July 4, 1933. A. BOUWERS ET AL 1,917,090

X-RAY APPARATUS

Filed Oct. 15, 1931 3 Sheets-Sheet 1

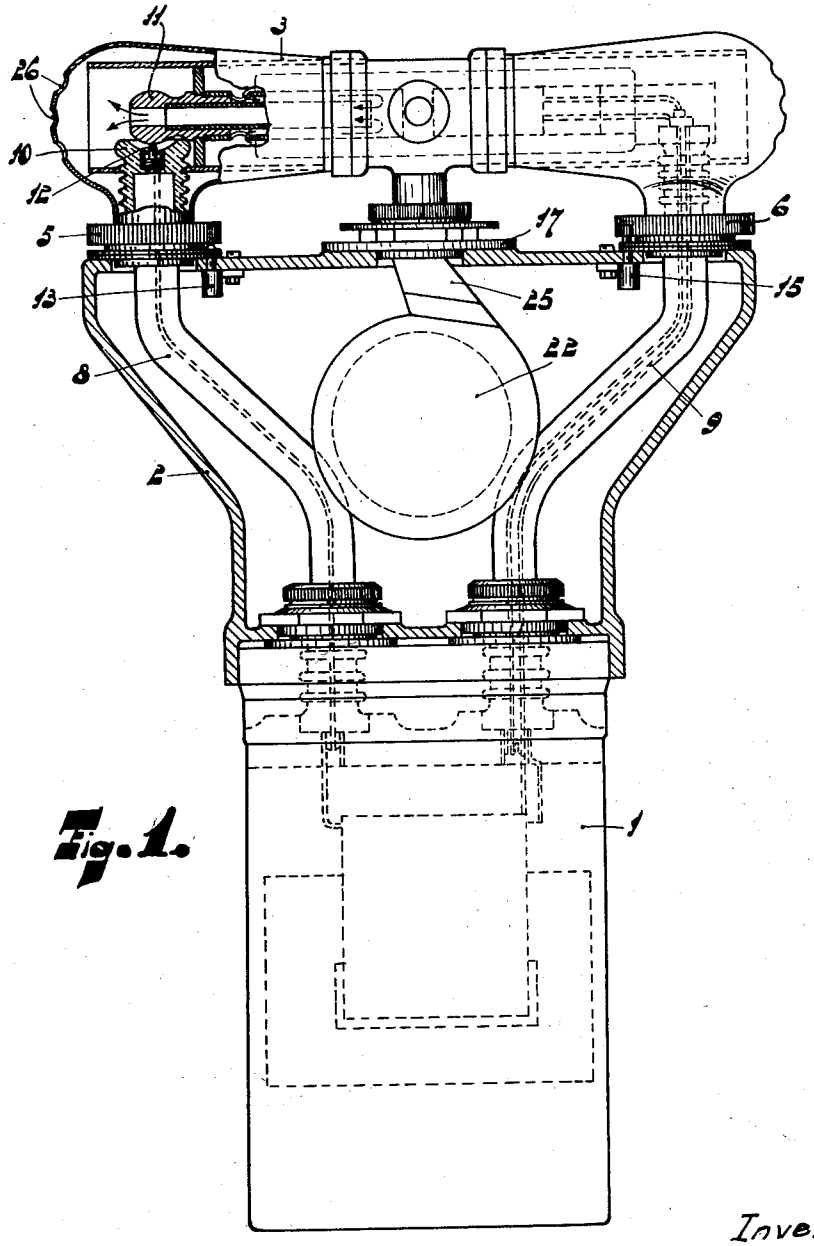


Fig. 1.

