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SPIRAL X-RAY IMAGE INTENSIFIER
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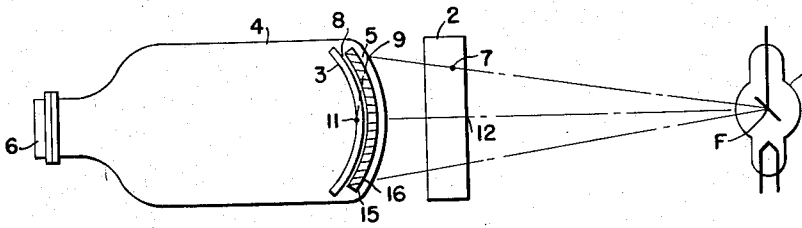


Fig. 1.

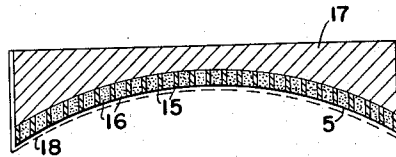


Fig. 2

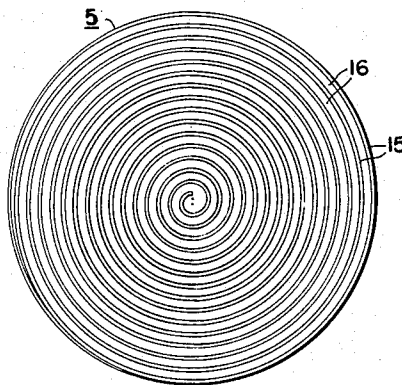


Fig. 3

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SPIRAL X-RAY IMAGE INTENSIFIER

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13 Claims. (Cl. 250—62)

My invention relates to X-ray devices and, in particular, relates to an improved form of "Bucky grid" for X-ray apparatus.

The images appearing on the fluorescent screens of X-ray apparatus normally are produced by X-rays traveling in straight lines from the focal spot on the anticathode of the X-ray tube. Actually, however, there is incident upon the screen a certain amount of stray X-radiation emanating from other points than this focal spot, this being scattered radiation from atoms lying in the path of the main stream of X-rays. For example, the object being observed intervenes between the focal spot and the fluorescent screen, and each atom of such a body becomes a potential source of secondary X-rays which scatter, some of these striking the fluorescent screen from a direction out of line with rays coming from the focal spot. The glass wall of an enclosure around the fluorescent screen is another source of such rays. The fluorescent screen in the X-ray image intensifier shown in Mason and Coltman U. S. Patent 2,523,132 is a specific instance of this. Such scattered X-radiation blurs the image produced by the primary X-rays from the focal spot and so its elimination is desirable. In general, a device known as a "Bucky grid" may be used for this purpose. A "Bucky grid" may be described as a network of spaced thin plates of material positioned with their edges toward the focal spot so that X-rays emanating from the focal spot find free passage between the plates, but rays emanating from other directions strike and are absorbed by the faces of the plates.

My present invention resides in an arrangement in which the absorbing plate has the form of a spiral wound up from a thin ribbon of heavy metal faced with a substance of low atomic weight, the ribbon being so formed that the face of the ribbon is at all points parallel to the path of X-rays from the focal spot.

One object of my invention is accordingly to provide a new and improved arrangement for reducing stray radiation in X-ray apparatus.

Another object is to provide a new and improved method of forming a direction filter for X-ray apparatus.

Still another object is to provide an improved form of X-ray image intensifier.

Another object is to provide a "Bucky grid" capable of being enclosed in a vacuum tube and of being baked at sufficiently high temperature to process the tube.

Other objects will become apparent upon reading the following description and claims in which:

Figure 1 is a schematic showing of an X-ray image intensifier of the type described in the above-mentioned Mason and Coltman patent which is provided with a stray radiation absorber embodying the principles of my invention;

Figure 2 is a detailed view in section of the radiation absorber of Figure 1 at an intermediate point in its process of manufacture; and

Figure 3 is a plan view of the same absorber.

