Nov. 9, 1937. S. HIRSCH 2,098,900

X-RAY APPARATUS

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Fig.1.

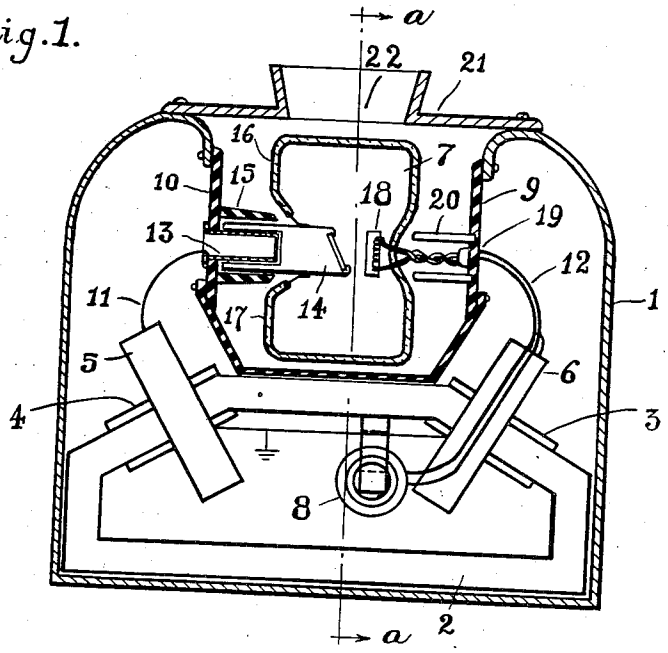
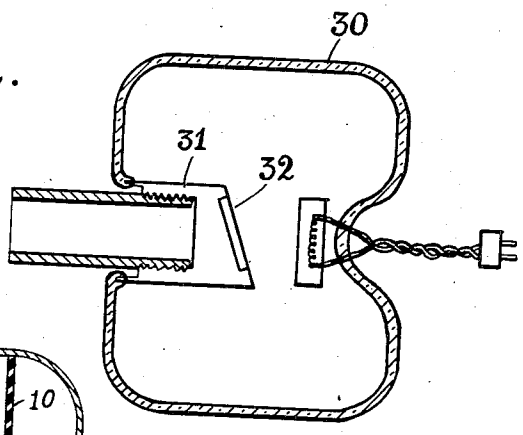


Fig.2.



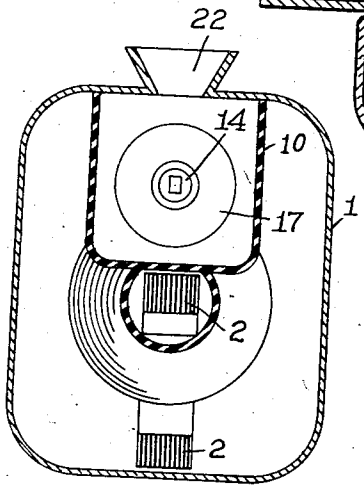


Fig.3

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X-RAY APPARATUS

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10 Claims. (Cl. 250—34)

This invention relates to new and useful improvements in X-ray apparatus and methods of connecting the X-ray tubes to their energizing transformers whereby a highly useful new combination is obtained.

More specifically stated, I have made improvements in the design and construction of X-ray tubes and transformers so that when a combination thereof is operated in air or in insulating fluids or insulating gases the space within which electrical discharges can take place to persons or nearby objects is less than that required for the old combination of tubes and transformers known in this art. It is therefore possible, through my invention, to construct a more compact and smaller combination of a transformer with an X-ray tube than is possible with the now known types and forms of X-ray tubes and transformers.

The tendency in this art is to so combine the high voltage transformer with the X-ray tube as to form a so-called shock proof unit. In a unit of this kind there are no high-tension carrying parts of the transformer or of the tube exposed therefore a patient or other bystanding person can not receive a shock of high voltage current. There is ordinarily required a housing to surround all these parts which may consist either of metal connected to ground or of insulating substances which prevent a discharge from reaching a person touching the apparatus. But then, these protective parts must be placed a sufficient distance away from the high-tension carrying parts to prevent arcing over through the air or the tube must be placed into a container and be surrounded with oil which is then for the purpose of permitting a decrease of the distances between the high-tension carrying parts and the housing to about one fourth of what these distances would have to be in air.

