April 9, 1929. G. BUCKY 1,708,494

X-RAY TUBE

Filed Aug. 20, 1926

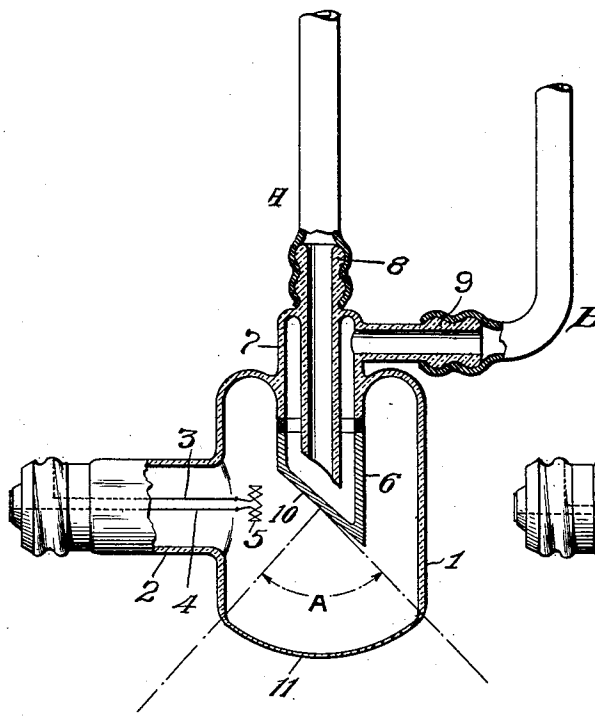


Fig. 1.

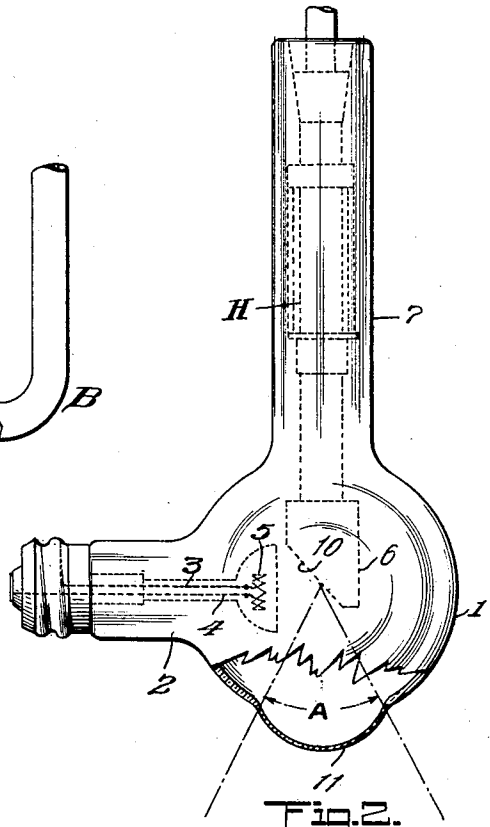


Fig. 2.

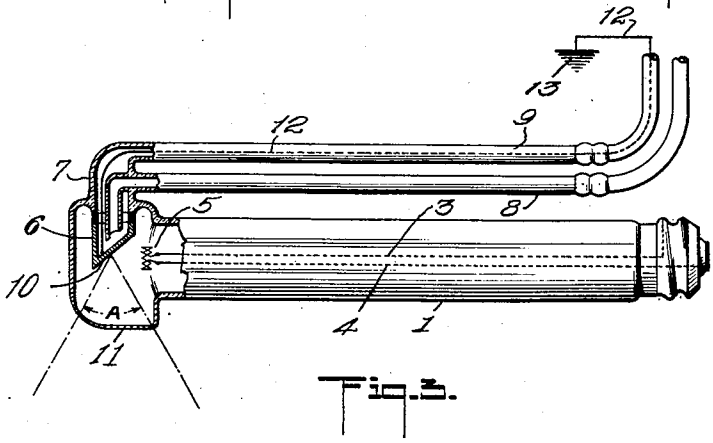


Fig. 3.

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UNITED STATES PATENT OFFICE.

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X-RAY TUBE.

Application filed August 20, 1926, Serial No. 130,557, and in Germany May 8, 1923.

My invention relates to X-ray tubes and more particularly to such as are intended for the treatment of diseased or abnormal conditions of the human body. It is well known that X-rays have different degrees of penetration and that an X-ray tube may be caused to emit waves having a higher or lower degree of penetration by adjusting the voltage impressed on the electrodes of such a tube. It is also well known that X-rays of high penetrating power, so-called hard rays, have to be employed with great care on account of the danger of serious injury to internal tissues.

