Oct. 15, 1957 J. BALL ET AL 2,810,078

PHOTO TIMER

Filed Jan. 19, 1952 3 Sheets-Sheet 1

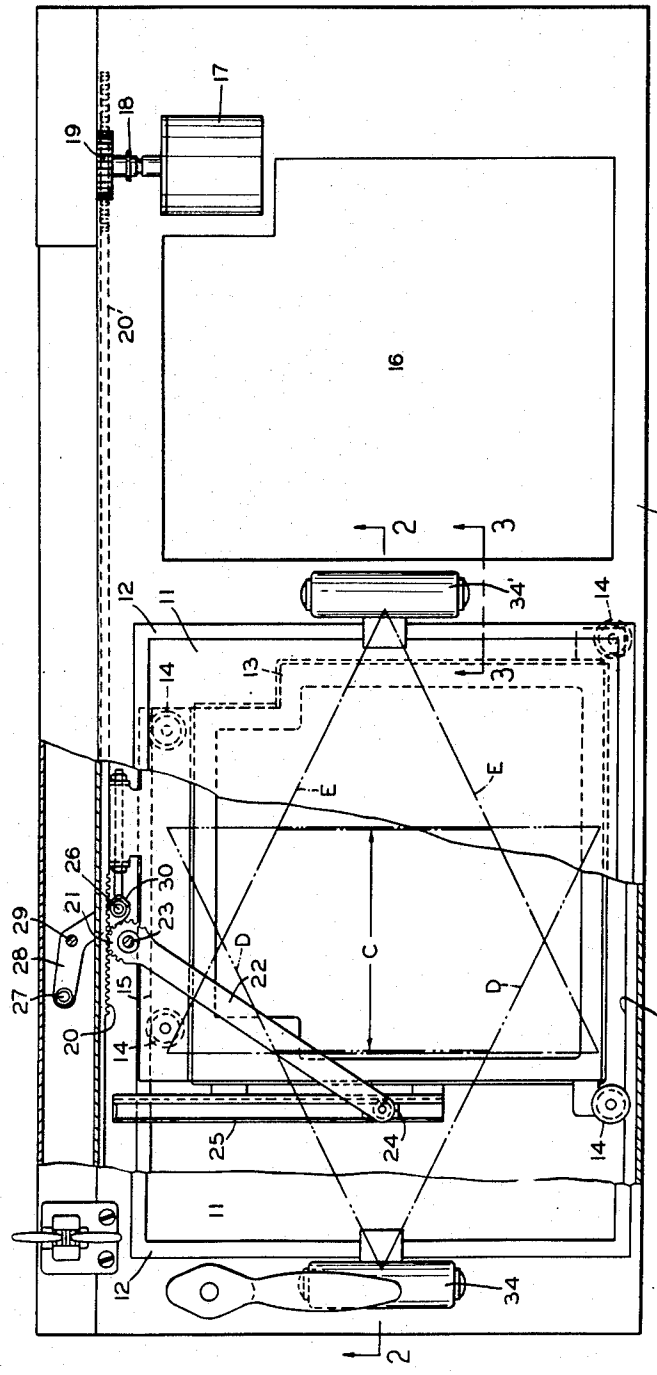
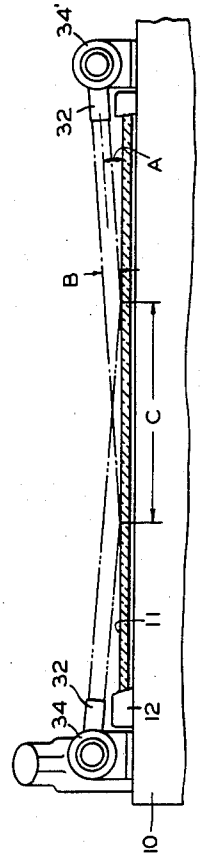


