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M. EHRHARDT.

X-RAY TUBE.

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Fig. 1.

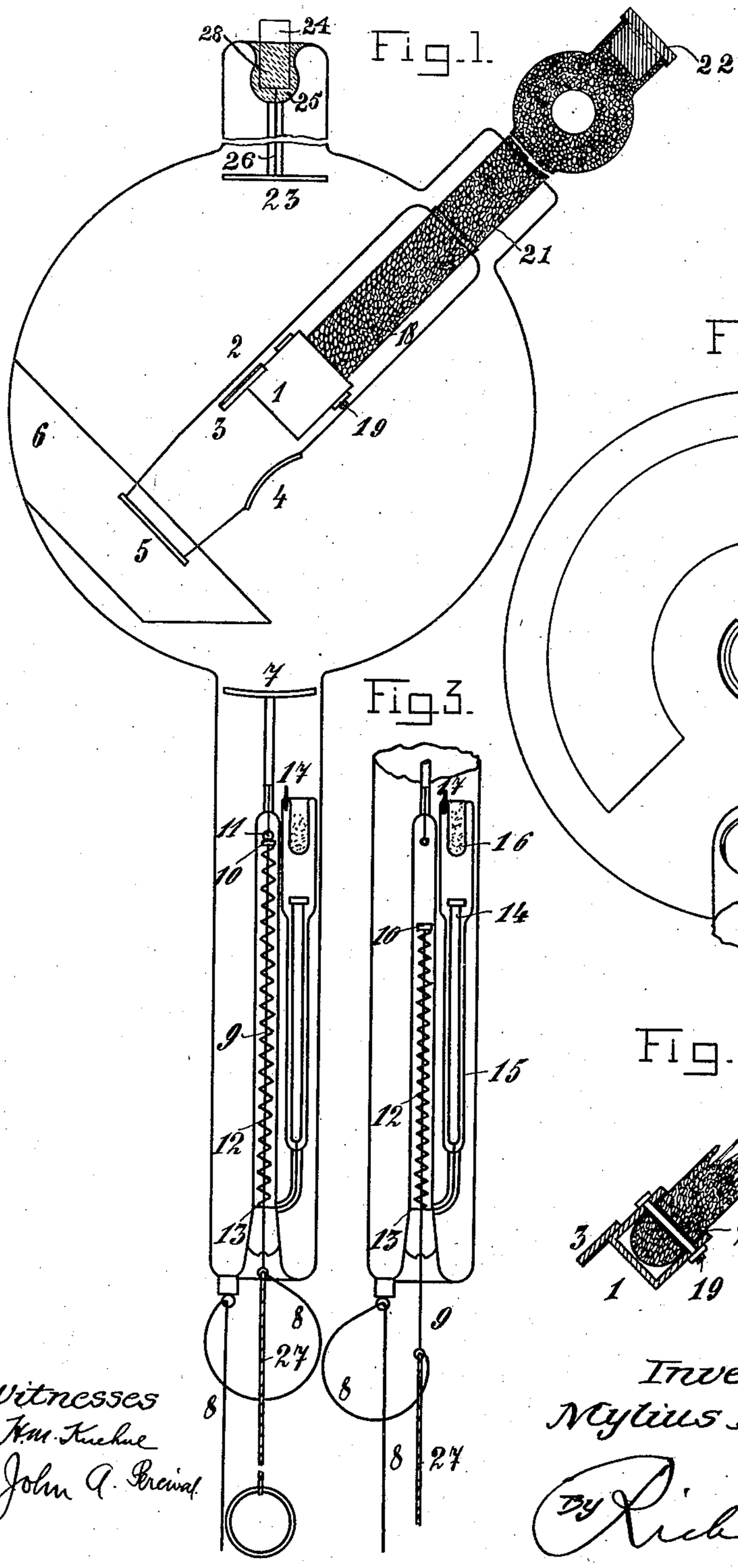

Fig. 2.

