May 24, 1938. A. BOUWERS 2,118,457

X-RAY APPARATUS

Filed Dec. 21, 1933

Fig. 2

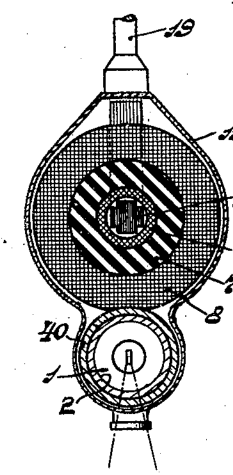


Fig. 1

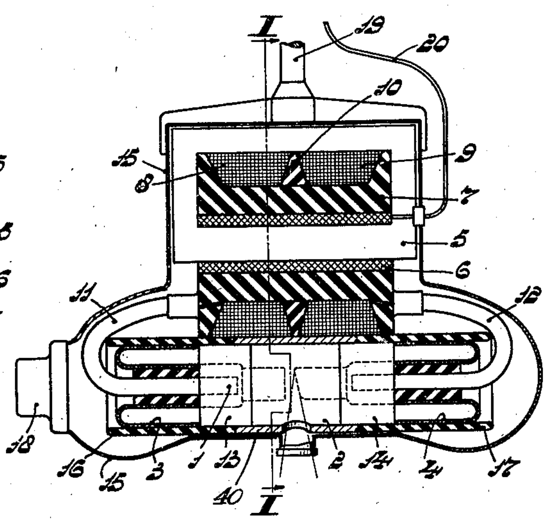


Fig. 4.

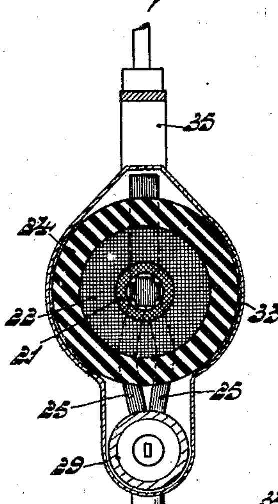
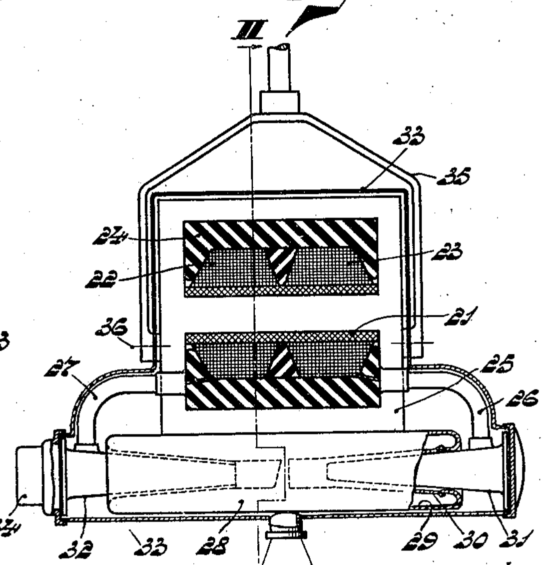


Fig. 3



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By [signature]
Atty.

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UNITED STATES PATENT OFFICE

2,118,457

X-RAY APPARATUS

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Application December 21, 1933, Serial No. 703,460
In Germany December 23, 1932

10 Claims. (Cl. 250—34)

My invention relates to a compact X-ray apparatus.

X-ray apparatus are known in which an X-ray tube and a supply transformer therefor form constructively an assembly. To keep the size of such an apparatus as small as possible it has been proposed to immerse both the tube and the transformer in oil. In this manner also the distance between the iron bodies of the transformer, which in operation are at ground potential, and the X-ray tube could be kept smaller than when arranging them in air.

According to my invention, an X-ray tube is placed against the core or other transformer parts which are grounded during operation, without providing intermediate space or insulation capable of withstanding high potential differences. With a glass tube this is impossible without providing further means. Similarly, X-ray tubes in which an equipotential central envelope portion surrounds the discharge path and is separated from both electrodes by equivalent glass portions—although this equipotential can usually be maintained at a potential amounting to one-half of the potential set up between the electrodes—cannot bear against the transformer core because of the danger of arcing over on the glass portions. Extending the equipotential portion to the full length of the transformer iron, while at the same time retaining the usual insulation length of the glass portions, requires such an increase of the overall length of the tube that there is no decrease in volume over an apparatus in which intermediate space is provided.