It is then however difficult to obtain the full radiation output from the tube owing to the necessity of the rays to pass through a certain layer of the oil which decreases not only the intensity of the low penetrating components of the radiation but also of the high-penetrating wave lengths. Furthermore, if it should become necessary to exchange the tube, then this operation would require the opening of the oil tank which is difficult, messy and not easy to tighten again after the tube is replaced.

With the tube and transformer of my invention these and other difficulties are avoided. The tube is operated in air and it is easily removable, also the losses of useful radiation in the oil layer and the difficulties in changing the tube are no longer present. But then, by virtue of its new construction the space around the tube at which the insulation or protective housing must be kept in order to prevent arcing over from the high-tension carrying parts can be reduced to dimensions probably not larger than those required for the oil insulated tube. Therefore, the result of my invention consists in the possibility of constructing a shock-proof unit enabling the full utilization of the radiation produced, while being of such small size and of such compactness as is ordinarily attainable with oil insulation and thereby it becomes easily possible to manipulate it and to apply the unit to such positions and so close to the patient's body that all parts of the body can be easily radiographed without over exerting the patient. Also such a unit is particularly suitable for portable work when the X-ray apparatus is to be brought to the bedside of the patient and for use in his home.

These and other advantages of my device are best illustrated by the following description of one typical application of the principle of my invention.

Fig. 1 is a semi-schematic illustration of a tube of my invention in combination with a high tension transformer to form a so-called shock-proof unit, being a cross sectional view through the middle of the unit.

Fig. 2 is a detailed cross-sectional drawing of the tube.

Fig. 3 is a sectional view taken on line *a—a* of Fig. 1.

In Fig. 1 is shown a metallic tank 1 filled with oil and containing a high tension transformer having a core 2, two primary windings 3 and 4 and two secondary windings 5 and 6 connected in such a way that this transformer produces the required current and potential to energize the X-ray tube 7 in conformity with the intended performance of the tube. There is a filament heating transformer 8 with a grounded core, a primary and a secondary winding; the latter is insulated from the primary and the core for one half of the total secondary voltage of the high tension transformer. The windings 5 and 6 of the high tension transformer are connected to the core and grounded so that the potential applied to the tube is one half positive from ground and one half negative from ground as is well understood in this art.

The tank 1 is U-shaped as is shown in Fig. 1 and its inner portions 9 and 10 consist of plates of insulating material so that the high tension terminals 11 and 12 can be brought to the terminals of the tube without causing the high tension current to short circuit to the metal tank. The terminal 12 consists of two wires leading back to the filament transformer 8 which supplies the heating current for the filament of the X-ray tube. This winding is also connected to the secondary of the high tension transformer 6 so that it carries both the heating current and

the high tension current to the cathode of the X-ray tube.

The insulator plate 10 is provided with a short tubular extension 13 consisting of heat conducting material into which the oil contained in the transformer case 1 may freely flow whereby the tubular extension readily absorbs and carries away the heat transmitted to it from the anode of the X-ray tube. This anode 14 is hollow and it fits over the tubular extension 13 so that any heat generated upon the target of this tube is readily transmitted to the oil contained in the tank 1. Over this anode there may be placed a tubing 15 of insulating material and attached to the insulating plate 10 in such a way that high tension discharges cannot take place to the exterior or to the tank from any other place except the anode and only from that part of it which is within the contour or outline of the body of the X-ray tube. That is, an electrical discharge could not take place either from one electrode of the X-ray tube to the other or to the grounded metal tank from any part of the high tension carrying parts which are located outside a straight line represented by the two sides of the X-ray tube 16 and 17.

The cathode 18 consists of a part to be heated to electron emission and it has two conductors for the heating current and the high tension voltage. These are insulated for the low tension current and are flexible. At the point 19 there is provided a plug mounted oil tight into the insulator plate 9 by means of which connection can be made with the two transformers through the conductors 12. A tube 20 is provided so that electrical discharges from the cathode conductors are not possible from any part outside of the contour of the X-ray tube. This tube is screwed or bayonetted into a groove cut into the insulator plate 9 so that it is removable and so that the plug 19 can be easily pulled out of its socket. When this plug is pulled out, then the flexibility of the cathode leads makes it possible to remove the tube 20 after it is unscrewed and then there is sufficient space left that the X-ray tube can be pushed over in that direction until the anode sleeve has slipped out from over the cooling tube 13. Then the X-ray tube can be removed by displacing it upward and out from its location in the container.