FIG-1

FIG-2



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PHOTO TIMER

Filed Jan. 19, 1952 3 Sheets-Sheet 2

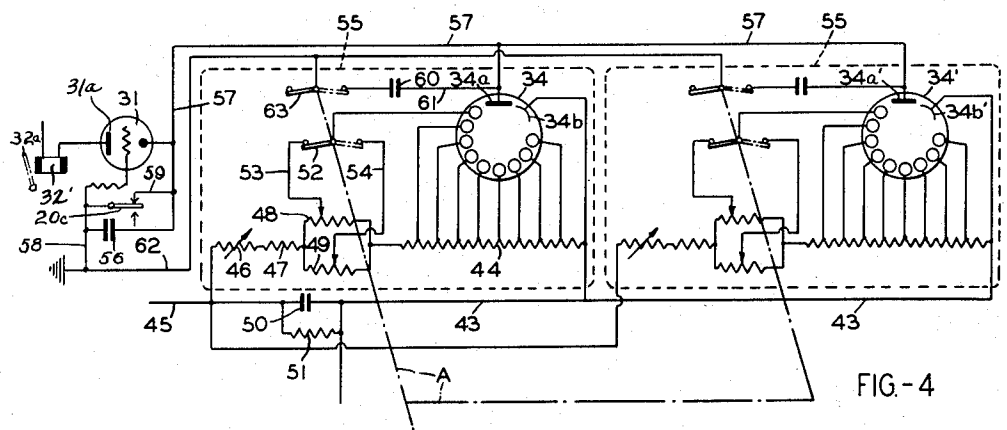


FIG.-4

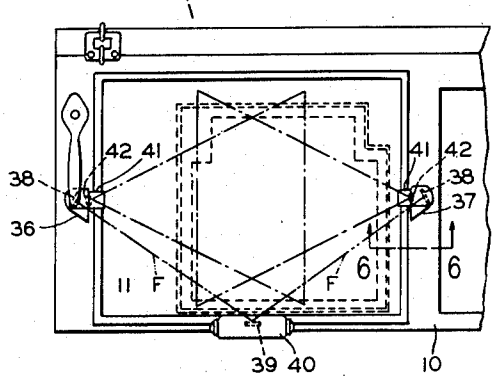


FIG.-5

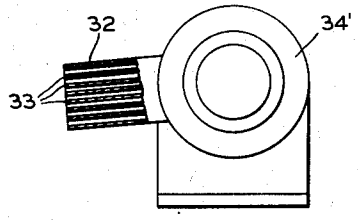


FIG.-3

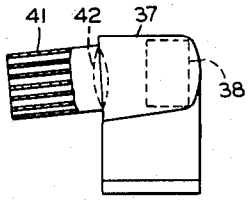


FIG.-6

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Oct. 15, 1957 J. BALL ET AL 2,810,078

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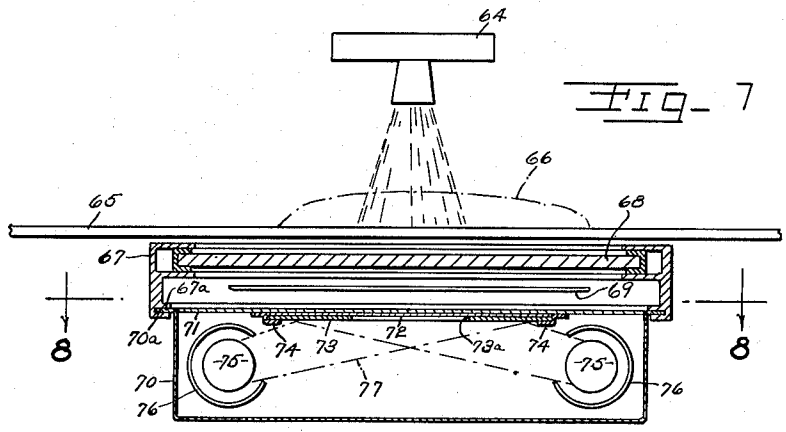


