S. TOUSEY.

X-RAY APPARATUS.

APPLICATION FILED APR. 10, 1919.

1,372,110.

Patented Mar. 22, 1921.

Fig. 2.

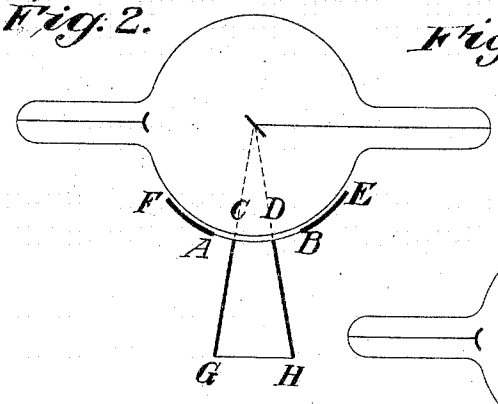


Fig. 3a

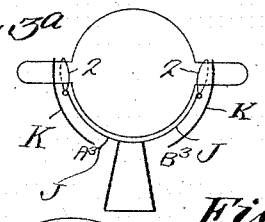


Fig. 1.

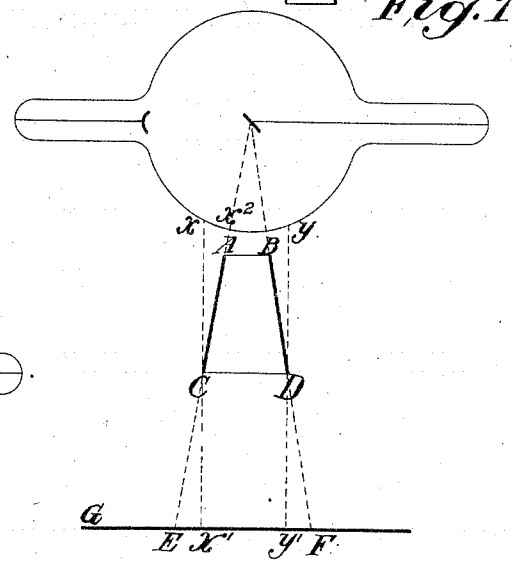


Fig. 3.

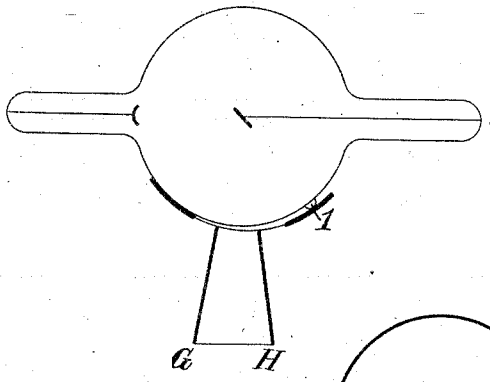


Fig. 4.

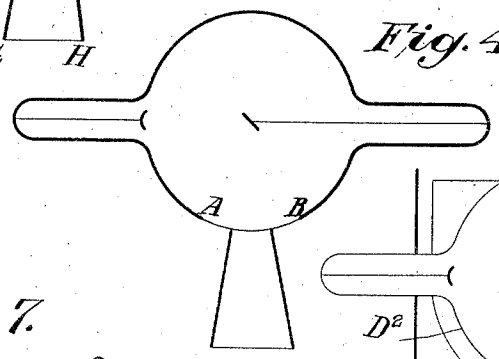


Fig. 5.

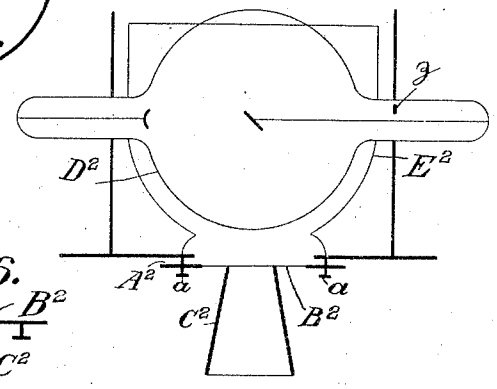


Fig. 7.

