Oct. 7, 1941. B. K. M. MAGNUSSON 2,258,141

X-RAY TUBE AND METHOD OF MAKING

Filed Feb. 9, 1940

Fig. 1,

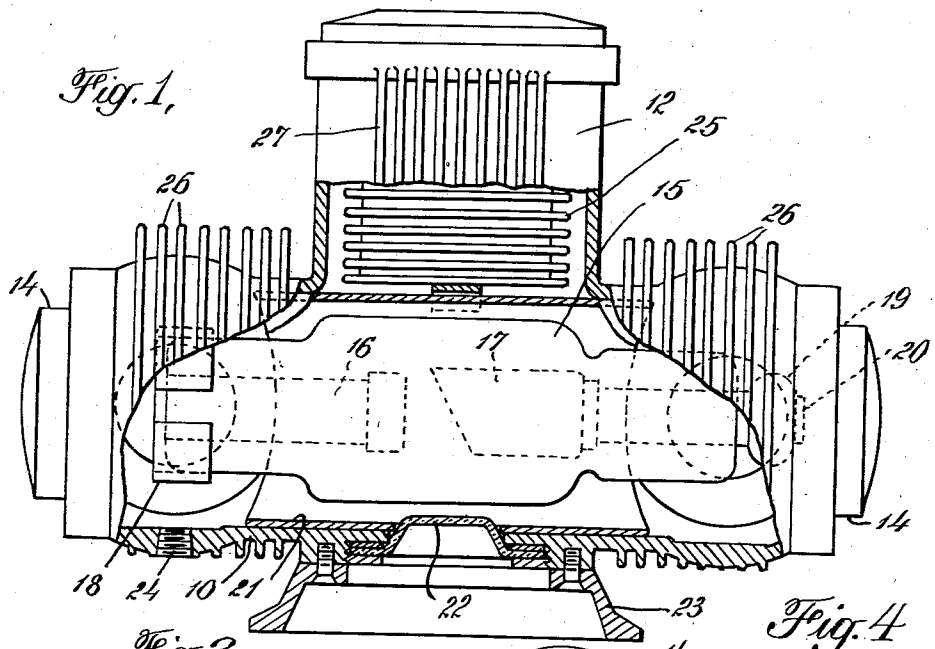


Fig. 2,

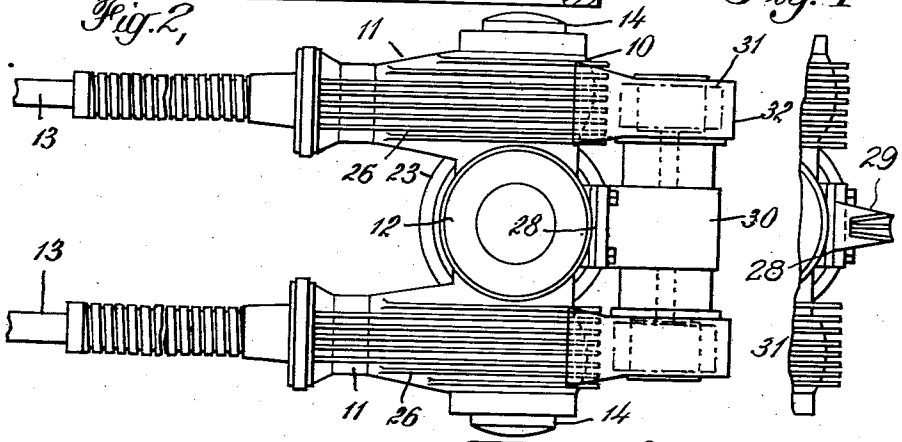


Fig. 4

Fig. 3,

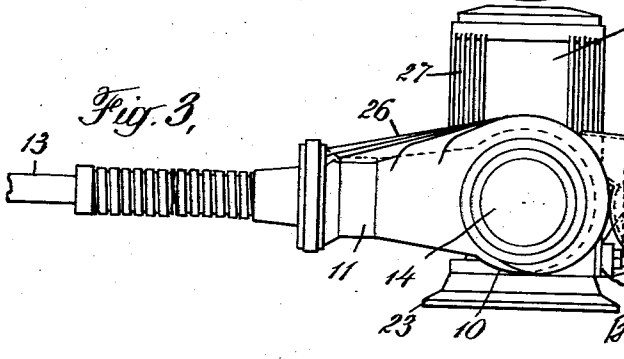
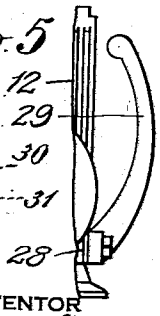