FIG. 7

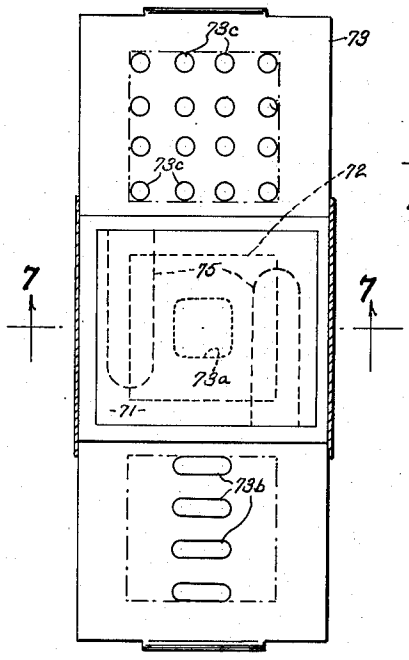


FIG. 8

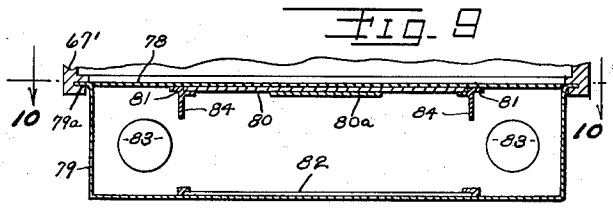


FIG. 9

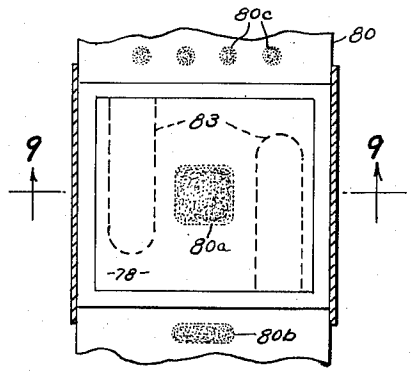


FIG. 10

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2,810,078

PHOTO TIMER

Jack Ball, Cleveland, Ohio, and John J. Russell, Greenville, S. C., assignors to Picker X-Ray Corporation, Waite Manufacturing Division, Inc., Cleveland, Ohio, a corporation of Ohio

Application January 19, 1952, Serial No. 267,281
7 Claims. (Cl. 250—95)

This invention relates to improved means sensitive to the luminosity of an image on a fluorescent screen and useful for controlling a timing period in a photographic process.

This application is a continuation in part of our copending application Serial No. 116,112, filed September 16, 1949, for Photo Timer, now abandoned.

One of the objects of the present invention is to provide light sensitive means subject to the luminosity effect of an image on a fluorescent screen as observed from opposite sides of the same surface thereof so as to average the light effects over a large portion of the entire image whereby a light area of the image which is nearer to one of the luminosity responsive devices will be farther away from the luminosity responsive device on the opposite side of the image, thus averaging the total light effect and obtaining a more accurate value for photographic timing purposes.

In one form of our invention, two photoelectric cells are positioned respectively on opposite sides of the image in position to receive light rays from a large area of the image and the electrical output of the two photoelectric cells is totalized or averaged for timing purposes.

In another form of our invention, the luminosity effect from opposite sides of the image is focused by means of mirrors simultaneously from two mirrors on to a single photoelectric cell, thus averaging the light effect from opposite sides of the image in a single cell, the output of which is utilized in a timing circuit.

Another object of the present invention is to do away with the errors which occur by timing an X-ray photograph where the timing value is determined from one side only of the image.

Still another object of the present invention is to do away with cumbersome movable light-sensitive devices which have to be moved over the image in the screen for operative purposes and thus are sensitive to the particular spot on which the light-sensitive device happens to be focused and which is undesirable because of the wires connected to the device which have to be bent back and forth each time, together with the undesirability of having the vision of the operator obstructed.

Another object of our invention is to provide a regular non-biological pattern of fluorescent luminosity on an area viewed by two photoelectric cell means located on opposite sides of the pattern area so that the light rays from the area approach the cells at a very flat angle, thus providing means for averaging the luminosity from the area as received at opposite sides thereof and at the same time providing a regular pattern diaphragmed upon said area. This gives a more accurate source for timing a radiograph or a photograph than any other method now known to us.

In carrying out the purpose of the next preceding paragraph, this invention utilizes either a light-opaque mask interposed between the luminous fluorescent screen and the light sensitive cells so as to provide a pattern of the visible light between the luminescent screen and the cells; or we may provide fluorescent material arranged in a regular non-biological pattern and subject to the X-rays which pass through the film upon which a radiograph is being taken and this luminous pattern is then viewed by the photoelectric cell means.

In another form of our invention, the regular light pattern from the fluorescent material may be reflected in a parallel mirror and the photoelectric cell means may be subject to light from both the original and the reflected sources.

Other objects and advantages of our invention will be apparent from the accompanying drawings and description and the essential features will be summarized in the appended claims.