Whatever may be selected adjusted voltage, the emitted waves will always be so-called hard rays as the walls of the tube, as generally constructed, absorbs the soft rays and especially the very soft rays. Even where it has been attempted by the use of a gas-filled X-ray tube provided with a glass window, the elements of which have low atomic weights, to afford an opportunity for the soft rays to pass through the walls of the tube, hard rays also pass through, and soft rays of low intensity were never maintained or capable of being maintained. I have found, however, that if treatments are applied with very soft rays of maintained low intensities, effects of an unusual and hitherto unknown character can be produced. With X-ray tubes as constructed and operated hitherto, one can not obtain in available form the very soft rays that are requisite for treatments to which reference will be made later. When the tube is made of ordinary glass of the usual thickness, very soft rays can not pass through it. It is, however, only such very soft rays which I require for the treatments with which I am particularly concerned in this case. In order to permit the soft rays to pass out of the tube as rays of maintained low intensities, I employ a window of a character which offers much less resistance to soft X-rays than ordinary glass and is substantially pervious to such rays. The resistance which a substance offers to the passage of X-rays depends on the thickness of the substance and somewhat, apparently, on the atomic weights of the chemical elements of which such substance is formed. Ordinary glass consists chiefly of sodium or potassium, calcium, and silicon, the atomic weights of these four elements being 23, 39, 40, and 29, respectively. When an X-ray tube is constituted of the said ordinary glass of the usual thickness, substantially all of the soft rays are prevented from emerging from such a tube. In my improved X-ray tube, I therefore preferably employ a window made of a substance, the constituents of which have a much lower atomic weight than those of ordinary glass, although I may, in some cases, employ a window made of very thin ordinary glass, say 0.1 mm. in thickness or made of beryllium or of aluminum. As an instance of a preferred type of window, I employ a window of the so-called Lindemann glass which is made of elements none of which has an atomic weight higher than 16. It will be obvious that with such windows X-rays of much lower penetrating power can pass through to the outside of the tube, and become available for curative purposes, than when the entire bulb consists of ordinary glass of the usual thickness. It is important, however, in view of my requirement of a maintenance of soft rays of low intensities, that the X-ray tube should be of a character which permits the maintenance of sustained low tensions and enables the penetrating power of the rays to be adjusted to predetermined voltages within said low tension range. I make use of a tube of the so-called heated cathode type, as illustrated for example by the Coolidge patents, for instance, No. 1,203,495. When I refer to a tube of the heated cathode type, I mean a tube which permits the penetrating power of the X-rays maintained as soft rays of low intensities to be varied by altering the voltage of the discharge passing through the tube, but keeps such penetrating power constant as long as said voltage remains unchanged.

In the use of an X-ray tube emitting soft rays, it is desirable for effective and uniform treatment of a patient that the field covered by the soft rays be as great or greater than the whole of the area to be treated. With X-ray tubes having a Lindemann glass window incorported in a tubular extension of the glass bulb, only a limited field can be obtained, thus necessitating scanning of the entire area under treatment, i. e. shifting the field from one position to another until all of the afflicted portion of the patient has been exposed to X-ray treatment. This, of course, does not give a uniform treatment as one portion is likely to be over-treated and

another portion under-treated, nor is it generally a wholly satisfactory practical procedure. In my improved X-ray tube I preferably incorporate the soft ray transmitting window in such a position with respect to the anti-cathode that the solid angle of the cone of rays is relatively large and the field covered by the rays is correspondingly large. By the use of a tube of this character I am able to treat, under the more general conditions, an afflicted portion of a patient with one exposure and without the necessity of scanning the area under treatment. It will be apparent, therefore, that more effective and uniform and better controlled treatments may be given with my improved X-ray tube than hitherto was possible with tubes having very limited soft ray emitting areas. The usual hot cathode type of X-ray tube is constructed so as to respond to a wide range of voltages. Inasmuch, however, as the more important treatments with my new tube are generally within the range of approximately 5 to 15 kilovolts, I prefer to construct my tube, as is well understood by those skilled in this art, so that it will have a limited voltage capacity, the upper limit being generally about 15 kilovolts. The result, of course, is that with such a tube any danger of operating, even accidentally or inadvertently with rays of higher intensities than those desired is excluded. Thus my tubes may be used with great safety and without fear of harmful action on the patient. Speaking generally, some of the more important treatments are applied with X-rays of approximately 1.8 Angstrom, having a half value absorption in aluminum of approximately 0.0323 mm.

By a combination of the aforementioned features I obtain results which have not been available hitherto and which thus far have not even been understood or appreciated.