Referring in detail to the drawings, a conventional

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X-ray tube 1 projects its rays through a body 2 into incidence with a fluorescent screen 3 of an image intensifier tube 4 of the type shown in the above-mentioned Mason and Coltman Patent 2,523,132. The screen 3 is shown as having the form of a watch glass, though a plane screen may be used. Between the screen 3 and the end wall of the tube 4 is the stray-radiation absorber 5 shown in more detail in Figures 2 and 3.

The screen 3 has a layer of fluorescent material closely spaced from a layer of photoelectric material. X-rays projected from the focal point of tube 1 produce a picture of body 2 on the fluorescent screen 3, and the light rays from the latter in turn produce a corresponding electron image at the surface of the photoelectric layer. Suitable electrical potentials accelerate the electron image into impact with an electron-phosphor screen 6 at the other end of tube 4 to produce a light picture for viewing at greatly enhanced brightness by an observer.

As previously pointed out, the primary X-rays from the focus of tube 1 generate secondary X-rays which scatter in all directions from atoms such as those in the glass end of tube 4, or those composing body 2. Thus, for example, an X-ray projected from focal point F through point 7 of body 2 would normally register an image of point 7 on screen 3 at point 8. However, a certain number of X-rays traversing the direction F-7 would be absorbed by an atom at point 9 in the end wall of tube 4 or point 7 of the composing body, to scatter X-rays in all sorts of directions such, for example, as 9-11. The latter would thus produce light at point 11 superposed on, and confusing the image of point 12 of body 2 produced also at point 11 by the primary ray F-12-11.

The element 5 is provided to permit primary X-rays such as 7-8 and 12-11 from focal point F to pass through to screen 3 while absorbing such rays as 9-11 or 7-11. It comprises a thin ribbon 15 of material having atoms of high atomic weight, and so great absorptive power for X-rays, wound into a spiral with its turns separated by spacing material 16 of low atomic weight and hence of little X-ray absorbing power. The metals gold, tungsten, tantalum, and molybdenum are of suitable absorptive power for ribbon 15. The thin edges of the ribbon 15 face the X-ray source 1 and the ribbon is disposed so that its faces coincide substantially with radial lines radiating from the focal spot of tube 1. The spaces between turns of the ribbon are large relative to the thickness of the ribbon but small relative to its width. Preferably the edges of the ribbon adjacent screen 3 is parallel and close to the back face of the latter. It will be seen that most primary rays like F-7 and F-12 radiating from the focal spot will pass through material 16 between turns of ribbon 15, but scattered secondary rays like 9-11, being of non-radial direction, will strike one point or another on the face of ribbon 15 and be absorbed before reaching screen 3 and confusing the primary image there.

In order to remove both the 9-11 and the 7-11 type scattered rays it is necessary to enclose the "Bucky grid" in the envelope of the tube. The conventional grid needs only to remove 7-11 type scattered radiation. Because this new grid must be placed in the envelope, it must be composed of refractory materials to withstand the processing to which components of high-vacuum apparatus must be subjected.

A structure in which the spiralled ribbon is tilted so that its surface lies in radial lines from the focal spot and which is composed only of refractory materials may be formed by several methods, some of which will now be described. A plastic material containing only atoms of low atomic weight is first produced. For example, carbon powder of particle size passing a 300 mesh-per-inch screen may be mixed with the minimum quantity

of polyvinyl alcohol and ethyl borate which will make a plastic or dough-like mixture. Instead of ethyl borate, other similar substances such as borax, or other glassy low atomic weight material such as a phosphate, may be used. Still another alternative would be to use a plastic mix of magnesium oxide with a silicone binder. A coating, say 0.03 inch thick, is then formed from the dough on one side of the metal-absorbing ribbon to be used. This may be tantalum, tungsten, molybdenum, or other high atomic weight metal, say $\frac{1}{8}$ inch wide by 0.005 inch thick. An Archimedean spiral is then wound up to the desired diameter from this compound ribbon. A ring of metal is then put around the spiral to hold it together. After further forming to tilt the ribbon sides to conform to radial lines from the focal spot as described below, the spiral is baked at high temperature in a suitable atmosphere to reduce the dough to nearly pure carbon held in a porous matrix held together by a glassy binder, which also holds the separating layer to the metal ribbon. The stray-radiation absorber is then complete and ready for installation in front of the screen 3.