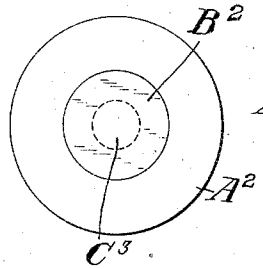
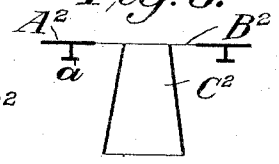


Fig. 6.



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X-RAY APPARATUS.

1,372,110. Specification of Letters Patent. Patented Mar. 22, 1921.

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To all whom it may concern:

Be it known that I, SINCLAIR TOUSEY, a citizen of the United States, and resident of Westhampton Beach, New York, have invented certain new and useful Improvements in X-Ray Apparatus, of which the following is a specification.

My invention relates to means for improving radiographs by reducing the quantity of secondary rays, reaching any given part of the plate, from the glass wall of the X-ray tube while permitting direct rays from the focus point to reach every part of the plate.

In the accompanying drawings:

Figure 1 is a diagram of an X-ray tube with a radiating cellular diaphragm and plate associated therewith, as proposed by me.

Fig. 2 is a similar view showing a radiating cellular diaphragm combined with a section of a sphere substantially conforming to the spherical portion of the tube.

Fig. 3 is a similar view showing compensating means by which the same diaphragm can be used with different X-ray tubes of the same size, but which vary as to the location of their focus points.

Fig. 3ª is a view of another form of the invention.

Fig. 4 is a view of another form of the invention.

Fig. 5 is a diagrammatic view of a further modification in which the cellular diaphragm is supported from the X-ray tube stand.

Fig. 6 is a digrammatic view of a cellular diaphragm and its attaching diaphragm.

Fig. 7 is a plan view of Fig. 6.

In Fig. 1 a single radiating cell of trumpet shape is shown in section, as A, B, C, D, whose walls are straight and thin but opaque to the X-ray. This cell is so placed that its walls form a truncated hollow cone whose apex is at the focus point upon the anticathode. Consequently the shadow of this radiating cellular diaphragm upon the photographic plate is the circumference of a circle whose diameter is from E to F.

Inside this circle, if the diaphragm were absent, an effect would be produced partly by direct rays from the focus point, which alone are desirable, and partly by secondary rays from the glass wall of the tube, say for illustrative purposes from the part marked x, y. With the diaphragm in place, the direct rays are in full force and so are the small amount of secondary rays which can reach the part E, F of the plate through the small opening A, B of say 1/3 the diameter or say 1/9 the surface of secondary radiation, or in other words 1/9 of the surface of the entire portion of the glass wall of the tube from which secondary X-rays arise.

Also secondary radiations passing outside the diaphragm on one side from the part of the X-ray tube between x and a portion near A marked X^2 reach the part of the circle E, F between E and x'. The secondary rays reaching the circle E, F from x A anywhere near x' arise from a very small part of the tube and even those near E are small in amount compared with what they would be if the wall B, D were not present to cut off secondary rays from the tube between B and y.

A similar reduction in the amount of secondary rays is noted at y'.

x' to y' is a region receiving rays only through the opening A, B, *i. e.* direct rays in full force and a small quantity of secondary rays.

The portion of the plate to the left of E receives direct rays in full force but secondary rays only from the part of the X-ray tube A to x. A similar condition is noted at the other side of the illustration.

Commonly a larger flat diaphragm of opaque material at about the same distance from the tube as A, B will give a sufficiently large field of illumination at the plate and at the same time substantially reduce the surface of the tube from which secondary rays may reach the part of the plate outside of E, F.

More than one cell either concentric or discrete may be used.

In Figs. 2 and 3 I show improvements on the above.

In one form, see Fig. 2, I employ a section of a hollow sphere F, E in part of material opaque to the X-ray and of a nature not to conduct electricity or to damage the X-ray tube or to be itself damaged by contact with the X-ray tube. Lead glass is a suitable substance. In an opening in this member F, E there is inserted a portion extending from A to B having similar properties except that it is transparent to the X-ray, glass such as X-ray tubes are ordinarily made from is a suitable substance. Extending preferably though not necessa-

rily from the middle part of this transparent section A, B is a trumpet shaped radiating cellular diaphragm G, H as described above, made of material opaque to the X-ray and not injurious to the X-ray tube and itself not being injured by contact with the tube or if separated from it by a thin layer of glass.