In the drawings, Fig. 1 is a top plan view of a frame equipped with a fluorescent screen and a movable cassette or film holder and equipped with that form of our device which requires two photoelectric cells;

Fig. 2 is a fragmental sectional view taken along the line 2—2 of Fig. 1;

Fig. 3 is a fragmental sectional view enlarged taken along the line 3—3 of Fig. 1 and partly broken away to more clearly show the construction;

Fig. 4 is a diagrammatic view of a portion of an electrical timing circuit for use with the device of Figs. 1, 2 and 3;

Fig. 5 is a top plan view of the left-hand portion of Fig. 1 to somewhat smaller scale and showing a modified form of our device using mirrors;

Fig. 6 is a fragmental sectional view enlarged taken along the line 6—6 of Fig. 5;

Fig. 7 is a somewhat diagrammatic showing of another modification of our invention and including a sectional view through a Bucky housing below an examination table, the sectional view being taken along the line 7—7 of Fig. 8 and somewhat enlarged;

Fig. 8 is a fragmental sectional view taken along the line 8—8 of Fig. 7 but drawn to a somewhat smaller scale;

Fig. 9 is a fragmental sectional view similar to Fig. 7 but showing another modification of our invention and taken along the line 9—9 of Fig. 10; while

Fig. 10 is a fragmental sectional view taken along the line 10—10 of Fig. 9, the scale of Fig. 9 being somewhat larger than the scale of Fig. 10.

Our invention is useful for photo-timing an X-ray photograph or for timing an ordinary photograph of an X-ray image on a fluorescent screen. In either case, the parts to be photographed are viewed as an image on a fluorescent screen and some measure of the luminosity of the image must be utilized for timing purposes. One common device for photo-timing a picture under these conditions, consists in the use of a photo-sensitive tube which is moved to a central position of the picture when it is desired to time an exposure. One of the difficulties of this device is that the phototube is in the way for viewing the screen when it is moved to a position over the screen, and furthermore the device has high voltage wires connected to it, which have to be bent back and forth each time the phototube is placed in position or pushed out of the way. Another difficulty with this type of timing is the great difference in the effect depending upon whether the phototube is focused over a dark shadow such as the spine would make or over a brighter spot such as light tissue would make. This is particularly noticeable where a patient has been fed bismuth which, of course, provides a very dark spot, and if the phototube were placed over such a spot, a very dark picture would result.

Another manner of photo-timing such pictures is the provision of a photo/electric tube or cell along one side of the fluorescent screen and directed toward the image on the screen. This is a satisfactory arrangement except that it does not average the light over the entire screen, but has a greater effect from the areas lying close to the phototube rather than from the areas farther away. The effect of the light of the image on the phototube follows the in-

verse square law and therefore the image areas nearer to the phototube give a much greater effect.

For instance, if it is desired to take a picture through one-half of the human body, if the phototube is toward the center of the body, then the dark portion of the body image will be nearer the phototube and the image farther away from the phototube may have a certain amount of "splash" where the view extends outside the confines of the body itself, giving a very bright spot on the screen. However, this bright spot on the screen is distant from the phototube and therefore the darker portion of the body nearer the phototube will control and one will obtain a dark picture. On the other hand, if the phototube is near one side of the body looking toward the center, then any "splash" will be close to the phototube and the darker portion of the body image will be further away from the phototube. In this case, the timer will cut off the exposure tube quickly and a light print will develop.

We have chosen to show our invention in combination with a frame **10** which carries a fluorescent screen **11** in a binding frame **12** and mounted by means not shown for movement to various positions relative to the body of the patient to be observed. A cassette or film tray **13** is mounted by means of rollers **14** for movement along parallel tracks **15** either to a photographing position as shown in Fig. 1 or to a loading and unloading position in the area **16**. For moving the tray **13** back and forth, a motor **17** is provided which through a slip clutch connection **18** drives a pinion **19** meshing with a rack **20** which in turn meshes with a mutilated gear **21** formed on one end of an arm **22** which is oscillatable about a fixed pivot **23** connected with the main frame **10**. At the opposite end of lever **22** it has a pivotal engagement with a shoe **24** which is slidable in a slotted frame **25** which is rigidly carried and is a part of the tray **13**. Movement of the rack **20** thus oscillates arm **22** to carry the tray **13** from loading to photographic position and back again. The particular device shown in the drawings is a spot film arrangement with stop members **26** and **27** carried by arm **28** which is pivotally mounted at **29** on the main frame and is movable by means of a handle not shown. A V-shape stop **30** adjustably mounted on the tray **13** engages the stop **26** in the position shown in Fig. 1 so that the tray can move no farther toward the left. The slip clutch arrangement **18** provides a safe manner of stopping at any desired point, the motor **17** being arranged to overdrive until a stop member is reached. In this particular device, the tray **13** may be set to take a picture for each of its four quarters or for the left half or the right half or for the upper half or for the lower half or for the entire area of the screen. The particular arrangement of the main frame **10** and the movements of the tray **13** have no special bearing on the present invention and are only shown to illustrate one embodiment thereof.