Where the screen 3 has a plane back surface, rolling the ribbon into a plane Archimedean spiral will insure that the front edge of the ribbon conforms to the slope of the screen. Where the screen 3 has a watch glass form, the required shaping of the unit may be attained by pressing the spiral, before baking, into a mold such as 17 in Fig. 2, or by winding the ribbon into a spiral while maintaining its edge in contact with a spherical guide surface.

Formation of the ribbon so that its side faces comprise lines radiating from a common focal center may be effected in several ways. One of these would, for instance, be to roll the ribbon of dough-like carbonaceous material thinner on one edge than the other, then using the thin edge as that positioned to face the X-ray focus. For many cases it would suffice to make the thin edge about 99 per cent of that of the thicker edge. When wound into a spiral and baked out as described above with a heavy metal ribbon of uniform thickness, the turns of the heavy metal ribbon will be radial to a common focus.

Another method would be to use a heavy metal ribbon which was rolled thinner on the edge which is intended to face the X-ray focus than on the other edge. When rolled into a spiral as above described with a carbonaceous ribbon which is either uniform or tapered in thickness, the turns will have faces radiating from a common focus; however, in view of its thinness, the taper of the metal ribbon will usually have to be greater than the one per cent mentioned in the preceding method.

A third method which may be used either with ribbons of uniform thickness or, as a supplement, with the tapered ribbons of the method just described, is to expose the edge of the coiled spiral which is to be adjacent the screen 3 to vapors which will cause the plastic material to swell. To facilitate this, the screen 18 may be provided to align the concave face of the unit in Figure 2. For example, water vapor will cause polyvinyl alcohol to take on a permanent swelling. Silicon tetrachloride, various silicones, and other substances which would leave non-volatile residues of low atomic weight are other examples of substances suitable to cause swelling. Still another way would be to use ordinary rubber as the binder between the carbon particles, and to use silicon tetrachloride vapor to cause swelling on the side of the filter remote from the X-ray source.

It will be noted that the substances mentioned above as components of the material spacing the turns of heavy metal are all of low atomic weight, chlorine being of the largest weight.

I claim as my invention:

1. An X-ray direction-filter comprising a substantially spiral ribbon containing atoms of high atomic weight, the spaces between its turns containing carbon particles

bound with a substance having no atom of atomic weight substantially greater than that of chlorine, and the broad faces of said ribbon radiating from a common center.

2. An X-ray direction-filter comprising a substantially spiral ribbon containing atoms of high atomic weight, the spaces between its turns containing carbon particles mixed with a boracic binder, and the broad faces of said ribbon radiating substantially from a common center.

3. In combination with a source of radiation a vacuum-tight enclosure containing a screen and a direction filter traversed by radiation projected to said screen through the wall of said enclosure in diverging rays from said source, said screen and said source lying on opposite sides of said filter, said radiation filter comprising a convolute ribbon containing atoms of high atomic weight, the spaces between its convolutions being substantially free of atoms of high atomic weight, and the broad faces of said ribbon radiating substantially from said source.

4. A vacuum-tight enclosure containing a screen and a direction filter for radiation projected to said screen from a central point, said radiation filter comprising a convolute ribbon containing atoms of high atomic weight, the spaces between its convolutions containing carbon particles mixed with a substance having no atom of atomic weight substantially greater than that of chlorine, and the broad faces of said ribbon being radial to said central point.

5. A vacuum-tight enclosure containing a fluorescent screen and a direction filter for radiation projected to said screen from a central point outside said enclosure, said radiation filter comprising a convolute ribbon containing atoms having a high absorptive effect on said radiation, the spaces between its convolutions being substantially free of atoms having a high absorptive effect on said radiation, and the broad sides of said ribbon radiating substantially from said central point.

