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X-RAY TUBE

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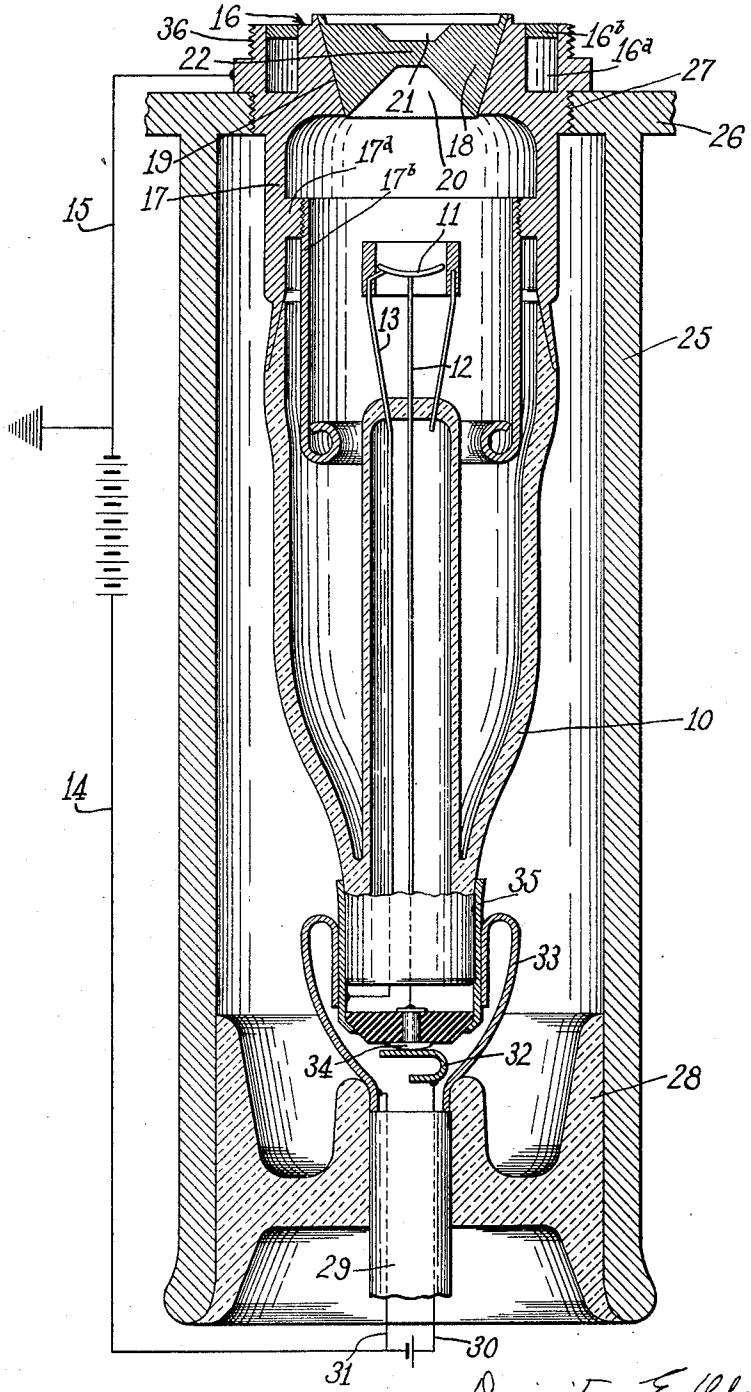

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X-RAY TUBE

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8 Claims. (Cl. 250—149)

This invention relates to X-ray tubes and especially to a tube for the generation and transmission of X-rays wherein the rays may be more readily controlled as to direction and be generated at a point close to the outer surface of the tube so that the object to be examined may be placed in a position close to the target or source of the rays. The present application is a division of my co-pending application, Serial No. 500,583, filed December 6, 1930 (Patent No. 2,090,636).

