

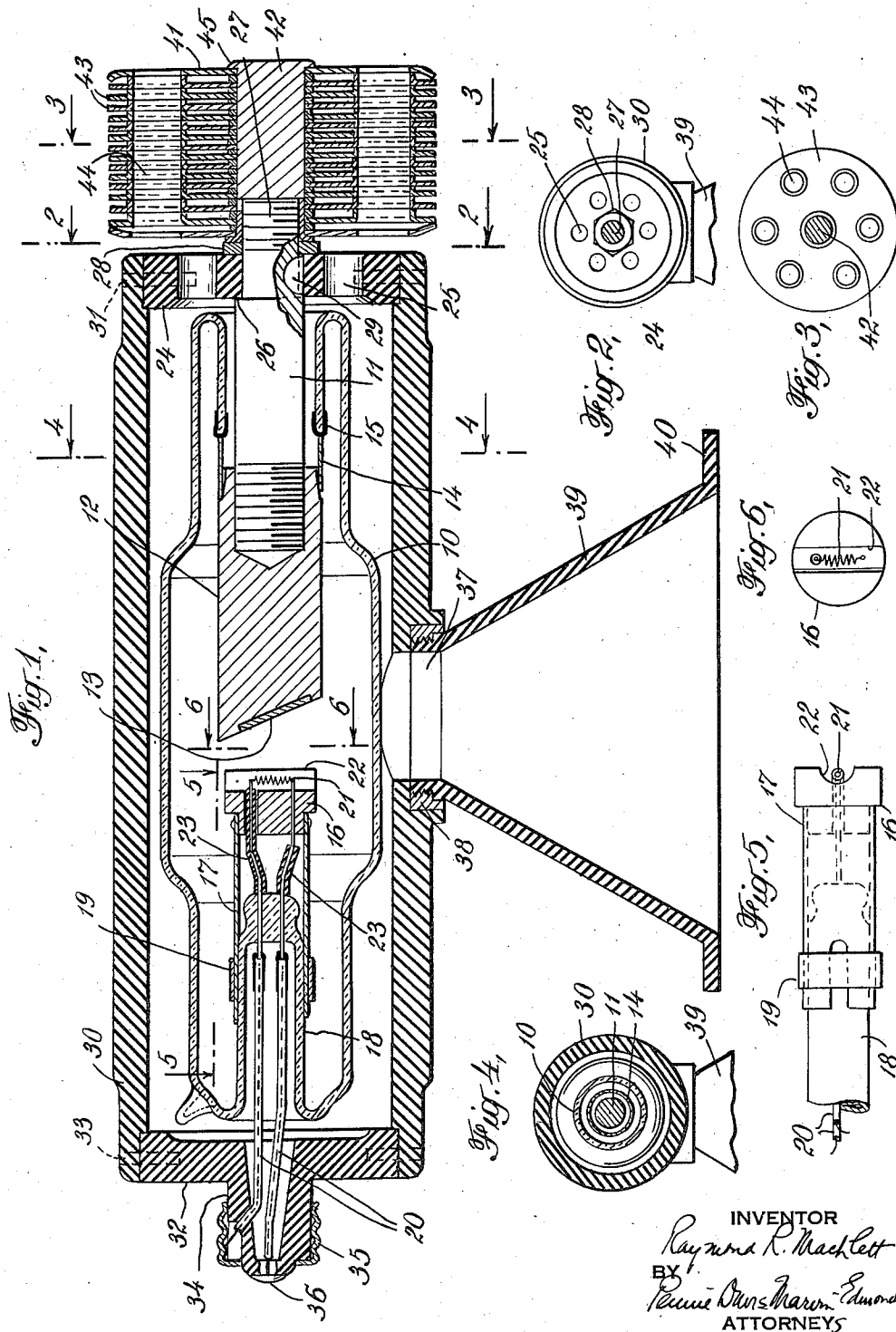
Oct. 4, 1938.