Fig. 5



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X-RAY TUBE AND METHOD OF MAKING

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4 Claims. (Cl. 250—89)

This invention relates to shockproof X-ray apparatus in which the X-ray tube is immersed in an insulating fluid within a housing. More particularly, the invention is concerned with a novel apparatus of the type referred to which, although small and light in weight, may be operated at a high rating for long periods.

Modern shockproof X-ray apparatus for use in radiography and similar work must be light and compact to meet the present demands of the market and while various forms of such apparatus are commercially available, they all have the disadvantage, as compared with the older air-insulated tubes, that they are not suitable for long operations in which large quantities of heat are generated. The reason for this is that, because of their small size, their heat storage capacity is relatively small and the rate at which they dissipate heat is less than that of air-insulated tubes, because they cannot be operated at comparably high temperatures. Accordingly, the present commercial shockproof units may not be safely employed for such operations as protracted fluoroscopy or therapy.

The present invention is, accordingly, directed to the provision of a novel shockproof X-ray apparatus which fulfills the present demand for a small light-weight device and is at the same time capable of operation for longer periods and at higher ratings than prior comparable devices of the shockproof type. The new unit is capable of such performance because it includes a number of features adapting it to fulfill the various requirements hereafter set forth.

In the construction of a shockproof unit for operation under the conditions referred to, the broad problem presented is that of greatly increasing the heat dissipating property of the structure so that the unit as a whole has a heat dissipating characteristic approaching the heat dissipating capacity of the tube itself. An increase in the heat dissipating capacity of the unit can be obtained by increasing the superficial area of the enclosure and such an increase in surface can be obtained, without substantially increasing the bulk of the unit, by providing the surface with cooling fins. The use of such fins permits an increase in rating of approximately 25%, but this is in itself insufficient to solve the problem. Thus, one standard shockproof unit now available has a rate of heat dissipation of approximately 5000 pkv. ma. units and such a unit will operate continuously at fluoroscopic voltage, that is, at 85 pkv. at about 1 ma. However, the desired rating is at least two and one-half times this value and, therefore, merely increasing the superficial area of the housing is a relatively small step toward the desired result.

The maximum temperature of operation at which the unit referred to is now operated is about 150° F. and experiments indicate that by increasing this temperature to 200° F., the heat dissipating capacity can be increased by more than 100%. Accordingly, by equipping the housing of the unit with cooling fins and operating the unit at 210° F. mean temperature with a room temperature of 70° F., it will readily dissipate sufficient energy to develop the desired rating.

In attempting to devise a shockproof apparatus to be operated at such a higher temperature, a number of problems are at once encountered. Thus, provision must be made for a much greater expansion of the insulating fluid and the insulators within the housing must be made of materials which will withstand such operating temperatures for long periods without deterioration of their dielectric qualities. The major problem, however, is that of maintaining the insulating fluid at a high dielectric value under the severe operating conditions mentioned and this is a matter of the utmost importance in view of the small clearances employed in compact apparatus of the type referred to.

Experiments have shown that insulating fluids as commonly employed in shockproof apparatus contain gases in solution, the principal ones being atmospheric oxygen and nitrogen. When such apparatus is subjected to successive heating and cooling cycles in ordinary use, the surfaces exposed to the fluid apparently give off occluded gases during heating and the gases become dissolved in the fluid. The quantities of the gases so liberated and dissolved depend on the temperatures to which the parts are heated and even though the best fluid is employed and it is introduced into the housing under the most favorable conditions heretofore known, it has been found that the dielectric value of the fluid is invariably impaired after it has been subjected to repeated heating and cooling within the temperature limits specified.