In the form of our invention shown in Figs. 1 to 4 inclusive, a photoelectric cell **34** is mounted in fixed position on the frame **10** at the left-hand side of the fluorescent screen **11**. A second photoelectric cell **34'** is mounted in fixed position on the frame **10** at the right-hand side of the fluorescent screen as shown in Figs. 1 and 2. As shown in Fig. 2, these photoelectric cells extend a very short distance above the level of the frame, approximately one and one-half inches, so that they are entirely out of the way and are not obstructing the view of the operator. As clearly shown in Fig. 2, the angle A between the beam of light coming from the image on the fluorescent screen toward each of the photoelectric cells is very flat, not over five to ten degrees. It results from this construction that a very shallow beam of depth B thus intercepts a wide area of width C on the fluorescent screen. In other words, the light beams coming from the image toward each of the photoelectric cells is derived from a very large area of the fluorescent screen **11**. The openings to the photoelectric tubes are provided with devices **32** for columnating the light entering the cell openings. As shown in Fig. 3, this comprises a plurality of parallel plates **33** and this insures that the beams of light directed to celis **34** and **34'** come from substantially the same exact area. In other words, the two beams overlap for the width of the image indicated at C in Figs. 1 and 2. The rays from each cell converge along the broken lines as shown in Fig. 1. The rays toward the cell **34** converge along the dot-dot-dash lines D and converge toward the cell **34'** along the dot-dash lines E. Thus, except for the outer corners as shown in Fig. 1, the light beams moving toward cells **34** and **34'** come from substantially the same area of the fluorescent screen and come from quite a large area thereof so that there is no specialized effect from a particularly light or dark spot of the image on the screen. It will be obvious that a light spot of the image nearer tube **34'** will have a strong effect there but will have a weak effect on the tube **34**. Thus the luminosity effects from opposite sides of the image are averaged.

An electrical connection between photoelectric cells 34 and 34' so as to average out the results and to utilize this result in a timing circuit is illustrated in Fig. 4. The view of Fig. 4 is intended to be incorporated in the timing circuit shown and claimed in the copending patent application Serial No. 785,664 of Jack Ball and Edward B. Graves for Photoelectric Timer for X-ray Apparatus, filed November 13, 1947, now Patent No. 2,541,187, granted February 13, 1951, to which reference may be had for a more complete description. It will be noted that the left-hand portion of Fig. 4 is exactly like a similar part of the drawing in the above mentioned copending application wherein a photoelectric cell **34** is shown in a broken line box indicated as **55**. The right-hand portion of Fig. 4 is a complete duplication of the left-hand portion and any parts thereof may be referred to with reference characters having the suffix "prime." The photoelectric tubes 34 and 34' are illustrated as being of the type shown in United States Patent No. 2,231,697, granted February 11, 1941, to V. K. Zworykin et al. The cathodes *34b* and *34b'* of the present application are intended to be the equivalent of the cathode 5 of the above mentioned Zworykin et al. patent. It will be noted that whereas, in the above mentioned copending application the termination of a photographic exposure depends upon the firing of the trigger tube **31** responsive to the output from a single photoelectric cell **34**, the timer circuit when connected according to the teachings of Fig. 4 and the above mentioned copending application connects in parallel the plates *34a* and *34a'* of the two phototubes by means of the connector **57**. It is well known to fire a trigger tube when a connected condenser has collected sufficient electrons from an anode such as *34a* of cell **34**. The present invention supplies means for charging such a condenser responsive to the average luminosity of substantially the entire screen by connecting the anodes *34a* and *34a'* in parallel.

A trigger tube **31** is shown as of the cold cathode type. The plate *31a* of this tube is connected through relay **32'** having an armature *32a* the purpose of which is to open a set of contacts and terminate the X-ray exposure responsive to the timing apparatus herein disclosed.