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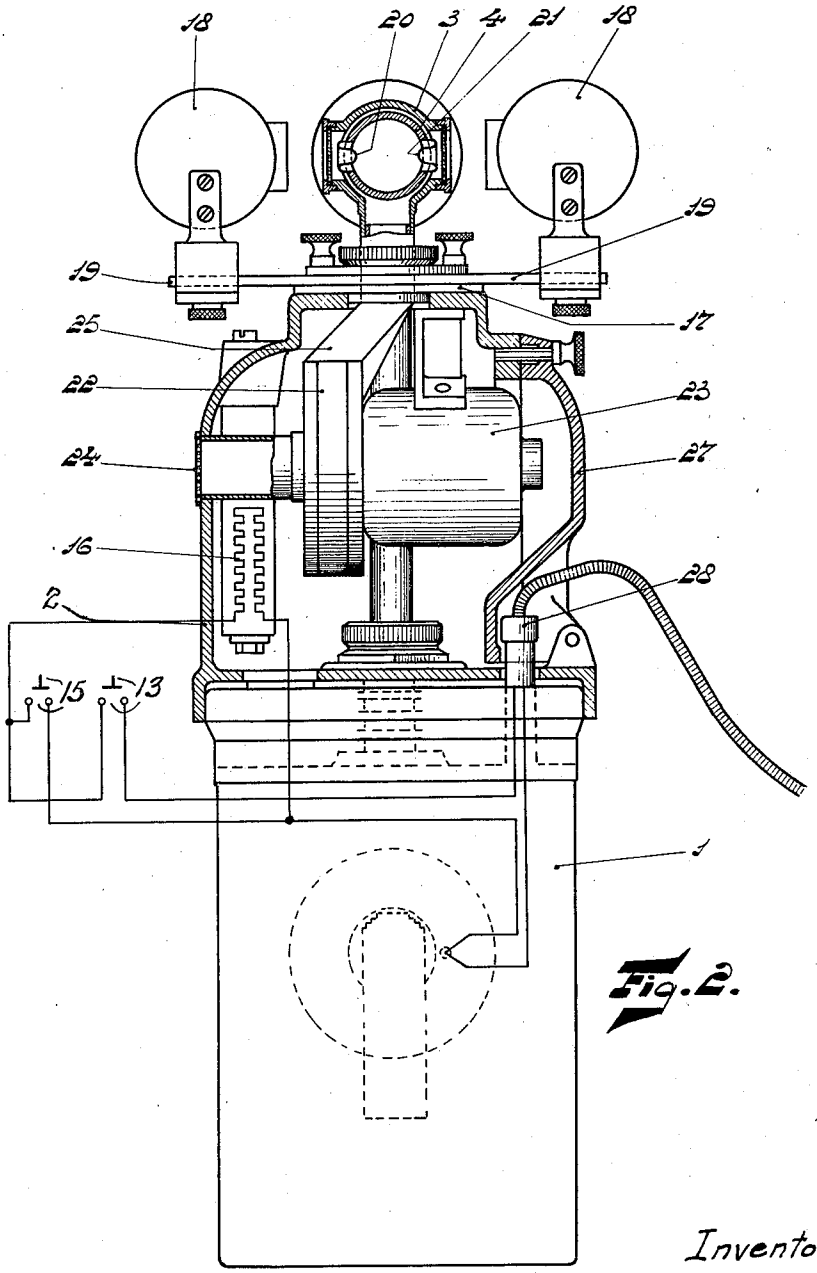


Fig. 2.

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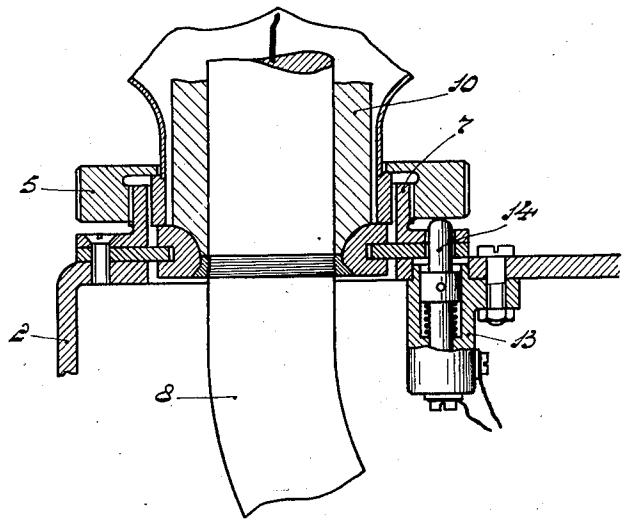


Fig. 3.

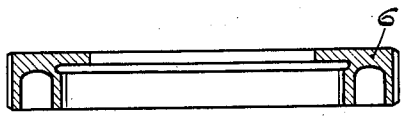


Fig. 4.

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UNITED STATES PATENT OFFICE

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X-RAY APPARATUS

Application filed October 15, 1931, Serial No. 569,090, and in the Netherlands October 11, 1930.

The invention concerns an apparatus which is particularly suitable for the radiological examination of the structure of crystals. The apparatus may, however, be utilized for many other purposes both in the field of the testing of materials and of therapeutics.

The apparatus according to the invention essentially consists of a part comprising a high-voltage transformer contained in a metal case and of an X-ray tube surrounded by a conducting envelope. The X-ray tube is detachably secured to the transformer case, which acts as a carrier of the tube, by means with the aid of which the contact members for the electric connection of the tube and the transformer are united.