R. R. MACHLETT

2,132,174

X-RAY APPARATUS

Original Filed Dec. 8, 1934



UNITED STATES PATENT OFFICE

2,132,174

X-RAY APPARATUS

Raymond R. Machlett, Scarsdale, N. Y., assignor
to Machlett Laboratories Incorporated, Spring-
dale, Conn., a corporation of Connecticut

Original application December 8, 1934, Serial No.
756,570. Divided and this application Septem-
ber 29, 1936, Serial No. 103,068

6 Claims. (Cl. 250—34)

This invention relates to X-ray apparatus used for radiographic and therapeutic purposes and is concerned more particularly with a new X-ray unit for the uses referred to, which includes an X-ray tube and a ray-proof housing therefor, both of novel construction. The new tube is shorter and more rugged and has higher electrical and cooling ratings than prior tubes of the same general type, and because of these and other features, the X-ray unit may be conveniently installed in a shock-proof enclosure and offers numerous other advantages over prior devices of the same general type.

Radiographic X-ray tubes as heretofore constructed are of great length, such for example, as 22" to 24" overall, and these tubes are supported either by means of the terminal caps or bases used for making the electrical connections or else by their glass necks. With either arrangement, the weight of the metal elements, which are supported in position within the tube by parts sealed in the glass wall, is transmitted through the seals to the tube supports, and the elements must, therefore, be made of relatively light weight, since otherwise their inertia would be so large that the tube would be extremely fragile and would require great care in handling. The use of such light weight elements imposes a limitation upon the electrical and cooling ratings of the tube, but it has not been possible heretofore to employ larger and heavier elements because of the manner in which the tubes are mounted.

In radiographic equipment, it is of the utmost importance to protect the operator and the patient from contact with the high voltage connections, and various expedients have been used for the purpose. In some cases, the tube is placed within a grounded metal shell or enclosure and metal sheathed high voltage cable is used to connect the tube to an existing high voltage aerial system, while, in others, the tube is enclosed in the same housing as the transformer with the connections between the transformer and the tube inside this housing. In some constructions, the tube is insulated by being immersed in oil, and in those forms of equipment in which the enclosure also contains the transformer, the tube may be immersed in the same body of oil as the transformer. In other apparatus, the tube is insulated from the grounded enclosure only by air, and in that event, corona-proof terminals or insulating baffles are required at the ends of the tube to prevent sparking between the terminals and the grounded

enclosure. All these forms of apparatus built for the reception of radiographic X-ray tubes of prior construction are large and bulky because of the great length of the tubes.

When the prior cylindrical X-ray tubes are installed in shock-proof equipment, the shock-proof enclosure is lined with lead to provide protection against the rays and the tube is mounted in the enclosure in holders. These holders have invariably given both mechanical and electrical trouble and it has been frequently impossible to manipulate the long shock-proof enclosure built around the conventional tube on the tube stand.

The present invention is directed to the provision of a new X-ray unit which is capable of operation in air and which overcomes the objections to prior devices, the new unit being much shorter than prior air-operated devices made for operation at the same voltage, and the tube of the new unit being so constructed that the weight of the metal parts within it is not supported by seals through the glass walls. Also by reason of the new construction of the tube, the mounting thereof in the unit is greatly simplified and forms part of an insulating ray-proof housing which can be conveniently installed in a shock-proof enclosure. The anode of the new tube is much shorter and heavier than anodes previously used so that the heat from the focal spot can be dissipated at a rapid rate, and the tube thus has much higher electrical and cooling ratings than prior tubes. In fact, a tube of the new construction and employing only air cooling may have a cooling rating closely approaching those of tubes with water cooling which has been found to be a constant source of trouble in practice.

The new tube includes a glass envelope which preferably has reentrant ends through which the connections to the anode and cathode are sealed, but instead of being provided with the usual terminal caps which are employed to support the tube as well as to make the connections to it, the anode of the new tube is supported from without and in turn supports the envelope and other parts of the tube. For this purpose, the anode is mounted on a rigid rod which extends through an opening at one end of the tube, the anode being sealed to the glass wall, preferably by means of a cylindrical metal member. The rod on which the anode is mounted is in turn supported in a mounting, and thus the only parts of the tube which are supported through the seal are the envelope and the relatively light cathode assembly. When the new tube is mounted in the

ray-proof housing of the invention, the envelope of the tube is entirely out of contact with the housing wall and wholly unsupported thereby, the anode shank passing through a portion of the wall of the housing and being secured rigidly thereto. Because of the small size of the tube, the housing is similarly short and compact and the entire unit may consequently be readily installed in a shock-proof enclosure.