From the above it will be understood that the spherical section from F to A and from B to E is opaque to X-ray. From A to B it is transparent to X-ray. From C to G and D to H it is opaque to X-ray.

The spherical section is of a curvature to correspond with the size of the X-ray tube with which it is to be used and the conical diaphragm is of such an angle as to its walls and is set in such a direction that if the focus is at the center of the X-ray tube the walls of the cone will coincide with the lines of the direct rays as previously explained, when the spherical portion F, E is simply tied in contact with the glass wall of the X-ray tube. An X-ray tube of the proper size but with focus not exactly at the center, can be adjusted for use with this diaphragm either by changing the place of the focus, or by making one or more projections as at 1, Fig. 3, upon the tube which will sufficiently alter the direction of the conical part G, H, when the diaphragm is placed in contact with the tube to compensate for the variations in the location of the focus point. In this way one diaphragm can be used with many different X-ray tubes of the same size.

By the structure of Fig. 2 I secure the advantages of a small contact diaphragm A to B, reducing the total secondary radiation to the minimum consistent with a sufficient area of illumination at the plate.

I secure the advantages of a radiating cellular diaphragm without the very great difficulty of extemporaneously placing a separate apparatus at a distance from the X-ray tube, so as to secure the circular line shadow of the wall of the cone which is essential to a satisfactory picture.

My new construction makes it necessary only to bind the diaphragm in contact with the X-ray tube without any extemporaneous adjustment.

The improvement includes a contact diaphragm supporting a transparent portion which in turn supports a radiating cellular diaphragm by simply placing this and the X-ray tube together.

In another form this diaphragm is permanently fastened to an X-ray tube as would result from attaching the diaphragm of Fig. 3 to the tube.

In the form shown in Fig. 4 the X-ray tube itself has a transparent section at A, B supporting near its middle a radiating cellular diaphragm and either all the rest of the X-ray tube consists of lead glass or similar substance opaque to the X-ray, or at least the rest of the active hemisphere consists of lead glass or similar opaque (to X-rays) substance.

I secure the advantages of a small contact diaphragm, and of a small radiating cellular diaphragm. I provide an X-ray tube with an external diaphragm and an external radiating cellular diaphragm forming integral parts of the X-ray tube.

Another form of the invention consists simply of a radiating cellular diaphragm of say lead glass attached permanently to the X-ray tube as in Fig. 4. And the benefit to be derived from the diaphragm A, B may for example be derived from the use of a shield of opaque material in which is an opening A, B, in the center of which the conical diaphragm is located, said shield surrounding the X-ray tube as in Fig. 5.

Another form consists of a spherical part J of glass ordinarily used for X-ray tubes supporting a radiating cellular diaphragm of opaque material say lead glass. The whole is to be bound to the X-ray tube as shown in Fig. 3^a by cords or the like at 2_i And here, as in the form just mentioned, the benefit to be derived from the diaphragm A, B may be obtained by having the X-ray tube surrounded by a shield K of material opaque to the X-ray in which is an opening A^3, B^3, at the center of which the conical diaphragm is located.

In the several forms which are not permanently fastened to the X-ray tube a suitable number of members, such as projecting rings are provided for the attachment of cords by means of which the apparatus may be conveniently bound in contact with the X-ray tube.

The structures shown in Figs. 2 to 4 inclusive and their modifications mentioned relate to an apparatus designed either to be part of the tube, or to be attached temporarily or permanently directly to it.

The following description of Figs. 5, 6 and 7 relates to an apparatus not to be fastened directly to the tube, but to be held in proper relation to the X-ray tube by a suitable third apparatus which may for example be part of the tube stand.

In this modification shown in Figs. 5, 6 and 7 there is a radiating cellular diaphragm C^2 of a rigid opaque substance, hard silver for example, as in Fig. 1, whose smaller end is fastened to a flat sheet B^2 of thin X-ray transparent material (aluminum for example), the latter is stretched across the opening of a diaphragm A^2 of rigid material, such as iron, which is readily attachable as by set screws, to the tube stand in such a position that the radiating cellular diaphragm C^2 opaque to X-rays will function properly when any particular X-rav

tube is placed in the tube stand, indicated diagrammatically at D^2, in a position previously determined by careful trial and marked upon the X-ray tube as indicated at *z*, Fig. 5. The marking is important to enable one to quickly place the tube in proper position in the stand and thus in proper registration with the diaphragm.