A phototube of the above mentioned Zworykin type is diagrammatically shown at 34. This tube has a plate *34a*, a cathode *34b* and a plurality of dynodes. Suitable taps on resistor **44** supply the dynodes with proper voltage all except the last one. This last dynode is connected to switch **52** which, in the full line position shown in the drawings, engages contact *52a* for radiography. The series resistor **46** is used as a calibrator. The phototube units are sent out fully assembled including the parts within the broken line **55**. By adjusting the resistor **46**,

each phototube unit may be adjusted to the same sensitivity so as to give identical output.

A capacitor **56** is provided for collecting the electrons from the anode **34***a* of the phototube until a sufficient charge is collected to fire the trigger tube **51**. This condenser is connected with line **57** which in turn connects the anode **34***a* of the phototube with the cathode of the trigger tube. The other side of the condenser is grounded through line **58**. The capacitor **56** is normally short-circuited through line **59** and switch **20***c* until an exposure starts. At that time, the switch **20***c* opens and the capacitor begins to collect a charge. By proper selection of the capacity of the capacitor **56**, the potential to which it is charged in order to fire the trigger tube, and the sensitivity of the phototube, an exposure may be terminated when a recording film has been properly exposed. The capacitor **56** and the trigger tube **31** are so selected and arranged as to take care of the output from the two photoelectric cells **34** and **34'** so as to terminate the X-ray exposure after the film has been properly exposed.

Certain refinements will occur to those skilled in this art in order to make the above device operate properly. In the first place, each of the cells **34** and **34'** will be separately focused on the same area, lighted in the same manner, and each of the phototube units will be adjusted to the same sensitivity so as to give identical output for identical input. This is done by adjusting the resistor **45** for cell **34** and by adjusting the equivalent resistor for the cell **34'**.

The apparatus mentioned so far utilizes two photoelectric cells and totalizes the output of the two cells electrically in order to obtain an average result from the image on the fluorescent screen. The modification shown in Figs. 5 and 6 averages the luminosity effect observed from each side of the image by simply adding together the light rays as they effect a single photoelectric cell. All of the parts of Fig. 5 are understood to be the same as those described in connection with Fig. 1 except those now about to be described. Positioned in fixed relationship to the frame **10** on opposite sides of the fluorescent screen **11**, I provide housings **36** and **37**. In each of these housings there is a mirror **38** so positioned as to receive light rays from the image on the fluorescent screen and to reflect these rays parallel to the dot-dot-dash lines F of Fig. 5 to the cathode **39** of a photoelectric cell **40** which is mounted on the frame **10**. The cathode **39** is of a similar character to that previously described at **34***b* and **34***b'*. Columnating device **41** exactly equivalent to the devices **32** are positioned in front of each of the mirrors **38** to provide parallel rays of light coming from the fluorescent screen toward each mirror and limiting the area covered by the rays of light going in opposite directions to the same width of image as indicated at C in Figs. 1 and 2 in connection with the first form of our device. If necessary or desirable, a lens **42** may be positioned between each device **41** and the associated mirror **38** so as to converge all of the stray rays of light on to the mirror **38**.

The operation of the device of Figs. 5 and 6 should now be apparent. The phototube **40** takes the position of the photoelectric cell **34** as shown in the above mentioned copending application. The cathode **39** takes the place of the cathode **34***b* of the copending application. The output equivalent to **34***a* of the photoelectric cell **40** is directed to a trigger tube such as shown at **31** in the copending application to produce a timing operation. The necessary corrections can be made to take care of the light coming from two sources toward the cathode **39** in the present instance, but it will be obvious to those skilled in this art how this may be done so as to utilize the photo-timing circuit of the above mentioned copending application.

In a modification shown in Figs. 7 to 10 inclusive, our invention is shown in connection with a diaphragm or equivalent means for supplying a regular pattern of luminosity viewed by the phototubes so that the phototubes are not exposed to the entire area of the fluorescent screen but only to a selected pattern thereof. We find that a much better timing job is performed when this pattern is used in connection with two phototubes viewing the pattern from opposite sides thereof.