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

Figure 1 is a view of the longitudinal section of the new tube installed in a ray-proof housing; and

Figures 2, 3, 4, 5, and 6 are views on the lines 2—2, 3—3, 4—4, 5—5, and 6—6 of Figure 1.

As shown in the drawing, the tube of the invention is mounted within a ray-proof housing and it includes an envelope preferably having a central enlargement and necks extending therefrom in opposite directions, each neck having a reentrant end portion extending into the neck a substantial distance toward the enlargement. In the construction illustrated, each reentrant end portion projects into the neck at least one half the length of the neck. An anode structure is mounted in the envelope and it includes a rigid conducting member 11 which is preferably a metal rod forming the shank of an anode 12 threaded on the rod and lying within the tube. The anode is of copper and of massive construction as shown, and it is provided with the usual insert 13 of tungsten or like metal set into its end surface and forming a target. The opening through which the rod enters the envelope is sealed by a relatively short sleeve 14 of platinum or other suitable metal, the sleeve encircling the anode and being secured thereto and to the end of the reentrant portion of the neck through which the anode shank extends as indicated at 15.

The cathode 16 of the tube is mounted in the end of a split bushing 17 which fits over the reentrant end portion 18 of the other neck of the envelope and is secured fast thereon by means of a metal sleeve 19. Flexible lead-in wires 20 are sealed through the end wall of the reentrant portion 18 of the neck of the envelope and are connected to the filament 21 which lies in a vertical channel 22 in the face of the cathode. These lead-in wires are enclosed in insulation 23 but a portion of one wire passing through the cathode is bare and in electrical contact therewith.

The anode shank 11 of the new tube is employed as a means both for conducting current to the anode and for supporting the entire tube. For this latter purpose, the shank is attached rigidly to a suitable mounting, and with the shank so supported, the entire weight of the anode, the tube, and the cathode assembly is supported by the shank, and only the weight of the tube and the cathode assembly is transmitted through the seal 15. The weight, thus supported by the seal, is relatively light, and no difficulty is encountered in making a seal, particularly one of the type illustrated and described, which is sufficiently strong to support the tube without requiring extreme care in handling.

The tube is mounted within a ray-proof housing forming part of the invention, with the anode shank passing through and rigidly mounted in the end wall of the housing. This end wall which forms part of the insulating ray-proof housing is preferably a circular plate of ceramic material

having ventilating openings therethrough, and the shank is provided with an annular shoulder 26 which lies in contact with the inner face of the plate. At its end, the shank is threaded as at 27 and a nut 28 on the shank forces the plate 24 against the shoulder. In order to prevent relative rotation of the shank and the end member when the nut is being tightened, the shank is provided with a keyway adjacent the shoulder, a similar keyway is formed in the plate 24, and a key 29 is inserted in these keyways.

With the construction described, it will be apparent that the distance along the anode structure from the target area to the shoulder 26 is fixed and depends only on the machining of the anode shank, rather than upon the accuracy of the glass-blowing operation incident to the manufacture of the tube. Accordingly, the new tubes are uniform in construction, and variations in manufacture which would result in variations in the distance between the target and a fixed part of the tube mounting are largely eliminated.

The mounting member 24 lies within the end of a cylindrical housing member 30 and is held in place therein by pins 31. The other end of the cylindrical member 30 is closed by an end member 32 likewise held in place by pins 33, and the cylindrical member 30 and end member 32 are preferably made of a phenolic condensation product which has been loaded with lead so as to be impervious to X-rays. The end member 32 has a boss 34 extending therefrom upon which is mounted a threaded cap 35 to which one of the lead-in wires 20 is connected. The other lead-in wire is connected to a stud 36 at the end of the boss and out of contact with the cap 35. The cap and stud serve as the usual threaded plug employed for making electrical connections.