I have found that the expected necessary extension of the tube can be avoided, and that a cylindrical X-ray tube can be made to contact with a grounded metal surface of a transformer of normal size throughout its entire length without the occurrence of any detrimental arcing over, provided the part of the tube wall opposite said metal surface consists entirely of metal or is provided with a metal coating, for instance with a tinfoil coating. I have found that, even if the insulation length over the glass parts lying between this metal portion or this metal coating, and the electrodes is materially reduced thereby, this need not entail arcing over. On the contrary, arcing over occurs when the metal coating or the metal portion of the tube wall are shortened. This is probably due to ionization occurring in the enclosed air unavoidably present between the glass envelope parts and the metal body of the transformer bearing thereon.

If, by the measure referred to above, the required insulation length would be exceeded, the points for instance where the electrodes of the tube contact with the glass—can be further displaced towards the middle of the tube so that the re-entrant parts of the tube envelope can withstand a higher potential difference. Preferably, insulation is also provided about the electrode supply conductors and extends into these re-entrant parts.

An X-ray tube which is particularly adapted to be used in an apparatus according to the invention, has an envelope consisting entirely of a metal sleeve, and glass parts which are sealed to the ends thereof, project inside the tube, and are completely surrounded by the metal sleeve. Such a tube is extremely solid, since all breakable parts, with the possible exceptions of a window for the passage of the rays, are located within the metal sleeve. A suitable material for this metal sleeve is ferro-chromium, which is often used for sealing to glass. However, also other metals and metal alloys, for instance chromium-nickel alloys may be used.

In an apparatus according to the invention, tubes of the usual construction, having a central envelope portion consisting entirely of metal, can also be used provided this central portion is lengthened to at least the length of the opposite metal body of the transformer by means of metal coatings bearing intimately against the glass portions sealed thereto.

A metal envelope surrounding both the tube and the transformer may bear on the tube, if desired with the interposition of a lead layer by which the undesired rays are absorbed.

It is not necessary to provide high-voltage insulation between this envelope and the transformer, if a transformer of the construction known per se is used, i. e. a transformer in which the secondary winding is separated from the primary winding by such insulation and in which the ends of the secondary winding lie on the inner side, whereas the outer layer of turns of this winding has the average potential and may be connected to the envelope. In this case the transformer envelope can be grounded during operation, owing to which the terminals of the transformer secondary acquire equal potential differences with respect to ground.

With an apparatus according to the invention the oil-filling may often be dispensed with.

The invention will be more clearly understood by reference to the accompanying drawing which represents, by way of example, some embodiments thereof, and which illustrates how the weight of the apparatus is reduced and its handling is facilitated by utilizing its volume as efficiently as possible.

Figure 1 is a longitudinal sectionized view of an apparatus in which the secondary winding of the transformer is grounded at the outside.

Figure 2 is a section along line I—I of Figure 1.

Figure 3 is a longitudinal sectionized view of an apparatus in which the secondary winding is grounded on the inner side, and

Figure 4 is a section along line II—II of Figure 3.

The cylindrical X-ray tube 1 shown in Figures 1 and 2 has a metal central portion 2 to the ends of which are sealed glass portions 3 and 4 forming re-entrant parts carrying the electrodes of the tube.

On the leg 5 of the iron core of a high-tension supply transformer is provided a primary winding 6, surrounded by an insulator 7 in the form of a spool. Upon the spool are wound two secondary coils 8 and 9 separated by an insulating ring 10. Coils 8 and 9 have their outer ends connected together and are wound in such a manner that the electro-motive forces induced in both coils act in the same direction. The inner ends of the secondary coils 8 and 9 pass laterally through an insulator to the outside and are connected to the electrodes of the X-ray tube by tubes or cables 11 and 12 provided with high-tension insulation. The insulating tubes or cables extend into the re-entrant parts of portions 3 and 4 nearly to the sealing points of the electrodes; the intermediate space between them and the glass wall of the re-entrant parts being filled with insulating material.