The transformer casing preferably includes a head-piece which carries the X-ray tube and encloses conductors leading from the transformer to the points for the attachment of the tube. This attachment may be effected at openings in the head-piece of the transformer case, and of the envelope of the tube, which openings are in alinement. One set of openings serves for the anode-side and a second set for the cathode-side of the tube while the insulated electric conductors pass through these openings.

The head-piece of the transformer casing may be employed for enclosing an electric motor with a fan for the cooling of the X-ray tube.

The apparatus may be equipped with interchangeable tubes for different voltages and be provided with a device for adjusting the appropriate value of the voltage. The fact that the tube and the transformer case are combined in the manner as above described so as to form a unit renders it possible to employ a device by means of which the adjustment of the correct voltage is automatically effected. In fact, the device for adjusting the different voltages may be combined with the means for the attachment of the tube in such manner that the connecting devices to the tubes, owing to a mutual deviation in their construction, bring the device for switching-in the different voltages into the position required for the corresponding voltage or maintain said device in this position.

This is effected in a simple manner by providing the devices for the connection to the fixed part (this should be understood to mean that part of the apparatus which contains the transformer) with one or more members which, when the tubes are mounted, may be actuated by the means of attachment with which the tubes are provided, and by means of which the voltage is varied by short-circuiting a resistance, by cutting out transformer turns or the like. The devices for the connection to the tube may be provided with recesses whereby the said members are left free according as the tube requires the actuation of these members or not.

It is desirable to construct these members as pressure switches and to employ for the attachment of the tubes coupling nuts which, if these switches are to be left free, are provided with a circumferential groove which is engaged by the pressing member of the switch so that the nut when screwed-on leaves this member free and does not push it inwards.

If more than two different values of the voltage have to be adjusted, this may be effected by employing two or more switches and combinations of recesses or again by different positions of a movable member and recesses formed in accordance with these different positions in the means for the attachment of the tubes.

In order to prevent the connecting contacts from being at a high potential when a tube has not yet been secured to the apparatus, the primary circuit of the transformer may comprise a switch which is adjacent the connecting means and the closure of which is brought about or rendered possible, when the tubes are being mounted, by a device connected to the means for the attachment.

Such a switch may be similar to the described device for adjusting the right voltage.

In apparatus embodying the invention the use of electric high-tension conductors outside the apparatus proper is entirely avoided while changing the tubes, which is necessary for the irradiation with different wavelengths, and the substitution of one tube for

another becomes extremely simple owing to the combination of the means for the attachment with those for the electrical connection and may be even combined with those for the adjustment of the correct voltage. This will distinctly appear from the description of the accompanying drawings which represent, by way of example in two projections an apparatus according to the invention and which shows some details thereof on an enlarged scale. In the drawings:

Figure 1 represents the apparatus partly in section, in a vertical position, the tube being parallel to the plane of the drawings.

Figure 2 represents, likewise partly in section, a lateral elevation of the same apparatus and

Figures 3 and 4 show details.

As shown in the drawings, a preferred construction embodying the invention comprises a metallic transformer casing having a portion 1 enclosing the high-tension transformer and a hollow extension, head-piece or pedestal 2 through which pass the insulated current conductors 8 and 9 leading to the X-ray tube. The envelope 3 of an X-ray tube 4 is provided with openings registering with openings in the top of the head-piece 2. The ends of the conductors 8 and 9 leading from the transformer extend into the openings in the envelope 3 of the X-ray tube and are provided with terminals forming transformer contact terminals adapted to contact with cooperating contact terminals on the X-ray tube as described below.

The attachment of the tube is effected with the aid of coupling nuts 5 and 6 which are screwed on to a projecting rim 7 of the head-piece 2 as shown in Fig. 3. The transformer contact devices comprise insulating members 10 at the ends of the conductors 8 and 9. These insulating members carry at their end contact members which cooperate with the contact members secured to the poles of the tube. For the anode terminal of the tube this electrical connection is shown in section in Figure 1. In this figure 11 is the end of the supply conductor of the anode. A resilient contact piece 12 is secured to the connecting piece 10 and comes into contact with the end 11 when the tube is mounted. Furthermore there is a pressure switch 13 which is included in the primary circuit of the transformer. This switch is closed by screwing on the nut 5 which depresses the pin 14 (see Fig. 3). So long as this has not occurred no high voltage can consequently be applied to the connecting contacts and there is thus no danger of the operator receiving an accidental shock from the high-tension terminals of the transformer. Instead of the switch 13 a locking device of a switch in the primary circuit may be actuated by the securing member owing to which the closure of the circuit is only possible after the tube has been mounted.