In the past it has been the usual practice to generate X-rays by the discharge of electrons from a heated filament against a target which is opaque to the passage of the X-rays and reflects these rays through the walls of the tube. Usually the surface of the target is disposed at an angle of about 45° to the electron beam, and the X-rays generated by the stoppage of the electrons are reflected through the side of the bulb at substantially a right angle to the path of the electrons. In such instances it will be apparent that the source of the X-rays is some little distance from the wall of the tube and hence, as the rays radiate in all directions from the target, the beam of the rays will spread considerably before the rays pass through the wall of the tube where they may be applied to the object to be examined. The result is that the rays which emerge through the wall of the tube cover a much greater area than is necessary or desirable, but where the rays are reflected, it is impossible to entirely overcome disadvantage.

To most effectively generate X-rays, it is necessary to employ a target of a hard metal having a relatively high atomic number. Such metals are, however, more or less opaque to the passage of the rays, and hence a target of such metal, unless extremely thin, will not permit the X-rays to pass therethrough, but on the other hand the rays will be reflected from the surface of such a target.

At least one attempt has been made in the past to use a relatively thin target of a metal having a high atomic number and which would not only generate the X-rays, but would allow the transmission thereof through the target, but such attempt has not been attended with great success, on account of the fact that the impinging of the electrons on the target tends to heat the latter excessively, and, as the target must be very thin to permit the passage of the rays, the dissipation of the heat therefrom is substantially negligible.

One object of the present invention is to provide an X-ray tube which will overcome the disadvantages referred to above and will provide for the generation of X-rays at a point adjacent the outer surface of the tube.

Another object of the invention is the provision of an X-ray tube which will employ a target of such a nature that, while the X-rays will be efficiently generated, at the same time the target will be transparent to such rays, and will also be of such a character that it will not become overheated.

A still further object of the invention is the provision of an X-ray tube having a target consisting of two or more elements distributed in such a way as to insure superior conditions as to X-ray generation, X-ray transmission and heat dissipation.

More specifically the invention relates to an X-ray tube having at one end thereof a multipart target which shall consist partly of a metal having a relatively high atomic number, and partly of a metal having a lower atomic number, the metals being alloyed or compounded, the first-named metal being relatively thin and adapted to generate the X-rays, and the last-named metal serving as a support for the first and being of such a nature as will permit the passage of the rays and also allow of efficient cooling of the target by ordinary heat conduction to the other parts of the tube, by direct radiation, or by being cooled by the circulation of water therethrough.

To these and other ends, the invention consists in the novel features and combinations of parts to be hereinafter described and claimed.

The figure of the drawing is a sectional view of an X-ray tube embodying my improvements.

To illustrate one preferred embodiment of my invention, I have shown in the drawing a tube 10 having therewithin either a source of electrons or a source of positive rays. This source may be a heated filament, a cold point, a gaseous discharge or other suitable means. In the embodiment illustrated there is employed an electronic filament 11 to which are connected the usual positive and negative leads 12 and 13 to heat the filament, and also one terminal of a high tension circuit 14, the other terminal 15, of which is connected to the base of the tube, designated generally by the numeral 16, at the central portion of which in the form shown is a target which will be described more particularly hereinafter. The tube 10, as shown, may preferably be formed of glass to which is sealed a substantially cylindrical member 17 preferably

made of some metal such as copper, for example, so that a tight seal may be made between it and the glass portion of the tube. The cylindrical portion 17 serves to join the glass portion of the tube to the base 16, and in this instance is shown as formed integrally with the base. The member 17 is provided with an annular shoulder 17a to which is threadedly secured an electrostatic shield 17b which serves to prevent an electrostatic field being set up between the filament and the wall of the tube. The electronic filament 11, which is the source of electrons, may preferably be formed of tungsten, but variation in this respect may, of course, be resorted to, and any material used which will serve as the source of electrons.

The base 16 is provided with an opening at its central portion, and in this opening is secured a target 18, which will in the present instance be made of an alloy of some metal of lower atomic number, such as forged aluminum, and a metal having a high atomic number, such as molybdenum, silver, tungsten or gold. The joint 19 between the alloy comprising the target and the base 16 will preferably be tightly sealed. Also, in the form shown, the base is preferably provided with water passages 16a closed by the plates 16b.

It will be apparent that with this construction the target member 18 can be removed from the base 16, and replaced with another target if desired. This will, of course, break the vacuum within the tube, and if the target is removed, it will be necessary to restore the vacuum, which may readily be done by connection with a pump for this purpose.