The tube 11 contains two conductors between which exists the voltage for heating the incandescent cathode of the X-ray tube and which voltage is supplied from a portion of the secondary winding.

The glass parts of the wall of the tube 1 are provided with conductive coatings 13 and 14, which extend from the metal portion 2 to such an extent that a conductive surface is obtained corresponding in length to the opposing surface of the transformer coil. The transformer coil is provided with a metal coating (not shown) connected to the core, whereas the metal surface of the X-ray tube contacts with this metal coating so that its potential corresponds to that of the middle of the secondary winding, i. e. the potential at the outside of coils 8 and 9.

The tube and the transformer are enclosed within a common envelope 15 which bears directly on the metal surface of the coil, (see Figure 2), on the outer parts of the iron core, and on the outer surface of a lead sleeve 40. Sleeve 40 surrounds the central portion 2 in contacting relationship and is provided with an aperture for the exit of the X-rays. Between envelope 15 and glass portions 3 and 4, an intermediate space is provided in which insulating cylinders 16 and 17 are placed.

The envelope 15, which may consist of several parts which are screwed together or are connected by other suitable means, surrounds the insulated cables 11 and 12 so that there are only grounded parts at the outer surface of the apparatus.

An electric fan 18 is secured to the metal envelope, opposite the anode end of the tube 1, and serves for cooling. The apparatus is pivotally suspended on a support 19, although other supporting means, for instance, a stand consisting of bars, may be used. A conductor 20 is provided for the primary windings through which the apparatus may be connected to an alternating current supply.

The apparatus represented in Figures 3 and 4 comprises a shell type transformer, in which only low-tensioned insulation is provided between the primary winding 21 and the secondary winding consisting of the coils 22 and 23. The high-tensioned ends of the secondary winding are provided at the outside, whereas the inner ends are connected together and to the iron core of the transformer. The coils are wound in such a manner that the sum of the tensions is obtained, and are surrounded by an insulator 24 which is encircled at two points by the magnetic circuit. The yoke 25, as shown in dotted lines in Figure 4, is divided at the lower portion to form a space through which the high-tension supply conductors 26 and 27 are led.

The X-ray tube 28 which bears on the iron core 25, consists of a metal sleeve 29 extending the length of the tube, and having inwardly-bent edges to which are sealed glass funnels 30 located within the tube. These funnels serve to support the electrodes, and to insulate the same from the metal sleeve 29, which is grounded during operation.

Insert pieces 31 and 32 of insulating material extend into the glass funnels 30 and surround the supply conductors of the tube. Between insert pieces 31 and 32 and the transformer terminals extend insulating tubes or cable pieces 26 and 27 which serve to connect the electrodes of the tube to the transformer windings. These tubes or cables must be insulated for high tension so that they may bear on the grounded enclosing envelope 33 without any danger of arcing. Envelope 33 surrounds the insulator 24, (see Figure 4) the transformer core, and the tube 28, and is preferably grounded during operation.

An electrically driven cooling fan 34 is secured to the envelope 33. The apparatus is suspended on a support 35 by means of journals so as to be rotatable about the axis 36, which axis is eccentrical relatively to the transformer so that the apparatus is balanced.

The invention also includes many modifications of the construction and of the supporting means of the apparatus.

What I claim is:

1. An X-ray apparatus comprising an X-ray tube having an envelope, a high-tension supply transformer for said tube having a peripherally-exposed metallic portion adapted to be grounded during operation, and a housing enclosing said tube and transformer, said envelope having a portion extending the length of said metallic portion and provided with a metallic outer surface, said envelope portion being closely spaced from an opposing part of said metallic portions without the interposition of an insulation adapted to stand high voltages and extending the length of said opposing part.