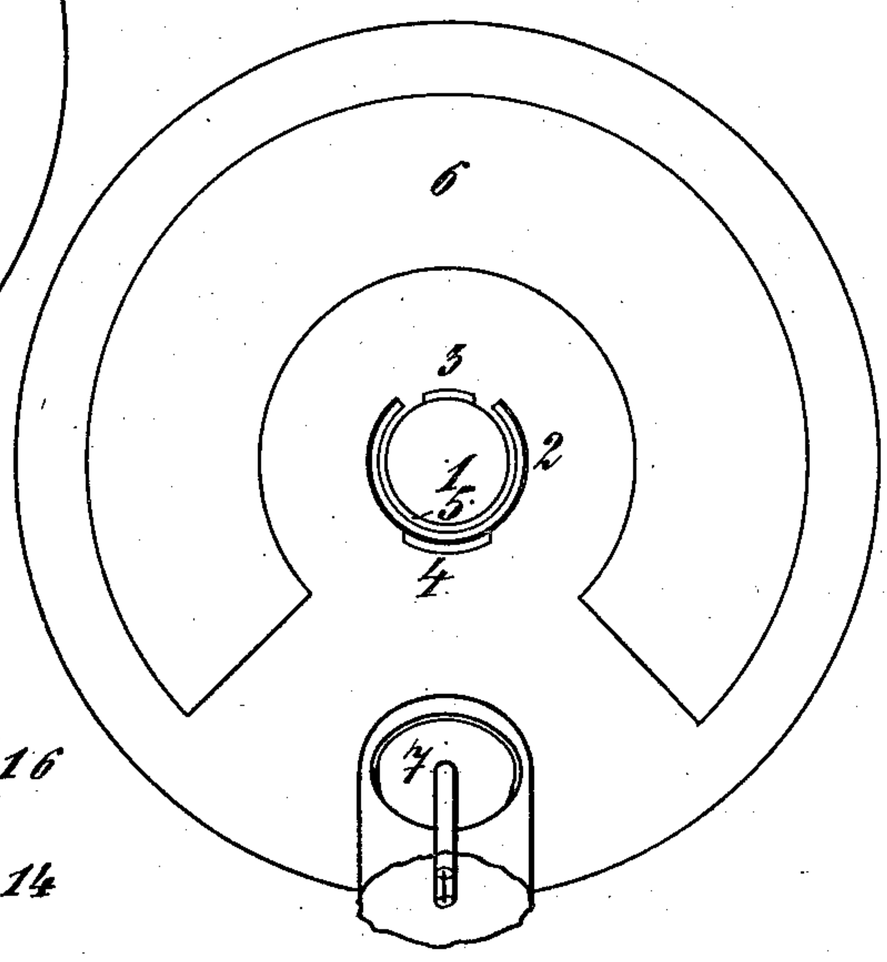

Fig. 3.

Fig. 4.

Witnesses
Wm. Kuehne
John A. Brevital

Inventor
Nylius Ehrhardt
By Richards & Co
Attorneys

UNITED STATES PATENT OFFICE.

MYLIUS EHRHARDT, OF BERLIN, GERMANY.

X-RAY TUBE.

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Application filed October 18, 1904. Serial No. 228,999.

To all whom it may concern:

Be it known that I, MYLIUS EHRHARDT, manufacturer, a subject of the King of Prussia, German Emperor, residing at Berlin, in the Kingdom of Prussia, German Empire, have invented certain new and useful Improvements in X-Ray Tubes, of which the following is a specification.

This invention relates to an improved Röntgen tube adapted for use with medical investigations. This tube is provided with means for concentrating and conducting the cathode-rays to a certain definite direction; further, with means for regulating the vacuum, with means for conducting away the heat from the interior of the tube by cooling the anticathode, and, finally, with means for connecting the tube to an electric circuit.

The object of my invention is to do away with the annoyance of the physician and of the patient by rays leaving the tube in an undesired direction or by sparks; and further objects of the invention are the increase of the handiness and the certain effect of the tube.

There exist already Röntgen tubes in which a tube of normal glass or metal is shoved over the anticathode in order to collect the cathode-rays and to conduct them into a certain definite direction. Collecting-tubes of this kind have not proved useful, since the tube that consists of normal glass collects the cathode-rays only in an imperfect manner, whereas the metal tube collects the rays, it is true, but gives itself rise to the development of gases, whereby the tube when practically employed becomes soon ineffective.

The inventor has found that a tube manufactured from lead-glass is very well suited to concentrate and direct the cathode-rays, without, however, possessing the drawbacks of the tubes hitherto employed. As lead-glass when subjected to the action of cathode-rays easily melts at a place situated above the anticathode, the lead-glass tube is protected at that place by a plate consisting of a non-conducting material, such as china and the like, the plate being attached to the anticathode.

In order to make my invention more clear, I refer to the accompanying drawings, in which similar letters denote similar parts throughout the several views, and in which—

Figure 1 is a side view of my improved Röntgen tube, showing the same in an upright position. Fig. 2 is a plan of the tube, the anticathode being directed against the beholder; and Figs. 3 and 4 represent two details, which will be more fully described hereinafter.

Referring to said figures, 1 is the anticathode, 2 the lead-glass tube shoved over said anticathode, and 3 is the plate protecting the lead-glass tube against being melted, as before stated. The lead-glass has an orifice 4 for allowing of the entrance of the cathode-rays, and the end 5 of the tube is open in order to permit of conducting the rays against the body to be lighted.