Fig. 7 is somewhat digrammatic and indicates an X-ray tube at **64** positioned above a table **65** so that its rays penetrate a subject indicated in dot-dash lines **66** lying upon the table. Beneath the table is the usual Bucky housing **67**, in which is mounted a Bucky grid **68** and beneath that a film sensitive to X-rays indicated at **69**. It will be understood that this is diagrammatic as the film is always in a holder. Beneath the film is provided our phototube unit **70** which consists essentially of a substantially square light tight casing having at its upper edge outwardly extending flanges **70***a* which are slidable in ways **67***a* in the housing **67**. Extending across the open top of the casing **70** and suitably supported therein is a thin plate **71** of aluminum or the like. The underside of this plate at its central portion is provided with a fluorescent screen **72** mounted on the plate **71** in a known manner. Beneath the fluorescent screen is a mask **73** of opaque material, black cardboard being suitable, and mounted for sliding movement in ways **74** attached to the underside of plate **71**.

The mask **73** may be formed in various ways but I have shown in Fig. 8 how an elongated mask may be provided with three different patterns any one of which may be positioned within the casing **70** by simply sliding the mask **73** in the ways **74**. The regular patterns illustrated comprise a substantially square opening **73***a* located substantially centrally of the fluorescent screen area **72** but of less extent than the area **72**. This is the regular pattern which is in position in Fig. 7. Another regular pattern is shown at **73***b* in Fig. 8 and comprises four regularly spaced generally oblong holes, while a third regular pattern shown at **73***c* consists of sixteen regularly spaced round holes. Other patterns might be used or a combination of screens might be superposed one upon the other to give the desired number of patterns. In the case of the pattern shown in Fig. 8, the pattern **73***a* might be used when a narrow part of the body is being photographed such as an arm. The pattern of **73***b* might be utilized in taking a picture of the ribs of the human body from a lateral position, whereas the pattern of **73***c* might be used for a full front or a full rear picture of the human torso.

It will be noted in Figs. 7 and 8, that our invention has been aplied by placing two phototubes **75** on opposite sides of the fluorescent screen and positioned to receive the rays therefrom at a very flat angle so that each phototube views a large area. These tubes are shown diagrammatically in Fig. 8 but they are positioned in staggered relationship, the tubes coming into the casing **70** sufficiently far that the light sensitive portion thereof is centered on the area **72**.

The tubes in Fig. 7 might be columnated by providing devices like those shown at **32** in Fig. 3. However, much the same effect may be obtained by surrounding each phototube by a generally cylindrical shield **76**, open to light rays only as indicated by the dot-dash lines **77** in Fig. 7.

The tubes **75** of Fig. 7 are intended to be connected in a timing circuit exactly like that shown in Fig. 4 so that the combined effect of the luminous regular pattern upon the two tubes **75** positioned like the tubes **34** and **34'** of Fig. 4. will eventually charge the condenser **56** and fire the tube **31** so as to energize relay **32'** and terminate the X-ray exposure.

The modification of Figs. 9 and 10 are quite similar to those shown in Figs. 7 and 8 and intended to be used in the same combination. In Fig. 9, all parts of the housing **67'** above the parts shown in the drawing are

intended to be like those shown at 67 in Fig. 7 and the device is intended to be mounted beneath the table 65 with the X-ray tube 64 above the table so that the X-rays pass through the subject 66 and through a sensitive film 69 after which they impinge upon the plate 78. This plate covers the open top of a casing 79 which is a square casing having flanges 79*a* slidably received in suitable ways in the housing 67 wholly analogous to the mounting of the casing 70 previously described.

In the modification of Figs. 9 and 10, the regular pattern forming means comprises the arrangement of fluorescent screen material at 80*a* in a regular pattern on the under side of a thin plate 80 of a luminum or the like which is slidable in ways 81 mounted on the under side of plate 78. Another portion of the plate 80 is provided with the pattern 80*b* of four regularly arranged oblongs like those shown at 73*b*, while a third pattern 80*c* is provided comprising sixteen regularly placed round holes similar to those shown at 73*c*. In each case, the regular pattern is formed by fluorescent screen material arranged in this pattern on the plate 80. The X-rays coming through the film 69 and through the plate 80 impinge upon the fluorescent screen material so that only the patterns 80*a*, 80*b* or 80*c* have any luminosity.