The housing member 30 has an opening 37 through which the useful beam from the anode may pass and a metal bushing 38 is seated in this opening and is threaded to receive a portion of a conical shield 39 made of the same material as the housing. This conical shield has a flat circumferential rim 40 by which it may be mounted on a suitable support, and when the housing is thus mounted, the tube is supported entirely by the mounting of the anode shank in the end wall of the housing and the envelope is out of contact with the inner surface of the housing.

In order to radiate heat from the anode, a radiator 41 is mounted on the anode shank beyond the nut 28. This radiator may be of any suitable construction, and, as illustrated, it includes a metal core 42 threaded on the shank and carrying a plurality of thin circular plates 43. Each of these plates is provided with a plurality of openings 44 defined by circumferential flanges and the flanges on one plate contact with the surface of the adjacent plate and thus maintain the plates in proper relation. The series of plates is held on the core between circumferential edge flanges 45 at the ends of the latter. The connection to the anode is made to the core or the plates of the radiator in any convenient manner.

As will be apparent from the description, the new tube is much shorter and more compact than tubes of the prior construction used for the same purpose. For example, a new tube which has a fluoroscope rating of 110 PKV, 5 MA, 10 minutes, may be approximately 9 inches long and somewhat less than 3½ inches in overall diameter, while a housing of the construction illustrated for such a tube has an overall length of about 10% 75

inches from the outer surface of one wall to that of the other and an overall diameter of approximately $3\frac{5}{8}$ inches not including the conical member 39. In prior tubes almost twice the dimensions given are required for proper insulation.

By using the new type of support for the tube, the envelope may be made with reentrant ends so that the desired creepage distance is provided even though the overall length of the tube is less than half of that of prior tubes. The new unit may be employed in a shock-proof enclosure with either air insulation or oil insulation, and since the unit is small and compact, the enclosure is not large or bulky. At the same time, the novel structural features of the tube simplify the mounting in the enclosure and avoid the objections to prior mountings. Supporting the relatively light weight of the envelope and cathode assembly from the anode, which is in turn rigidly supported, not only makes the tube rugged and simplifies the provision of supports therefor, but also permits the use of a heavy anode. Similarly, the use of the threaded anode shank for attachment of the radiator increases the rate of heat conductivity along the anode structure. Such a threaded attachment of the radiator has not been practical in the prior tubes because threading the radiator in place puts a great strain on the metal to glass seal, but in the present tube, that strain is wholly eliminated. The new tube thus represents a great improvement over prior tubes in that it is smaller in all dimensions, is more rugged, and has higher ratings.

While I have described the new unit as operable either in air or in oil as desired, one of its principal advantages is that although it may be operated in air, it is short and compact. These features distinguish it from prior air-operated units with which I am familiar, which are large, bulky, and inconvenient to manipulate.

This application is a division of my copending application Serial No. 756,570, filed December 8, 1934.

I claim:

1. In an X-ray unit, the combination of an air-cooled, air-insulated X-ray tube having an elongated envelope with re-entrant end portions extending inwardly toward the middle of the envelope for a substantial distance to provide a long creepage path, an anode within the envelope having a solid shank projecting outside the envelope and of sufficient cross-sectional area to carry away effectively the heat generated at the focal spot during operation, a cathode within the envelope, and conductors sealed through the envelope wall and connected to the cathode, and a housing enclosing the envelope and wholly spaced therefrom, the housing having a wall at one end through which the shank projects, means on the shank engaging said wall for holding the shank against movement relative to the wall, and exposed terminals on the opposite end wall of the housing to which the conductors are connected, said anode shank and the wall through which it projects constituting the sole support for the envelope and cathode of the tube.