The securing device on the cathode-side is provided with a similar switch 15 which serves another purpose. Within the head 2 is arranged a resistance 16 which is included in the primary circuit of the transformer but which may be short-circuited with the aid of the switch 15. By screwing-on the nut 6, the pin terminating this switch at the top is pushed-in. This movement does not take place however, when the coupling nut has the shape shown in Figure 4. The nut represented in this figure has a groove to receive the pin of the switch 15 so that the latter is not actuated when for the attachment of the tube the nut is screwed-on. Such a nut is present with the tube for the operation of which the primary circuit of the transformer needs an extra-resistance (the resistance 16) so that the voltage applied to the tube is automatically adjusted at the required value. It is evident that this device may be extended at will with more such contact devices so that different combinations are possible. Such devices may also serve to adjust the voltage on the incandescent cathode at different values.

For a radiological examination with X-rays emitted by a tungsten anti-cathode, a higher tension across the electrodes is desired than with the use of a tube in which the active surface of the anode consists of copper. The securing device of a tube of the latter kind is consequently such that the resistance 16 serving to reduce the voltage remains included in the primary circuit. When mounting tubes of the former kind, on the contrary, this resistance must be short-circuited and for this reason the groove in nut 6 is omitted with these tubes.

The head-piece 2 carries a table 17 having secured to it instruments 18 for making crystallographic diagrams, for example according to the method Debye-Scherrer. These instruments are slidable, over projecting arms 19 and, if required, they can be removed therefrom. The X-ray tube 4 has two windows 20 and 21 for the passage of the rays to the outside.

A fan 22 mounted together with a driving motor 23 within the head piece 2 serves to cool the X-ray tube. Air is drawn-in by this fan through a screen 24 and blown through an air channel 25 into the space comprised between the X-ray tube and the envelope surrounding the latter. The air current passes then along the anode (see the arrows) and finds at the end of the envelope an opportunity to reach the outside by passing through apertures 26. Simultaneously with the transformer, the motor 23 is connected to the available network so that it requires no separate switch.

It appears from the above that the apparatus has no unprotected high-tension conductors accessible from the outside. Even

when the cover 27 affording access to the space enclosed by the head 2 is opened, there is no risk of coming into contact with parts under high tension owing to the fact that the conductors leading from the transformer to the connecting devices for this tension are insulated. Besides, owing to the fact that the contact plug 28 for the electrical connection of the apparatus is located in front of the cover 27 one is obliged to remove this plug before being able to open this cover. It is advantageous to connect the mid-point of the secondary winding of the transformer to the transformer casing so that relatively to the casing, which during the operation of the apparatus is connected to earth, each of the transformer poles possesses half the voltage existing across the electrodes of the tube.

What we claim is:—

1. In combination, a transformer, a casing therefor, spaced contact terminals on said casing connected to said transformer, an X-ray tube having contact terminals at the ends thereof adapted to register with said transformer terminals when the tube is mounted on the transformer casing, circuit-controlling means in circuit with said transformer and means for detachably securing said X-ray tube to said transformer casing with the terminals of said tube in engagement with the transformer terminals, said securing means being arranged to control said circuit-controlling means when the X-ray tube is mounted on the transformer casing.

2. In combination, a high-voltage transformer, a metal casing for said transformer, an X-ray tube, a conductive envelope surrounding the same, contact members connected with the tube, contact members and insulated conductors connecting the same with the transformer, said first contact members cooperating with said second contact members, and means for mechanically securing the envelope of the tube to the casing of the transformer, said means comprising threaded rims and coupling nuts surrounding said insulating conductors.

3. In combination, a transformer, a metal casing therefor including a hollow head-piece, a conductive envelope, an X-ray tube enclosed by the same and in partial spaced relation therewith, said envelope being mounted on said head-piece, means detachably connecting said envelope with said head-piece, insulated conductors connecting said X-ray tube with said transformer, means comprising an electrically driven fan within said head piece and a communicating tube between said fan and the inter-space between the X-ray tube and its envelope.

4. An X-ray installation comprising a casing including an extension, a transformer enclosed in said casing having a primary low-tension winding and a secondary high-tension winding, a conductive envelope detachably mounted on said extension, an X-ray tube in said envelope, insulated conductors leading from said secondary winding through said extension of the casing connecting the transformer with the X-ray tube, means for establishing a mechanical connection between said envelope and said extension including coaxial rims on the extension and the envelope respectively and surrounding said conductors, and a switch connected in series with said primary winding and cooperating with a part of the means for mechanically securing the conductive envelope to the extension of the casing so as to be closed when said connection is made.