6. The method of making a radiation direction filter which comprises winding into a convolute a composite ribbon made up of a first layer of material which is highly absorptive to said radiation faced on one side with a second layer of material which is substantially less absorptive to said radiation, exposing one edge of said composite ribbon to contact with a substance which causes expansion of said second layer, and then hardening said composite ribbon in the conformation so obtained.

7. The method of making a radiation direction filter which comprises winding into a spiral a composite ribbon made up of a first layer containing atoms of high atomic weight faced with a second layer of heat-hardening material which contains substantially no atoms of high atomic weight, exposing one edge of said composite ribbon to contact with a substance which causes expansion of said second layer, and then heating said composite ribbon to heat harden said second layer.

8. The method of making an X-ray direction filter which comprises winding into a spiral a composite ribbon having a first layer of metal drawn from the group which consists of gold, tungsten, tantalum and molybdenum faced on one side with a second layer of heat-hardening material containing substantially no atoms of atomic weight greater than that of chlorine, exposing one edge of said composite ribbon to contact with a substance that expands said heat-hardening material, and then heating said ribbon to harden said second layer.

9. The method of making a radiation direction filter which comprises winding into a spiral a composite ribbon of a first layer of material having a high atomic weight faced on one side with a second layer of material containing substantially no substance of atomic weight substantially greater than that of chlorine, the last said material being heat-hardening, one edge of one of said layers being thicker than the opposite edge, and heating said ribbon to harden it.

10. The method of making an X-ray direction filter

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which comprises winding into a spiral a composite ribbon having a first layer of metal drawing from the group which consists of gold, tungsten, tantalum and molybdenum and a second layer of carbon particles in a binder of polyvinyl alcohol and ethyl borate, exposing one edge of said ribbon to contact with water, and then baking said spiral to hardness.

11. An X-ray image intensifier comprising a vacuum-tight enclosure, a fluorescent screen therein, means positioned adjacent said screen for producing an electron-image corresponding to a light-image generated on said screen, means positioned on the opposite side of said electron-image producing means with respect to said screen for producing a second light-image by impact of the electrons within said electron-image and an assembly of members inside said enclosure, said members positioned adjacent to said screen and on the opposite side of said screen with respect to said electron-image producing means, said members containing atoms of high atomic weight and being separated in directions parallel to the surfaces of the said screen by intervals containing only atoms of low atomic weight, said intervals being small relative to the length of said members in the direction normal to such screen.

12. An X-ray image intensifier comprising a vacuum-tight enclosure, a fluorescent screen therein, means positioned adjacent said screen for producing an electron-image corresponding to a light-image generated on said screen, means positioned on the opposite side of said electron-image producing means with respect to said screen for producing a second light-image by impact of the electrons of said electron-image, and an assembly of members within said envelope positioned adjacent to said screen

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and on the opposite side of said screen with respect to said electron-image producing means, said members containing atoms which effectively absorb X-rays separated in directions parallel to the surface of said screen by intervals which are small relative to the length of said members in a direction normal to the surface of said screen, said intervals containing only matter which is an ineffective absorber of X-rays.

13. In combination with a source of radiation, an enclosed device containing means to intensify an image produced by projecting said radiation through the walls of said device on a receiving surface within said device, said radiation being capable of generating secondary radiation in passing through said walls and an assembly of members inside said device containing atoms of high atomic weight and positioned between said source and said receiving surface, said members being separated in directions normal to the path of projection of said radiation by intervals which contain only atoms of low atomic weight, said intervals being small relative to the length of said members in the direction in which said energy is projected.

References Cited in the file of this patent

UNITED STATES PATENTS

1,164,987	Bucky	Dec. 21, 1915
1,542,204	Akerlund	June 16, 1925
2,523,132	Mason et al.	Sept. 19, 1950
2,566,998	Strickman	Sept. 4, 1951
2,638,554	Bartow et al.	May 12, 1953
2,640,160	Collins et al.	May 26, 1953