The plate 80 bearing its fluorescent patterns 80*a*, 80*b* and 80*c* might be utilized in connection with phototubes 75 of Fig. 7 with their cylindrical shields 76. However, in Fig. 9 I have shown another modification wherein a mirror 82 is mounted on the bottom of the casing 79 with its reflecting surface upward and parallel to the plate 80. The phototubes 83 are positioned on opposite sides of the pattern 80*a* and in position to receive the rays therefrom at a very flat angle. The luminous pattern at 80*a* is reflected in the mirror 82 and the tubes 83 are positioned so as to receive the luminosity both from the pattern 80*a* and from its reflected image in the mirror 82. The tubes 83 are intended to be connected in the timing circuit of Fig. 4 in place of the tubes 34 and 34' with the proper balancing of the phototubes with the condenser 56 and trigger tube 31 to terminate the exposure at the proper time.

Another modification shown in Fig. 9 which is optional comprises light stops or barriers 84 positioned so as to shield the light sensitive element of phototubes 83 from rays coming from the portion of the fluorescent material closest to each phototube. Thus, each phototube will not view that portion of the fluorescent screen material which is closer to the tube in question, thus avoiding any intense effect which close bright areas might have upon that phototube.

In order to make these devices absolutely light tight where the flanges 70*a* or 79*a* slide in their respective ways, the flanges are filled with silver solder and ground perfectly smooth and the ways are also formed exactly. Where the mask 73 or the plate 80 slides horizontally in and out of the casing 70 or 79 respectively, light seals may be provided similar to those provided in a film holder sealing against the film as it slides in and out of the holder.

In the claims relating to Figs. 7 and 9 we have defined the X-ray tube 64 as being over the subject 66 and have defined the film 69 as being under the table 65. These terms "over" and "under" have reference to the table 65 in a horizonal position. It is understood that the table might be tilted to other angles and the positioning of the parts is to be the same relative position as shown in Fig. 7.

Prior to our invention, it has been known to utilize a pattern of light in connection with the timing of X-ray photographs beneath a table such as that shown at 65 in Fig. 7. These prior devices utilize the large lead disc to provide a pattern by interrupting some of the X-rays. The lead disc was so bulky that is necessarily had to be mounted below the equipment contained in the Bucky housing 67. With this prior known equipment, the height of the table 65 had to be raised between one and three-quarters to two inches because of the bulky lead disc. Utilizing our invention, the regular pattern forming means may be incorporated into the Bucky housing itself and requires a raising of the table top height only a matter of one-half inch to three-quarter inch. Obviously, our improved device is much lighter because it does away with the heavy lead disc of the prior device.

What we claim is:

1. In combination, two photoelectric cells sensitive to fluorescent luminosity from a generally predetermined area of a plane for photographic timing purposes said cells being located respectively on opposite sides of said area and having their photosensitive elements positioned to receive luminosity from substantially the same area, said cells being located adjacent said plane, whereby the light rays from said area approach said cells at a very flat angle so as to average the luminosity from a substantial area, means providing a regular pattern of luminosity from said area, an electrical circuit connected with both cells to average the output therefrom, and a timer control member responsive to said circuit.

2. The combination of claim 1 wherein said last named means comprises a fluorescent screen covering substantially said entire area, and an X-ray pervious light-opaque mask interposed between said screen and said cells, said mask having through openings arranged in a regular pattern.

3. The combination of claim 1 wherein said last named means comprises fluorescent material arranged in a regular pattern area.

4. The combination of claim 1 and including a plane mirror parallel to said first named plane and positioned to reflect said pattern, and said cells lying between said planes and positioned to receive luminosity simultaneously from said area and from said mirror.

5. In combination a fluorescent screen having thereon an image of unevenly distributed luminosity, two devices positioned so as to be responsive to the luminosity of substantially the same area of said screen, means limiting said image to a regular pattern selected from a portion only of said area, said devices located on opposite sides of said area and adjacent the plane of said fluorescent screen, whereby the light rays from said pattern approach said devices at a very flat angle less than approximately ten degrees relative to the plane of said screen so as to average the luminosity from a substantial area of said screen, and photoelectric cell means operatively associated with both of said devices connected to average the luminosity effects from said two devices.

6. Means as in claim 5 wherein said devices comprise two photoelectric cells positioned respectively on opposite sides of said image, and a timing circuit connecting the output of said cells in parallel, said timing circuit operatively connected with the source causing said image on said fluorescent screen.

7. The combination of claim 5 wherein said photoelectric cells are adjusted to approximately equal sensitivity.

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