In Fig. 5, E^2 is a protective shield which is often used but not essential to my apparatus. The cone C^2 can be attached to diaphragm B^2 by small projections of C^2 riveted to B^2. The member A^2 with diaphragm B^2 and cellular diaphragm C^2 can be attached to the tube stand by screws *a*.

The member in Fig. 7 having the portion B^2 transparent to X-rays may have its rim portion A^2 to function chiefly as a support for the conical diaphragm. And the opaque zone A^2 surrounding the transparent portion, which zone is desirable, but not essential, may be obtained in a way other than by making this rim portion opaque such for instance as by employing a part of the tube shield for this purpose as in Fig. 5.

The part of the transparent disk indicated at C^3, Fig. 7, within the small end of the cone must be of the same material as that portion marked B^2 surrounding the small end of the tube, Fig. 7, or at all events, the portion C^3 must have the same transparency to the X-ray as the portion B^2. The function of the parts C^3 and B^2 is to permit the free passage of primary X-rays from the focus spot. Secondary X-rays arising from the glass walls of the X-ray tube and passing through the parts B^2 and C^3 are, as to some of them, obstructed by the walls of the cone, as partially indicated in Fig. 1.

What I claim is:

1. In combination with an X-ray tube, a conical diaphragm having its walls opaque to X-rays and convergent toward the focus point upon the anticathode, the proximal end of the cone partly inclosing and being surrounded by a zone of limited extent transparent to X-rays outside of which there is a zone opaque to X-rays, substantially as described.

2. In combination with an X-ray tube, a conical diaphragm having its walls opaque to X-rays and convergent to the focus point at the anticathode and a diaphragm carrying said conical diaphragm and held in connection with the tube, said last mentioned diaphragm having a portion transparent to the X-rays at which the conical diaphragm is located, said transparent portion being surrounded by a portion opaque to the X-rays, substantially as described.

3. An X-ray tube having a conical diaphragm attached thereto whose walls are opaque and convergent toward the focus point upon the anticathode, the conical diaphragm having a zone about its small end transparent to the X-ray and an opaque zone outside the transparent zone.

4. An X-ray tube having a conical diaphragm attached thereto whose walls are opaque and convergent toward the focus point upon the anticathode, the conical diaphragm having a zone about its small end transparent to the X-ray and an opaque zone outside the transparent zone, said transparent and opaque zones being formed by a shield exterior to the tube, substantially as described.

5. In combination with an X-ray tube, a conical diaphragm having its walls opaque to X-rays and convergent toward the focus point upon the anticathode, a substantially flat diaphragm having a portion transparent to X-rays and a rigid rim portion, with the conical diaphragm attached to the transparent portion and having a part of the transparent portion surrounding it and means for holding the flat diaphragm with the conical diaphragm in proper relation to the tube, substantially as described.

6. In combination with an X-ray tube, a conical diaphragm having its walls opaque to X-rays and convergent toward the focus point upon the anticathode, a substantially flat diaphragm having a portion transparent to X-rays and a rigid rim portion, with the conical diaphragm attached to the transparent portion, with a part thereof surrounding it and means for holding the flat diaphragm with the conical diaphragm in proper relation to the tube, said means comprising a stand to which the diaphragm is fixed, said stand receiving the tubes removably which are marked individually to locate the tube in accordance with the position of the focus point thereof, substantially as described.

7. In combination with an X-ray tube, a conical diaphragm exterior to the X-ray tube and a member supporting the conical diaphragm at its proximal end and transparent to X-rays at said proximal end of the cone and throughout a zone surrounding the said proximal end, substantially as described.

8. In combination with an X-ray tube, a conical diaphragm having its wall opaque to X-rays and convergent toward the focus point upon the anti-cathode, said diaphragm being located external to the X-ray tube and between the same and the object to be depicted, and lying in the midst of the X-rays to be utilized, adapted to produce only a linear shadow and to prevent secondary rays from reaching the photographic plate.

In testimony whereof, I affix my signature.

SINCLAIR TOUSEY.