5. An X-ray installation comprising a casing including a head-piece, a transformer enclosed thereby having a primary low-tension winding and a secondary high-tension winding, an X-ray tube, an enclosing envelope for said tube, insulated conductors leading from said secondary winding through said head-piece and electrically connecting the transformer with the X-ray tube, said envelope having branch tubes and said head-piece having circular apertures through which said insulated conductors project, said branch tubes carrying gland nuts having a flat ring-shaped front surface opposed to the end surface of the head-piece, and said apertures being surrounded by a threaded flange fitting said gland nuts, and a push-button switch connected in series with said primary winding and mounted at the side of one of the upright rims of the head-piece and projecting therefrom in the direction of the axis of the associated gland nut so as to be pushed in by the ring-shaped front surface of said gland nut when the latter is screwed on the upright threaded rim.

6. An X-ray installation for utilizing either of two X-ray tubes designed for different operating voltages comprising a transformer having a primary low-tension winding and a secondary high-tension winding, a metal casing enclosing the same and including a supporting pedestal, an X-ray tube enclosed in a conductive envelope, means for securing said envelope on said supporting pedestal and means including electric conductors disposed in said supporting pedestal for connecting the X-ray tube to said secondary winding, said first means comprising a fastening member on the conductive envelope of the tube, a resistance connected in series with the primary winding of said transformer and disposed in said supporting pedestal and a switch for short-circuiting the same, said switch being mounted on the said supporting pedestal adjacent the fastening member of the tube envelope so as to be moved to its closed position by the fastening member when said envelope is attached to the pedestal.

7. An X-ray installation for utilizing

either of two X-ray tubes designed for different operating voltages comprising a transformer having a primary low-tension winding and a secondary high-tension winding, a metal casing for said transformer including a supporting pedestal, an X-ray tube enclosed in a conductive envelope, means for securing said envelope to said supporting pedestal and means comprising insulated electric conductors disposed in said supporting pedestal for connecting the X-ray tube to said secondary winding, said first means comprising upright threaded rims on the supporting pedestal and gland nuts cooperating with said rims and carried by the conductive envelope of the tube, the ends of said insulated conductors leading through said rims and gland nuts when a tube is operatively secured to said supporting pedestal, a resistance connected in series with the primary winding of said transformer and disposed within said supporting pedestal and a push-button switch for short-circuiting the same, said push-button switch being mounted on said supporting pedestal adjacent one of said upright rims, so as to be pushed in by the corresponding gland nut of said tube envelope.

8. In combination, a metal casing including a hollow head-piece having an apertured top portion, a transformer within said casing and having terminals, a conductive envelope, an X-ray tube in said envelope, said envelope having tubular extensions in cooperative relation with the apertures in the top portion of said head-piece, insulated conductors disposed within said head-piece and leading through said apertures and tubular extensions and connected to said terminals of the transformer, and conductive means for connecting said terminals with the X-ray tube.

9. An X-ray apparatus comprising a transformer, a metal casing enclosing the same and including a hollow head-piece, a substantially cylindrical X-ray tube, a conductive envelope therefor having a restricted waist portion and enlarged end portions, supports at the waist portion and two end portions of the envelope to support the latter on the head-piece of the transformer casing and insulated supply conductors disposed in said hollow head-piece and connecting said X-ray tube to the transformer.

10. An X-ray installation for utilizing either of two X-ray tubes designed for different operating voltages comprising a transformer having a primary low-tension winding and a secondary high-tension winding, a metal casing enclosing said transformer and including a supporting pedestal, an X-ray tube enclosed in a conductive envelope, means including conductors for connecting said X-ray tube to the secondary winding of said transformer when the envelope of the tube is mounted on said supporting pedestal, means connected with the primary winding of said transformer for varying the voltage to be applied to the tube and cooperating means on said envelope and pedestal for controlling said voltage-varying means.

11. An X-ray installation for utilizing either of two X-ray tubes designed for different operating voltages comprising a transformer having a primary low-tension winding and a secondary high-tension winding, a metal casing enclosing said transformer and including a supporting pedestal, an X-ray tube enclosed in a conductive envelope, means for securing said envelope on said supporting pedestal, means including electric conductors disposed in said supporting pedestal for connecting the X-ray tube to said secondary winding, said first means comprising a fastening member on the conductive envelope of the tube, a resistance connected in series with the primary winding of said transformer and a switch for short-circuiting said resistance, said switch being mounted on said supporting pedestal adjacent the fastening member of the tube envelope, said fastening member being so shaped that it does not actuate said switch when the envelope is attached to the pedestal.

In testimony whereof we have signed our names to this specification.

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