The target, which in this instance is an alloy, is constructed of two or more metals, each of which has its particular properties and particular functions to be performed. It will, as stated, contain a metal of low atomic number, which will comprise a principal portion of the target, and a metal of high atomic number to generate the X-rays. The metal of low atomic number must be one which is relatively transparent to the passage of the X-rays, so that it may have sufficient thickness to act as a support and a carrier for the X-ray-generating portion of the target, and not impede to any great degree the passage of the rays. It will be understood that metals having a low atomic number usually also have a low melting point, and as it is necessary to keep this metal at a comparatively low temperature, it will be found desirable to arrange for the cooling of the metal by water or other fluid, as described.

At the central portion of the target, depressions 20 and 21 are formed so as to leave a relatively thin part 22 through which the generated X-rays may easily pass. As the metal of high atomic number present as a part of the alloy comprising the target is relatively opaque to the passage of X-rays, a relatively small quantity of this metal is employed. It will be present, however, in a sufficient quantity to cause the generation of the X-rays, but not to prevent the passage of the X-rays through the alloy of the target; that is, it will not be sufficient to render the target as a whole opaque.

It will, of course, also be understood that considerable variation in the metals employed in the alloy may be resorted to, depending upon the character of the rays which it is desired to obtain, as some metals are relatively transparent to rays of certain wave lengths, but will not permit the passage of rays of longer wave length, and there will, at certain positions in the scale of atomic numbers, be metals which might be used either for the generation of X-rays or for the transmitting part of the target. For instance, I may use for the metal of low atomic number, constituting the greater portion of the body of the target, lithium, beryllium, boron, carbon, magnesium, aluminum, silicon, iron, nickel, cobalt, copper or silver, and for the X-ray-generating portion of the target I may use copper, chromium, molybdenum, silver, platinum, tungsten or gold. When two or more of these metals are alloyed together, as described, they will not only form a satisfactory target transparent to X-rays, but the two metals will be in intimate metal-to-metal heat-conducting relation by mutual molecular adhesion, so that the heat which is generated when the electrons strike the metal of high atomic number will be carried away by the main portion of the target, which in turn contacts closely with the base 16 of copper or similar material, this base in turn having provision for being cooled by a circulating fluid.

It will also be seen that, owing to the depressions 20 and 21, the more transparent central part of the target will be limited as to area, so that the X-rays will emerge from the base of the tube through a relatively small opening, and substantially at the point of generation of the rays, so that any object to be examined may be placed close to the source of the rays. Also the entire tube may be shielded so as to protect the user from the harmful effects of the rays, and for this purpose I have provided the shield 25, which may be of lead or rubber or other suitable material. As shown, this shield may be of substantially cylindrical form, and may be provided with a base 26 having an internally threaded opening 27 in which may be screwed a portion of the base of the tube.

The shield may be closed at the end opposite the target by means of an insulating member 28 which may be formed of lead-glass or other suitable insulating material. If desired, the shield 25 and closure member 28 may both be made of the same material which will be both an electric insulator and opaque to X-rays. The closure member 28 is provided with an opening in which is received the member 29 carrying the positive and negative low tension leads 30 and 31. These leads are connected respectively to the contact members 32 and 33, which are resilient so as to be urged into close contact with the members 34 and 35 on the tube.

It will be understood that the member 29 makes a tight connection with the surrounding portions of the closure member 28, and the interior of the shield 25 may be filled with oil or a suitable insulating medium to prevent the passage of current from the high tension lead to the wall of the shield. It will also be apparent, that with this construction, the parts of the shield including the contact members 32 and 33 may be assembled and thereafter the tube may be placed therein and screwed in place by means of the threaded connection 27 so as to provide for a ready and convenient assembly of the parts. It will be understood that, when the tube is screwed into place, the contact members 34 and 35 thereon will engage the members 32 and 33.

The outer portion of the base may be threaded, as shown at 36, to provide for the connection thereto of any suitable apparatus which it may be desired to use in connection with the tube.