The present invention will be readily understood from the following description taken in conjunction with the embodiments of my invention illustrated in the accompanying drawings, in which Fig. 1 shows an elevational view, partially in section for purposes of clarity of a preferred embodiment of my invention and Figs. 2 and 3 are views similar to Fig. 1 of modified forms of my invention.

Referring now more particularly to Fig. 1, the numeral 1 designates a bulb, preferably cylindrical in cross-section, made of ordinary glass and having a tubular extension 2 projecting from the side thereof. In this extension wires 3 and 4 are sealed and are electrically connected to cathode 5 positioned within the tube. This cathode has a heating arrangement, for instance, such as the one employed by Coolidge, enabling the degree of hardness of the rays to be varied in a well-known manner. Sealed in one end of bulb 1 is an anti-cathode 6 which may be made, for instance, of aluminum or magnesium. It has been ascertained that these metals, which have a low atomic weight, are of especial advantage in the production of soft X-rays. Not only do tubes with anti-cathodes of such metals produce a very high proportion of soft rays (accompanied by a relatively small proportion of harder rays) but the potential employed may be much lower than with anti-cathodes of high atomic weight, and the potential may be increased up to about twice the initial or starting potential without altering the characteristic that the discharge consists predominantly of soft rays. The anti-cathode has a cooling jacket 7 associated therewith in a manner well known to those skilled in the art. This jacket has an inlet tube 8, through which the cooling water is introduced and an outlet tube 9 through which the cooling water is withdrawn from the jacket. This holder has an anti-cathode 6 with a face 10 secured to the inner end thereof so as to reflect the rays emitted by the cathode to a window 11. This window as in the case of Fig. 1 may be made of very thin ordinary glass (0.1 mm. thick) or of Lindemann glass pervious to substantially all of the soft rays and may be secured to bulb 11 in any well-known way. The soft ray emitting area provided by window 11 is materially larger than any of the conventional Lindemann windows incorporated in ordinary X-ray tubes, so that improved results may be obtained by the use of my new X-ray tube.

Another modified embodiment of my invention designed especially for mouth and throat treatment and the like is shown in Fig. 3, wherein the numeral 1 designates a bulb of very small dimensions and preferably cylindrical in cross-section. At one end of the bulb electrically conductive wires 3 and 4 leading to an axial cathode 5 are sealed. Adjacent the cathode 5 and protruding from the side wall of bulb 1 is an anti-cathode 6 with associated cooling jacket 7. An inlet tube 8 leads the cooling water to the jacket 7, whereas tube 9 conducts the water away from the jacket. The face 10 of the anti-cathode, as usual, is set at an angle so as to reflect the rays emitted from the cathode through window 11. This window, as noted heretofore, is made either of very thin glass (0.1 mm. thick) or preferably of Lindemann glass substantially pervious to the softer X-rays and is positioned as close to the anti-cathode as is permissible, so as to include as large a solid angle A as is possible or desirable. In order to prevent any possibility of the patient receiving a shock, the anti-cathode is grounded by means of a wire 12 running to a ground 13. The

whole tube shown in Fig. 3 is so small that it can be used in a patient's mouth or throat without the least difficulty. Of course, as usual with instruments of this character, well-known observation and control means (not shown) are provided with my improved X-ray tube for watching any portion under treatment and directing the rays emitted by my tube to such portion.

Tubes of the character heretofore set forth are very efficient to produce X-rays of very great softness, in fact X-rays having a penetrating power considerably below any available hitherto, and are capable of emitting a cone of soft rays having a large solid angle and thus covering a relatively large field. In other words, my improved tube enables X-rays to be produced and to be sent outside of the tube which have a wave length greater than any X-rays produced hitherto, it being well-known that the greater the wave length, the smaller the penetrating power. Owing to the employment of the heated cathode type of tube, I am enabled to vary the penetrating power of these soft X-rays. The effect of these extra-soft X-rays is very remarkable and in many cases is apparently physiological rather than morphologically destroying or paralyzing, and a very important feature of their use is that harmful results are not likely to occur even when the exposure is very long. I am enabled, for instance, to produce X-rays which will affect only the outermost horny layer of the skin or only the automatic nerve system of the skin without striking deeper layers of the body and these are results which have never been obtained hitherto with X-rays. In other instances, for example, in the treatment of eczema, it was found that itching was stopped within two hours after a treatment, and the eczema itself disappeared within twenty-four hours, results which can be produced with ordinary X-rays only after several days. Acne and psoriasis have disappeared within relatively short periods after application of the new X-rays. Exposure to X-rays such as produced by my improved tube has produced a diminution of the leucocytes lasting for a short time, the effect being similar to that observed when the Mueller intracutaneous injection is employed. This diminution of the number of leuccocytes is characteristic of reactions taking place only within the skin but not below it, and, therefore the strong diminution of the number of leucocytes for a short time is an indication that the rays from my new tube produce a strong intracutaneous reaction.