The open space between the legs of the U-shaped tank which is occupied by the X-ray tube is covered with a shield of metal that is opaque to X-rays. This cover may also be made of rubber or other insulating material impregnated with X-ray-opaque substances such as lead or barium salts, for the purpose of protecting the bystanders against the unused rays coming out through the sides of the protective tank.

The X-ray tube shown in Fig. 2 consists of a glass body 30 that is cylindrical in shape. The closing ends are essentially flat and parallel to each other, i. e., perpendicular to the tube axis, so that the cross-sectional area through the lengthwise axis is oblong or approximately rectangular. The anode 31 carrying embedded in its surface a tungsten target 32 is hollowed out and its inner surface is provided with a screw thread into which a stout copper tube can be screwed. This copper tube is to conduct away the heat developed on the anode target. The outer brim of the hollowed out anode is provided with a thin edge suitable as a sealing junction to the glass body of the X-ray tube. This anode is joined to the glass body either in the described way or by means of a metal ring suitable for sealing on to the glass as is illustrated in Fig. 1. The wall of the glass body may then be either flat as is shown in Fig. 2, or it may be drawn inward into the body of the tube as is shown in Fig. 1.

The cathode of this X-ray tube consists of a portion to be heated to incandescence in the usual manner, which may be spiral or linear in form. Its two lead-in wires are sealed into the drawn-in portion of the side of the tube in the usual manner; but the two leads are made flexible and insulated the one from the other as above described.

The general shape of the tube and the drawn-in features are for the purpose of providing a longer than linear or practically linear path for electrical discharges as exist with tubes of the prior art. It is rather the purpose of my invention to so construct the glass parts of the tube, that voltages can be applied to its terminals which are in excess of the linear or straight line sparking distance from between the free and uncovered parts of the two electrodes of the tube. The body of the X-ray tube, therefore, serves as a barrier for the high tension current and by following this new construction it is possible to operate the tube at voltages higher than those which correspond to the sparking distances between the points where the electrodes are joined to the body of the tube.

Having thus described one typical application of my invention I do not confine it to this exact disclosure but extend it to the scope of the following claims.

I claim:

1. The combination of an X-ray tube and a transformer housing provided with an outwardly extending hollow portion, a high tension transformer located in said housing and insulated connections from it to the electrodes of the said X-ray tube, insulating and cooling material filling said housing and said extending hollow portion, said X-ray tube being outside of said housing and provided with an electrode having a metal-to-glass joint hollowed out beyond the said metal-to-glass joint of said electrode and fitting over the said hollow extending portion for the purpose of cooling the said metal-to-glass joint and the said electrode.

2. An X-ray generating unit comprising an X-ray tube having cooperating electrodes and an envelope with flattened circular portions surrounding the electrodes of said X-ray tube, a transformer housing containing a filament heating transformer and a high tension transformer with two secondary coils and insulating material for said high tension transformer coils and having a reentrant portion which in part is located between said two secondary coils and in which the said X-ray tube is located and insulated conductors from said transformers to the electrodes of said X-ray tube.

3. An X-ray generating unit comprising an X-ray tube having an envelope of dielectric substance and an electron emitting cathode and an anode mounted therein, said anode being provided with heat conducting means to carry the heat generated on said anode away to a cooling means outside of said X-ray tube, a high tension transformer having two secondary coils and a filament heating transformer to energize said X-ray tube with means for energizing said transformers, connections between said transformers and said X-ray tube and a housing filled with oil for said high tension and filament heating

transformers, said housing being provided with an inwardly extending cavity for housing said X-ray tube, a part of said cavity and of the X-ray tube located therein being located between the outer windings of said secondary coils whereby a closer spacing of the coils and the X-ray tube are obtained, said cavity having an X-ray opaque cover provided with a transparent portion for the passage of X-rays and having insulating portions for the passage of said connections and the oil in said housing being in heat absorbing contact with said cooling means of said X-ray tube.