It will be observed that the target opening in

the base is cone-shaped in form so as to provide a conical seat for the target, and thus assist in providing for a tight seal between the target and the base. The depressions 20 and 21 are also conical in form so as to provide a relatively thin portion adjacent the center of the target readily transparent to X-rays, and also to limit this portion to a relatively small area so that the rays will be confined adjacent the point at which they are generated, and will not spread out in a manner which would be harmful to the user. If desired, the depression 21 at the outside of the tube may be made quite shallow so that the object to be examined may be brought very close to the point at which the X-rays are generated.

While I have shown and described a preferred embodiment of my invention, it will be understood that it is not to be limited to all of the details shown, but is capable of modification and variation within the spirti of the invention and within the scope of the appended claims.

What I claim is:

1. An X-ray tube having an envelope, a source of electrons, and a target, the latter being a part of said envelope and emitting as useful radiation X-rays having passed through the target, said target being relatively transparent to X-rays, and consisting of an alloy of a plurality of metals, one of said metals having a relatively high atomic weight and serving as an X-ray generating substance, and the other having a relatively low atomic weight and serving as an X-ray transmitting substance, and the amount of said second metal present in the alloy being greater than that of the first metal.

2. An X-ray tube having an envelope, a source of electrons, and a target, the latter being a part of said envelope and emitting as useful radiation X-rays having passed through the target, said target being relatively transparent to X-rays, and consisting of an alloy of a plurality of metals, one of said metals having a relatively high atomic weight and serving as an X-ray generating substance, and the other having a relatively low atomic weight equal to or less than that of silver, and serving essentially as an X-ray transmitting substance, and the proportion of said lower atomic weight metal being greater than that of the metal of higher atomic weight.

3. An X-ray tube having an envelope comprising a target and a source of electrons and emitting as useful radiation X-rays having passed through the target, said target being transparent to permit the passage of X-rays therethrough and consisting of an alloy having tungsten as a component of heavy atomic weight, the remainder of the alloy being composed of metal of relatively low atomic weight, such as beryllium, aluminum or copper, the proportion of said low atomic weight metal being greater than that of tungsten.

4. An X-ray tube having an envelope and a target and a source of electrons, said tube emitting as useful radiation X-rays passed through the target, said target being transparent to permit the passage of X-rays therethrough and consisting of an alloy of a plurality of metals, one of the constituent metals having a relatively high atomic weight and serving as an X-ray-generating substance and another metal having a relatively low atomic weight equal to, or less than, that of silver and serving essentially as an X-ray-transmitting and heat-conducting substance.

5. An X-ray tube emitting as useful radiation X-rays having passed through the target, said tube having an envelope comprising a target and a source of electrons, said target being composed of a plurality of metals in the form of an alloy, one of said metals having a relatively high atomic weight and serving as an X-ray-generating substance and another having a relatively low atomic weight and serving mainly as an X-ray-transmitting substance, as a carrier for the heavy atomic weight component, and as a heat-conductor, and said alloy target being removably secured in the base of the envelope.

6. An X-ray tube having an envelope, a source of electrons and a target and emitting as useful radiation X-rays having passed through the target, said target being a part of the envelope and transparent to permit the passage of the X-rays therethrough and being composed of a plurality of metals in the form of an alloy, one of said metals having a relatively high atomic weight and serving as an X-ray-generating substance and another having a relatively low atomic weight and serving mainly as an X-ray-transmitting substance, as a carrier for the heavy atomic weight component and as a heat conductor, and said target being formed independently of the remainder of the envelope.

7. An X-ray tube having an envelope, a source of electrons, and a target, the latter being a part of said envelope and emitting as useful radiation only X-rays having passed through the target, said target being relatively transparent to X-rays, and consisting of an intimate mixture of a plurality of metals, one of said metals having a relatively high atomic weight and serving as an X-ray-generating substance, and the other having a relatively low atomic weight equal to or less than that of silver, and serving essentially as an X-ray-transmitting substance, and the proportion of said lower atomic weight metal being greater than that of the metal of higher atomic weight.

8. An X-ray tube having an envelope comprising a target and a source of electrons and emitting as useful radiation X-rays having passed through the target, said target being transparent to permit the passage of X-rays therethrough and consisting of an intimate mixture having tungsten as a component of heavy atomic weight, the remainder of the mixture being composed of metal of relatively low atomic weight, such as beryllium, aluminum or copper, the proportion of said low atomic weight metal being greater than that of tungsten.

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