, a movable carrier provided with means sensitive to the X-rays, and means to move the carrier relative to the plate.
85

11. In an X-ray picture machine, means for producing X-rays, a plate substantially impervious to the X-rays therebelow and having a plurality of apertures, means for
90 maintaining the plate and the object to be pictured in relatively fixed relation, a movable carrier provided with means sensitive to the X-rays, means to give the carrier a series of movements relative to the plate and separated by predetermined intervals of
95 time, and means to adjust said predetermined intervals of time.

12. In an X-ray picture machine, means for producing X-rays, a plate substantially impervious to the X-rays therebelow and
100 having a plurality of apertures, means for maintaining the plate and the object to be pictured in relatively fixed relation, a movable carrier provided with means sensitive to the X-ray, means adapted to move the carrier relative to the plate, an escapement
105 mechanism connected to interrupt the movement of said carrier at regular intervals for predetermined periods of time, and means to adjust the escapement mechanism to vary
110 said predetermined periods of time.

13. In an X-ray machine, means for producing X-rays, a plate substantially impervious to the X-rays therebelow and having a plurality of apertures, a movable carrier provided with means sensitive to the X-rays, a
115 shaft, rack and gear connections between the carrier and the shaft, means adapted to rotate the shaft and move the carrier relative to the plate through said rack and gear connection, an escape wheel on the shaft, a second shaft, means to steadily rotate the second shaft and to control the rate of such steady rotation, and means on the second shaft
120 adapted to co-operate with the escape wheel and to intermittently stop the movement of said carrier.
125

In testimony whereof, I affix my signature.

SAM KATZMAN.