The apparatus of the invention overcomes the difficulties above pointed out and the desired result is obtained by a new technique in the preparation of the fluid and of the housing prior to the final assembly of the apparatus. In preparing the fluid and housing, the dissolved gases are eliminated from the fluid and the occluded gases are removed from the surfaces ex-

posed to the fluid before the fluid is introduced into the housing and the latter hermetically sealed. Thereafter, repeated heating and cooling does not result in liberation of gases from the surfaces to such an extent that such gases, when dissolved in the fluid, impair its dielectric quality to an important extent. The apparatus of the invention thus includes a housing containing a fluid free from dissolved gases, which occupies the entire space within the housing around the tube, its connections, and the usual expansion means, and all surfaces of the parts exposed to the fluid are free from occluded gases. In addition, the tube housing is provided with external surface extensions, such as cooling fins, to increase its heat-dissipating capacity and the unit is equipped with means for blowing air over the fins. The new apparatus may be operated for longer periods and at higher ratings than prior similar shockproof devices and may be operated continuously for indefinite periods at full rating when the blower is employed.

For a better understanding of the invention, reference may be had to the accompanying drawing in which:

Fig. 1 is a view in front elevation of one form of the new X-ray apparatus with parts broken away;

Fig. 2 is a plan view of the apparatus shown in Fig. 1;

Fig. 3 is a view of the X-ray apparatus in end elevation;

Fig. 4 is a fragmentary plan view showing a modification; and

Fig. 5 is a fragmentary elevational view of the parts illustrated in Fig. 6.

The shockproof unit illustrated in Fig. 1 comprises a housing **10** of suitable metal having extensions **11** therefrom at its opposite ends and lying in one plane and a central extension **12** lying at a plane at right angles to the first. The extensions **11** contain the usual insulators provided with terminals, and the insulators are formed to receive terminal insulators on the cables **13**, the cable insulators having terminals making contact with those in the insulators within the housing. The housing is provided with the usual end caps **14** through which may be introduced the tube **15**.

The tube includes the usual cathode **16** and anode **17** having leads connected to the terminals in the housing insulators. The tube is supported within the housing in position in any convenient manner, as by having its cathode neck received within a bushing **18** attached to the terminal of the adjacent insulator while the exposed portion **19** of its anode shank is attached by a conductive strap **20** to the terminal of the other insulator. The housing contains the usual rayproof shield **21** and has a window **22** for the emission of the useful beam. Attached to the housing to surround the window is a cone **23** which may be replaced, if desired, by an adapter plate by which the housing can be secured to a suitable stand.

In final form, the interior of the housing, including the extensions, is completely filled by an insulating fluid, such as a highly refined petroleum oil, which is introduced into the housing through an opening closed by a filling plug **24**, and to permit expansion of the oil resulting from the heat generated during operation, the housing extension **12** contains a collapsible chamber **25** which may be a metallic bellows of conventional form.

The end portions of the housing are provided with spaced parallel cooling fins **26** which continue along the surfaces of the extensions **11**, and the front and rear surfaces of the extension **12** are provided with similar fins **27**. On the front of the housing below the extension **12** is a seat **28** to which may be attached a handle **29**. When the apparatus is to operate for long periods at high rating, the handle is removed and an air circulator is attached to the seat. This circulator includes a motor **30** having blower rotors **31** at opposite ends of its shaft, the rotors and shaft being enclosed within extensions **32** from the motor casing. The casing extensions have openings through which air propelled by the rotors is directed along the groups of fins **26**. The motor **30** is supplied with current through connections not shown.

When the unit is mounted ready for use, the housing is grounded and the housing assembly, including the tube, has been given a preliminary treatment by which occluded gases have been removed from the surfaces exposed to the insulating fluid. Also, the fluid has been treated to remove dissolved gases therefrom.

In preparing the unit for use, the housing assembly is first placed in an oven and baked at a temperature of about 225° F. for a period of about two hours or more. During this time, dry air is preferably circulated through the interior of the casing to facilitate the removal of volatile substances. When the baking is completed, the housing is attached to a pumping system and subjected to a vacuum. After a reasonable period of time when a good vacuum has been obtained in the housing, the oil, which has previously been outgassed, is introduced therein.