The lead-glass tube 2 prevents the cathode-rays from distributing in the direction of the hemisphere arranged in front of the anticathode 1 and to escape from said hemisphere and to molest either the physician or the patient. The rays are collected within the lead-glass tube 2 and are conducted against a limited space of the patient's body, so as to light that space intensely and delivering very distinct photos. This, however, occurs only so long as the Röntgen tube is still soft—that is to say, contains only a low vacuum. If the Röntgen tube during use becomes hard—that is to say, if its vacuum gets high—also the lead-glass tube would be unable to retain the rays and it would be necessary to decrease the vacuum in known manner, which would be troublesome when made during the lighting of the patient. In order to prevent also in such a case the physician and the patient against the effect of rays escaping in an unintended direction, I employ a metal lining 6, Figs. 1 and 2, consisting of metal powder or of thin sheet metal, secured in any appropriate manner to the outer surface of the tube. The rays meeting this lining are retained by the same, as they cannot penetrate said lining, and therefore the space outside the latter in so far as it is protected by the same is secured against the rays, as is also the physician and the patient in an adequate measure.

The metal lining 6 should not be extended very near to the electrode 7, as otherwise sparks strike across the remaining space directly from said electrode to the metal lining.

The lead-glass tube 2 with the protecting-plate 3 on one part and the metal lining 6 on

the other part support one another with respect to their effects; but in spite of this each of the two arrangements may be employed *per se*.

In order to soften the Röntgen tube which has become hard during the lighting, I make use of a vacuum-regulating device, which is known *per se* and the action of which consists in interrupting the circuit leading to the cathode, so that the current is conducted through an auxiliary cathode against a substance adapted to develop a gas and let the same get into the interior of the Röntgen tube when becoming hot. In vacuum-regulating devices of this kind there is first interrupted, by means of a cut-out, the connection between the cathode and the main circuit, and only then the connection between the auxiliary cathode and the main circuit is established. While this is being brought about sparks get over from the main conduit to and into the cathode or to and into the auxiliary cathode so long as is necessary to establish the new circuit. These sparks expose the physician to danger and make the patient nervous.

In my improved Röntgen tube the regulating device in order to prevent the arising of sparks is arranged in such a way that when the connection between the main conduit and the cathode is interrupted the current passes at once through the auxiliary cathode, which is constantly connected with the main conduit. Of course the auxiliary conduit must be arranged in such a manner that its distance from the anodes is greater than the distance between the cathode and the anodes.

The improved vacuum-regulating device is represented in Figs. 1 and 3 of the accompanying drawing.

The current passes from the main conduit 8 to the cathode 7, through the wire 9 and the contact-pieces 10 and 11. Around the wire 9 is wound a spiral spring 12, which is supported at its upper end by the contact-piece 10 and at its lower end by a small perforated metal plate 13 or by a simply bent piece of wire connected, by means of a conduit, with the auxiliary cathode 14, arranged in a side tube 15, the interior of which is not connected with the interior of the Röntgen tube.

When the wire 9 is removed from the tube, so that the contact between the pieces 10 and 11 is interrupted, Fig. 3, the current passes at once from the conduit 8 to the auxiliary cathode 14, through the wire 9 and the plate 13, and from this plate to the piece of wire, 17 along the glass bulb 16, which communicates with the interior of the Röntgen tube and contains caustic potash or another material developing gas when being heated. The glass bulb 16 becomes then hot, and the gas evolved from it makes the tube soft, upon which the wire, serving as a switch, is freed and the contact between the pieces 10 and 11 is under the action of the spring 12 again established. No sparks can arise while the current is thus diverted.