4. An X-ray generating unit comprising an X-ray tube with an anode and a cathode, heat transferring means for transferring heat from said anode to a cooling substance, a filament heating transformer and an X-ray tube energizing transformer having two secondaries with means for energizing them, conductors for connecting the electrodes of said X-ray tube with said energizing transformers, a housing containing said transformers and filled with an insulating and cooling substance, said housing having a recessed portion a part of which and of the said X-ray tube located in said recessed portion being located in part between the outer windings of said secondary coils of said X-ray tube energizing transformer, said recessed portion being closed with an X-ray opaque cover provided with an X-ray transparent portion and said recessed portion consisting in part of insulating substance for passing and insulating said conductors and said heat transferring means.

5. An electron discharge unit comprising a transformer housing having an inwardly and outwardly extending highly heat conducting portion and high tension transformers for energizing an electron discharge device located therein, said housing being filled with an insulating and cooling medium and making contact with said inwardly extending portion, an electron discharge device located outside said housing and having a glass envelope and cooperating discharge electrodes sealed therein, one of said electrodes being provided with a glass-to-metal joint and hollowed out beyond the glass-to-metal joint of said electrode and fitting over said outwardly extending portion for the purpose of cooling the said glass-to-metal joint of said electrode.

6. The combination of an electron discharge tube and a transformer housing provided with an outwardly extending hollow portion, high tension transformers located in said housing and insulated connections from it to the electrodes of said discharge tube, insulating and cooling material filling said housing and said extending hollow portion, said electron discharge tube being outside said housing and provided with an electrode having a metal-to-glass joint and being hollowed out beyond the said metal-to-glass joint of said electrode and fitting over the said hollow extending portion for the purpose of cooling the said metal-to-glass joint of the said electron discharge tube.

7. An X-ray generating unit comprising the combination of a high tension transformer having a single core, primary and secondary windings surrounding said core and said secondary windings comprising two spaced coils, and an X-ray tube connected to the terminals of said coils and having an anode and a cooperating cathode mounted in an evacuated envelope of dielectric substance and means for heating the said cathode to electron emitting temperature, said envelope having flattened end portions and said envelope being located in part between said coils and said coils being mutually inclined so that portions thereof and portions on said flattened tube envelope having different potentials therebetween are spaced, whereby a more compact arrangement of said parts and decreased magnetic losses are obtained.

8. An X-ray generating apparatus comprising a container in part of substantially X-ray opaque metal filled with insulating and cooling material, filament heating means and a high tension transformer and an X-ray tube having an anode and a cooperating cathode mounted in an envelope of insulating material, said high tension transformer having a single core, primary and secondary windings surrounding said core and said secondary windings comprising two spaced coils, the envelope of said X-ray tube having flattened end portions and being located in part between said secondary coils, said coils being inclined outwardly from said flattened end portions of said X-ray tube so that portions thereof and of said transformer coils having large differences of potential are spaced a greater distance than corresponding portions having less potential differences and said insulating and cooling material being in heat transferring relation with said anode, whereby a highly compact unit having low losses is obtained.

9. An X-ray generating apparatus enclosed in a housing at least in part of metal, having an X-ray transparent portion and being filled with insulating and cooling substance, comprising the combination of a low tension filament heating transformer, a high tension energizing transformer having a single core, primary and secondary windings surrounding said core and an X-ray tube having an anode and an electron emitting cathode mounted in an envelope of high dielectric substance, said secondary windings comprising two coils and said X-ray tube being in part located between said coils, parts of said X-ray tube and parts of the adjacent coils being placed at an angle so that large voltage difference carrying parts of said X-ray tube and of said coils are spaced more than parts carrying lesser voltage differences whereby the resulting apparatus is rendered compact and whereby the electrical and magnetic losses are made small.

10. An electron discharge unit comprising the combination of a high tension transformer having a single core, primary and secondary windings surrounding said core and said secondary windings having two spaced, mutually inclined coils with an electron discharge tube having an evacuated envelope of dielectric substance formed with flattened end portions in which are mounted opposed electron discharging and receiving electrodes connected to said coils and means for heating the filament of one of said electrodes to electron emitting temperature, said tube being mounted in the space between said coils with parts of said flattened end portions relatively near said coils and the remainder of said flattened end portions diverging away from said coils so that said flattened end portions and parts of said coils having large voltage differences are spaced further apart than corresponding portions having smaller voltage differences and whereby a compact unit having small magnetic and electrical losses is obtained.

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