2. An X-ray apparatus comprising an X-ray tube having an envelope consisting of a metal portion and at least one glass portion sealed to said metal portion, a high-tension supply transformer for said tube including coils, a housing enclosing said tube and said transformer, a metal member covering said coils and adapted to be grounded during operation, said metal portion being disposed adjacent to said metal member without the interposition of high-voltage insulation, and a conductive coating on the glass por-

tions of the envelope extending from said metal portion and adjacent to said metal member to the ends thereof.

3. An X-ray apparatus comprising an X-ray tube having an envelope consisting of a metallic waist portion and two glass portions, one sealed to each end of said waist portion, a high-tension supply transformer for said tube including coils, a housing enclosing said tube and transformer, a metal member covering said coils and adapted to be grounded during operation, said metallic waist portion being closely spaced from an opposing portion of the surface of said metal member without the interposition of an insulation capable of withstanding high tension, and a metal coating covering a portion of said glass portions, said coatings and waist portion extending along said metal member.

4. In combination as a unitary structure, an X-ray tube having a cylindrical envelope, a high-tension supply transformer for said tube including a magnetic core, and a common housing enclosing said tube and transformer, said housing having a conductive outer surface electrically connected to said magnetic core, said envelope having a portion closely spaced from an opposing portion of the surface of said core without the interposition of an insulation capable of withstanding high tension, said portion being provided with a metallic surface.

5. In combination an X-ray tube having an envelope and electrodes therein, said envelope having metallic portions and vitreous re-entrant portions carrying the electrodes, a high-tension supply transformer for said tube including coils, a common housing enclosing said tube and said transformer, said housing having a conductive portion adapted to be grounded during the operation of the apparatus, and a metal member covering said coils and electrically connected to said conductive portion, said metallic portions being disposed adjacent to said metal member without the interposition of an insulation adapted to stand high voltages.

6. As a unitary structure, an X-ray tube and a high-tension supply transformer therefor, a common housing for said tube and transformer, said transformer comprising high-tension coils, low-tension coils and a magnetic core, a conductive coating extending over said coils and in electrical contact with said core to form with said core an electric shield for said coils, said X-ray tube being disposed adjacent to said shield without the interposition of an insulation capable of withstanding high tension, insulating sleeves projecting through said shield, and electric supply leads connecting said tube to said high-tension coils and passing through said sleeves.

7. An X-ray apparatus comprising a high-tension supply transformer including a magnetic core having a peripherally-exposed portion, an X-ray tube comprising an envelope having a section provided with a metallic outer surface, said section extending the length of said peripherally-exposed portion and being closely spaced therefrom without the interposition of high-voltage insulation, and a housing enclosing said transformer and X-ray tube.

8. An X-ray apparatus comprising a high-tension supply transformer having a peripherally-exposed equipotential portion, and an X-ray tube comprising an envelope having a portion provided with a conductive outer surface and disposed adjacent to an opposing part of said peripherally-exposed portion without the interposition of high-tension insulation and extending the length of said part.

9. An X-ray apparatus comprising a high-tension supply transformer including a magnetic core having a peripherally-exposed portion, and an X-ray tube comprising an envelope having a conductive surface portion bearing upon an opposing part of said peripherally-exposed part throughout the entire length thereof.

10. An X-ray tube having an envelope and electrodes therein, said envelope comprising a cylindrical metallic waist portion and glass portions sealed one to each end thereof, a high-tension supply transformer having coils, a core and a peripherally-exposed metallic portion including said core and having a length greater than the length of said waist portion, conductors provided with high-tension insulators and connecting said coils to said electrodes, said waist portion being adjacent to said peripherally-exposed metallic portion without the interposition of an insulation capable of withstanding high tension, metal coatings on the surface of said glass portions and extending from said waist portions along the length of the opposing surface of the peripherally-exposed metallic portion, and a common housing enclosing the X-ray tube and transformers and having a metallic surface in electrical contact with said core.

ALBERT BOUWERS.

CERTIFICATE OF CORRECTION.

Patent No. 2,118,457. May 24, 1938.

ALBERT BOUWERS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, lines 7 and 10, for the word "tensioned" read tension; lines 58 and 59, claim 1, strike out the words extending the length of said metallic portion and; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of July, A. D. 1938.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)