In order to outgas the oil, the oil is forced through a line provided at its end with a spray nozzle lying within a chamber which is connected to a vacuum pumping system. The spraying of the oil in the chamber, which is under vacuum, results in the oil liberating its dissolved gases so energetically that the fine oil particles are disrupted with the formation of foam. As the foam settles down, the resulting fluid accumulating in the chamber is available for filling the housing. For this purpose, the chamber is connected to the housing while the interior of the latter is still under vacuum and the oil is admitted into the housing until the housing is completely filled. Thereafter, the housing is closed by means of the plug **24** which is inserted in the filling opening.

By preparing the housing and the oil in the manner described, it has been found that the gases dissolved in the oil and the gases occluded in the surfaces within the housing exposed to the oil can be removed to such an extent that the shockproof unit may be subjected to repeated heating and cooling cycles between a top mean operating temperature of 210° F. and a room temperature of 70° F. without serious impairment of the dielectric quality of the oil. The unit may, accordingly, be operated at higher ratings and for longer periods than prior comparable devices of the shockproof type and it may, therefore, be safely employed for fluoroscopy, therapy, and similar operations for which such prior devices are unsuitable. In the case of the new unit, these desirable results are obtained without increase in the bulk of the unit or substantial increase in its weight.

In the foregoing, the principles of the invention have been explained as applied in the production of a shockproof unit of specific construction. It is to be understood, however, that the

utility of the invention is not limited to the production of shockproof units of particular types and it may be employed in the manufacture of units for various purposes, including those containing rotary anode tubes.

I claim:

1. In an X-ray device for operation at high temperatures, the combination of a housing having a plurality of hollow extensions therefrom, the exterior of the housing and extensions being provided with cooling fins, terminals in two of said extensions which lie generally parallel to one another, an X-ray tube within the housing having terminals connected to the terminals in the extensions, a collapsible chamber in another of said extensions, a body of insulating fluid filling the remainder of the space within the housing and extensions with a tube immersed therein, and a motor-driven fan-unit removably mounted on the outside of the housing for propelling air over said fins.

2. An X-ray device for operation at high temperatures which comprises a housing having a plurality of hollow extensions therefrom, terminals in two of said extensions which lie generally parallel to one another, an X-ray tube within the housing having terminals connected to the terminals in the extensions, means defining a part of the space within the housing and capable of permitting enlargement of said space, a body of insulating fluid filling the remainder of the space within the housing and extensions with the tube immersed therein, the fluid being free from dissolved gases and the surfaces of the parts exposed to the fluid being sufficiently free of occluded gases that the residual occluded gases given off by said surfaces and dissolved in the fluid during operation of the device at high temperatures do not substantially impair the dielectric quality of the fluid, cooling fins on said extensions, heat developed at the anode during operation of the tube being transmitted through the fluid to the housing and fins, and a motor-driven fan unit on the outside of the housing for propelling air over said fins.

3. In an X-ray device for operation at high temperatures, the combination of a metallic housing having cooling fins on the exterior surface thereof, terminals mounted in the wall of the housing and accessible from the exterior thereof, an X-ray tube mounted within the housing and having terminals connected to the housing terminals, a body of insulating fluid within the housing, the tube and the connections between the terminals lying within the fluid and the fluid transmitting to the housing wall heat developed at the anode during operation, means defining a part of the space within the housing and permitting expansion of the contents of the housing upon heating, and a motor driven fan unit mounted on the outside of the housing for propelling air over said fins.

4. In an X-ray device for operation at high temperatures, the combination of a metallic housing having a pair of hollow extensions therefrom, cooling fins on the housing and extensions, terminals mounted in the extensions and accessible from the exterior of the housing, an X-ray tube mounted in the housing and having terminals connected to the housing terminals, a body of insulating fluid within the housing, the tube and the connections between the terminals lying within the fluid and the fluid transmitting to the housing wall heat developed at the anode during operation, means defining a part of the space within the housing and permitting expansion of the contents of the housing upon heating, and a motor driven fan unit mounted on the outside of the housing for propelling air over said fins.

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