To operate the switch, I employ instead of the small non-conducting rod hitherto used a cord 27 bound to the wire 9 and consisting also of a non-conducting material—for instance, silk. The physician may easily keep this cord in his hand in order to regulate the vacuum also during the lighting, if such regulation should prove necessary. This cord is obviously more advantageous than the said rod, which oftentimes is not at hand just when being needed. The anticathode 1 and the inner space of the lead-glass tube 2 are more highly heated in consequence of the concentration of the cathode-rays in said tube, whereby it is made requisite to conduct away the excess of heat. This may be effected by the known cooling devices using water; but these devices are, in fact, not advantageous, because they increase the weight of the Röntgen tube by the water-conduit and make the tube less handy. There is also the risk that in the case of the water-conduit becoming untight the water establishes a conducting connection between the Röntgen tube and the hand of the physician, so as to expose the latter to the danger of receiving electric shocks. To do away with these drawbacks, I employ an anticathode having a sleeve-like configuration. (See Fig. 4.) This sleeve is shoved over the glass tube 18, serving as a carrier for the anticathode, and is secured to the same by means of a metal pin 19, placed into a metal tube 20, cast into the glass tube 18. This tube has a filling 21 consisting of pieces of metal—such as metal chips, metal leaves, the so-called "lametta," and the like—and is closed by a stopper 22, consisting of conglobate tin-foil. The heat arising within the interior of the tube is conducted away from the anticathode to and into the open air through the metal pin 19, the metal tube 20, the metallic filling 21, and the stopper 22. A certain decrease of temperature is brought about also by the fact that every particle of the metal filling is surrounded with air. There is also provided a particular mode of fastening the binding-pieces 24 of the anode 23, said mode of fastening being also suited for the binding-pieces of the cathodes. Said binding-pieces were up to now provided with eyes or ears connected by conducting-wires or the like with the thin wires of the anodes or cathodes, these wires being led through the wall of the tube and the binding-pieces being secured to the Röntgen tubes by a cementing medium or the like. In consequence of this arrangement the binding-pieces in question get easily disconnected, upon which the thin conducting-wires get torn and make the Röntgen tube ineffective. To avoid this inconvenience, I provide in the wall of the Röntgen tube a cavity 25, situated near to the

binding-piece, and I insert into said cavity a comparatively strong bow 24, connected with the thin wire 26, after which gypsum is filled into the said cavity. In the case of the cavity 25 being suitably shaped the gypsum stopper 28 cannot get out of the cavity, and the connection of the binding-piece 24 with the wire 26, that leads to the anode 23, is maintained even then if the Röntgen tube is employed for lighting from below, so that the full weight of the current-conducting wire acts upon the said binding-piece.

Having now described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a Röntgen tube of the kind described, the combination with an anticathode 1, of a lead-glass tube 2 inclosing said anticathode, a lateral opening 4 provided in said tube and situated between the anticathode and the end opening 5 of the tube, and a plate 3 also located within the said tube and situated about opposite to said lateral opening, for the purpose as described.

2. In a Röntgen tube of the kind described, the combination with a cathode 7 and an anticathode 1, of a lead-glass tube 2 inclosing said anticathode, a lateral opening 4 provided in said tube and situated between the anticathode and the end opening 5 of the tube, opposite to said cathode, a plate 3 located also within the said tube and situated in a line with said lateral opening and the cathode, and a metal lining surrounding said end opening at some distance therefrom, for the purpose as described.

3. In a Röntgen tube of the kind described, the combination with the cylindrical portion of the Röntgen tube, of another tube 15 located in said cylindrical portion, the interior of this tube having no connection with the interior of the Röntgen tube; a glass bulb located at the end of said inner tube near to the ball-like portion of the Röntgen tube and communicating with the same, a substance adapted to develop a gas when being electrically heated and contained in said bulb, an auxiliary cathode 14 arranged within said side tube, a conducting-wire connected with said auxiliary cathode, and a switch 9 connected with the main conduit, substantially as and for the purpose described.

4. In a Röntgen tube of the kind described, the combination with the Röntgen tube proper, of a side tube 15, the interior of which has no connection with the interior of the said Röntgen tube, a glass bulb 16 located at one end of the side tube and communicating with the interior of the Röntgen tube, a substance adapted to develop a gas when being electrically heated and contained in said bulb, an auxiliary cathode 14 arranged within said side tube, a conducting-wire connected with said auxiliary cathode, and a switch 9 connected with the main conduit, substantially as and for the purpose described.

5. In a Röntgen tube of the kind described, the combination with the ball-like portion and the cylindrical portion of the Röntgen tube, of an anticathode located in the first-mentioned portion, a lead-glass tube 2 inclosing said anticathode, a lateral opening 4 provided in said tube and situated between the anticathode and the end opening 5 of the tube, and a plate 3 also located within the said tube and situated about opposite to said lateral opening; a tube 15 located in the cylindrical portion, the interior of this tube having no connection with the interior of the Röntgen tube; a glass bulb located at the end of said inner tube near to the ball-like portion of the Röntgen tube and communicating with the same, a substance adapted to develop a gas when being electrically heated and contained in said bulb, an auxiliary cathode 14 arranged within said side-tube, a conducting-wire connected with the main conduit, a switch 9, and a cord 27, consisting of a non-conducting material and being constantly connected with said switch, substantially as and for the purpose as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

MYLIUS EHRHARDT.

Witnesses:
WOLDEMAR HAUPT,
HENRY HASPER.