It will be obvious that the principles underlying my new tube can be incorporated in tubes of widely differing sizes, shapes or arrangement, according to some special use or requirement. Modifications of that character, so long as the fundamental features of this invention are retained, are intended to be included within the scope of the claims.

This application is in part a continuation of my application, Serial No. 711,561, filed on May 7, 1924, now Patent No. 1,679,332, issued July 31, 1928.

I claim:

1. An X-ray tube of the heated cathode type adapted for emitting soft X-rays of adjustable penetration provided with a cathode, an anti-cathode and an X-ray transmitting portion pervious to the soft X-rays and so positioned with respect to the anti-cathode that the cone of rays emitted from the latter has a relatively large solid angle.

2. An X-ray tube of the heated cathode type adapted for emitting soft X-rays of adjustable penetration, said tube being provided with an X-ray transmitting portion pervious to the soft X-rays and of relatively large soft X-ray transmitting area.

3. An X-ray tube of the heated cathode type adapted for emitting soft X-rays of adjustable penetration, provided with a cathode, an anti-cathode, and an X-ray transmitting portion made of a substance, the elements of which have a relatively low atomic weight, said X-ray transmitting portion being arranged with respect to the anti-cathode so that a cone of soft rays with a large solid angle is emitted from the tube.

4. An X-ray tube of the heated cathode type adapted for emitting soft X-rays of adjustable penetration, said tube including a cathode and an anti-cathode adapted for operation at sustained low tensions and being provided with an X-ray transmitting portion pervious to soft X-rays and positioned with respect to the anti-cathode so that the cone of rays emitted from the latter has a large solid angle.

5. An X-ray tube of the heated cathode type having an anti-cathode capable of emitting soft X-rays and a glass bulb provided with an X-ray transmitting portion adapted for transmitting soft X-rays of adjustable penetration, said X-ray transmitting portion being made of a glass, the elements of which have a much lower atomic weight than those of said bulb, and having a relatively large soft X-ray transmitting area.

6. An X-ray tube of the heated cathode type having a glass bulb of substantially cylindrical cross-section, a cathode projecting from the side of said bulb, an anti-cathode capable of emitting soft X-rays operatively associated with said cathode secured in one end of said cylindrical bulb, and an X-ray transmitting portion made of a substance non-absorptive of soft X-rays and so positioned with respect to said anti-cathode that the cone of rays emitted from

the latter has a relatively large solid angle.

7. An X-ray tube of the heated cathode type having a glass bulb of substantially cylindrical cross-section, a cathode within said bulb, an anti-cathode capable of emitting soft X-rays operatively associated with said cathode, and an X-ray transmitting portion of material non-absorptive of soft rays forming substantially the whole of the closure at the lower end of said bulb.

8. An X-ray tube of the heated cathode type adapted for emitting soft X-rays and for functioning close to the body of the person undergoing X-ray treatment, said tube having an X-ray transmitting portion of material non-absorptive of soft X-rays and of relatively large transmission area, said X-ray transmitting portion being located relatively close to the anti-cathode so as to provide for the transmission of a cone of rays having a relatively large solid angle and passageways for cooling means associated with said anti-cathode to positively remove heat from the latter and thereby to protect the patient from injurious heat effects.

9. An X-ray tube of the heated cathode type having a glass cylindrical bulb of such limited size as to fit in a person's throat, a cathode positioned substantally axially with respect to and adjacent to one end of said cylindrical bulb, an anti-cathode capable of emitting soft X-rays adjacent to said cathode, and a window opposite to said anti-cathode and forming a part of the side wall of the bulb at the cathode end of the cylinder, said window being made of a substance non-absorptive of soft X-rays and positioned with respect to said anti-cathode so that the cone of rays reflected from the latter has a relatively large solid angle.

10. An X-ray tube of the heated cathode type having a glass cylindrical bulb of such limited size as to fit in a person's throat, a cathode positioned substantially axially with respect to and adjacent to one end of said cylindrical bulb, an anti-cathode capable of emitting soft X-rays adjacent to said cathode, grounding means associated with said anti-cathode, and an X-ray transmitting portion opposite to said anti-cathode and forming a part of the side wall of the bulb at the cathode end of the cylinder, said X-ray transmitting portion being made of a substance non-obsorptive of soft X-rays and positioned with respect to said anti-cathode so that the cone of rays reflected from the latter has a relatively large solid angle.

In testimony whereof I have hereunto set my hand.

GUSTAV BUCKY.