2. In an X-ray unit, the combination of an air-cooled, air-insulated X-ray tube having an elongated envelope with re-entrant end portions extending inwardly toward the middle of the envelope for a substantial distance to provide a long creepage path, an anode within the envelope having a solid shank projecting outside the envelope and of sufficient cross-sectional area to carry away effectively the heat generated at the

focal spot during operation, a cathode within the envelope, and conductors sealed through the envelope wall and connected to the cathode, and a housing enclosing the envelope and wholly spaced therefrom, the housing having a wall of insulating material at one end through which the shank projects, means on the shank engaging the wall and holding the shank against longitudinal and rotational movements relative to the wall, and exposed terminals on the opposite end wall of the housing to which the conductors are connected, said anode shank and the wall through which it projects constituting the sole support for the envelope and cathode of the tube.

3. In an X-ray unit, the combination of an air-cooled, air-insulated X-ray tube having an elongated envelope with re-entrant end portions extending inwardly toward the middle of the envelope for a substantial distance to provide a long creepage path, an anode within the envelope having a solid shank projecting outside the envelope and of sufficient cross-sectional area to carry away effectively the heat generated at the focal spot during operation, a cathode within the envelope, and conductors sealed through the envelope wall and connected to the cathode, and a housing enclosing the envelope and wholly spaced therefrom, the housing having a wall at one end through which the shank projects, the shank having an abutment engaging the inner surface of the wall, means on the shank engaging said wall for holding the shank against movement relative to the wall, and exposed terminals on the opposite end wall of the housing to which the conductors are connected, said anode shank and the wall through which it projects constituting the sole support for the envelope and cathode of the tube.

4. In an X-ray unit, the combination of an air-cooled, air-insulated X-ray tube having an elongated envelope with re-entrant end portions extending inwardly toward the middle of the envelope for a substantial distance to provide a long creepage path, an anode within the envelope having a solid shank projecting outside the envelope and of sufficient cross-sectional area to carry away effectively the heat generated at the focal spot during operation, a cathode within the envelope, and conductors sealed through the envelope wall and connected to the cathode, and a housing enclosing the envelope and wholly spaced therefrom, the housing having a cylindrical body and disc end plates, one of said end plates being of ceramic material and having an opening through which the anode shank projects, means on the shank engaging said end plate for holding the shank against longitudinal and rotational movements relative to the plate, and exposed terminals on the opposite end plate of the housing to which the conductors are connected, said anode shank and the end plate through which it extends constituting the sole support for the envelope and cathode of the tube.

5. In an X-ray unit, the combination of an air-cooled, air-insulated X-ray tube having an elongated envelope with re-entrant end portions extending inwardly toward the middle of the envelope for a substantial distance to provide a long creepage path, an anode within the envelope having a solid shank projecting outside the envelope and of sufficient cross-sectional area to carry away effectively the heat generated at the focal spot during operation, a cathode within the envelope, and conductors sealed through the en-

velope wall and connected to the cathode, and a housing enclosing the envelope and wholly spaced therefrom, the housing having a wall of ceramic material at one end through which the anode
5 shank projects, means on the shank engaging said wall for holding the shank against movement relative to said wall, exposed terminals on the opposite end wall of the housing to which the conductors are connected, and a radiator mount-
10 ed upon the portion of the shank projecting through said wall, said shank and the wall through which it projects constituting the sole support for the envelope and cathode of the tube.

6. In an X-ray unit, the combination of an
15 air-cooled, air-insulated X-ray tube having an elongated envelope with re-entrant end portions extending inwardly toward the middle of the envelope for a substantial distance to provide a long creepage path, an anode within the envelope
20 having a solid shank projecting outside the envelope and of sufficient cross-sectional area to

carry away effectively the heat generated at the focal spot during operation, a cathode within the envelope, and conductors sealed through the envelope wall and connected to the cathode, and a
5 housing enclosing the envelope and wholly spaced therefrom, the housing having a wall of ceramic material at one end through which the shank projects, said shank having an abutment engaging the inner surface of said wall and being
10 threaded beyond said wall, a nut on the threaded portion of the shank engaging the wall for holding the shank with its abutment in contact with the wall, a radiator threaded on the shank beyond the nut, and exposed terminals on the
15 opposite end wall of the housing to which the conductors are connected, said shank and the wall through which it projects constituting the sole support for the envelope and cathode of the tube.

RAYMOND R. MACHLETT. 20