May 24, 1938. H. F. MESICK, JR., ET AL 2,118,413

X-RAY TUBE

Original Filed May 28, 1932 2 Sheets-Sheet 1

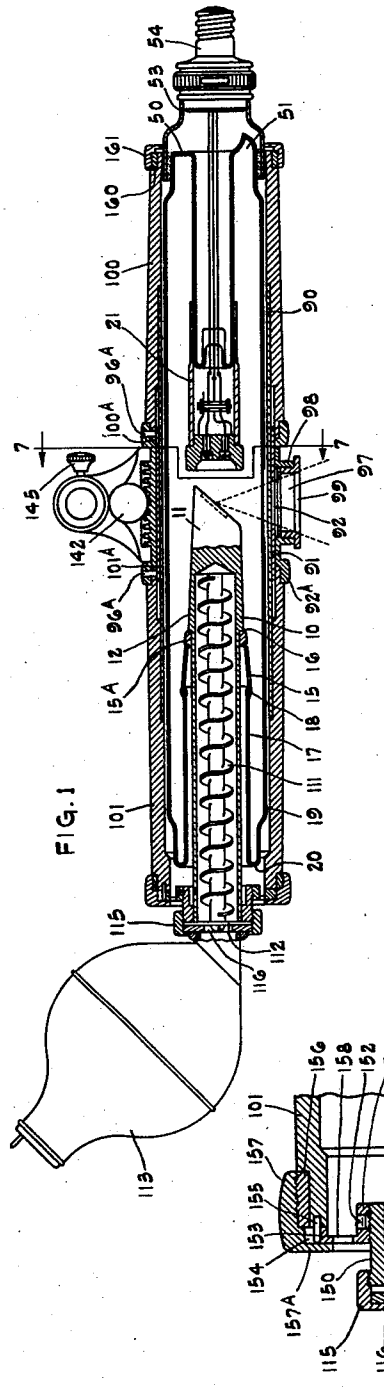


FIG. 1

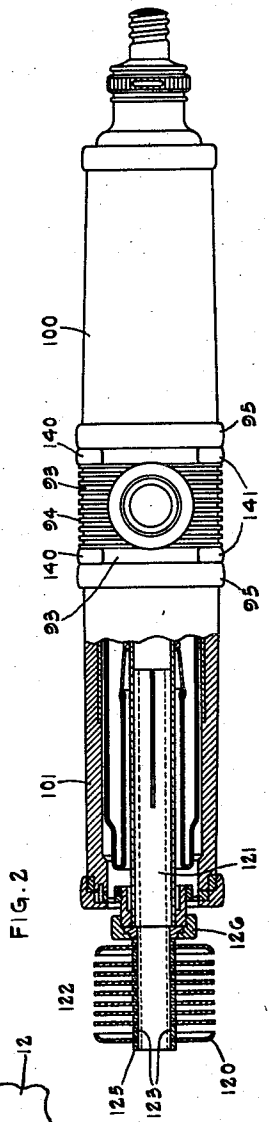


FIG. 2

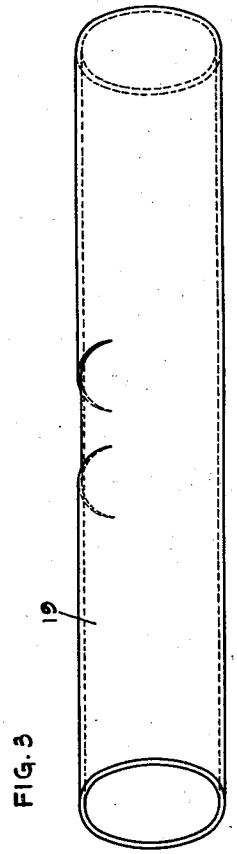


FIG. 3

FIG. 8

HARRY F. MESICK, JR
MALVERN J. GROSS
INVENTORS

BY Clarence M. Hogg

ATTORNEY

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X-RAY TUBE

Original Filed May 28, 1932 2 Sheets-Sheet 2

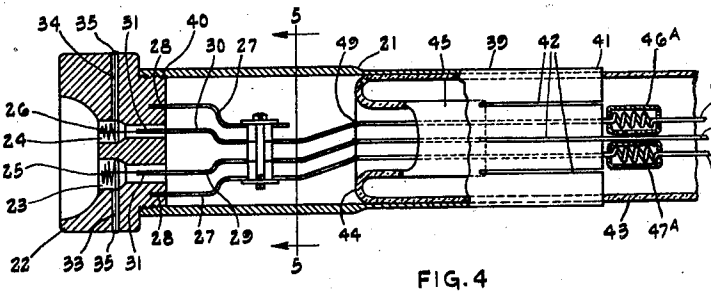


FIG. 4

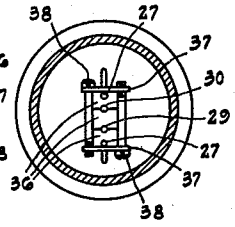


FIG. 5

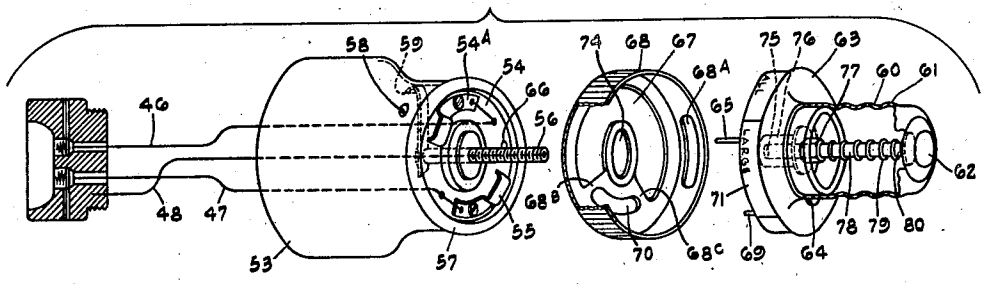


FIG. 6

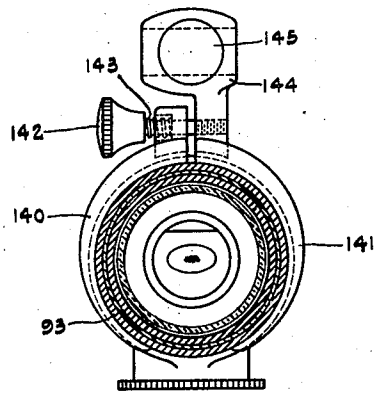


FIG. 7

HARRY F. MESICK, JR.
MALVERN J. GROSS
INVENTORS

BY Allen Wood

ATTORNEY

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UNITED STATES PATENT OFFICE

2,118,413

X-RAY TUBE

Harry F. Mesick, Jr., and Malvern J. Gross, Chicago, Ill., assignors to General Electric X-Ray Corporation, a corporation of New York

Original application May 28, 1932, Serial No. 614,124. Divided and this application July 26, 1934, Serial No. 737,098

15 Claims. (Cl. 250—35)

This invention has to do with an X-ray tube and relates particularly to improvements within such a tube and a casing therefor.

Up to the present time it has been the practice of the manufacturers of X-ray tubes to fabricate external casings for tubes in a manner that such casings are substantially permanently attached thereto as an integral part of the tubes.

Such form of casing has made it necessary for the user of the tube, when the tube was out of order, to send the casing as well as the tube to the manufacturer. Because of indentations or the like accumulated in the casing during use, during shipment, or by damage during its removal from the tube, usually it has been necessary to replace the casing as well as repair or replace the tube. Naturally this type of repair program is both costly and inconvenient, and undesirable from the standpoint of both the user and the manufacturer.

It is an object of the present invention to provide a casing for an X-ray tube easily removed from the tube proper thus making it possible for the tube to be sent to the manufacturer for repair without the casing.

Another object of the present invention is to provide an easily demountable casing for an X-ray tube which casing has means for measurably placing a window therein in fixed relationship with the focal spot or spots upon the anode of the tube.

Another object of the present invention is to provide for an X-ray tube, a casing having a window with a lead jacket adjacent thereto to absorb all but the useful cone of X-rays, there being insulating sleeves impregnated with a salt of a metal of high molecular weight extending from the lead jacket as an additional protection from other than the useful X-rays.

Still another object of the present invention is to provide a casing for an X-ray tube and having means for an adjustable mounting of the tube.

Another object of the present invention is to provide a casing for an X-ray tube and to which may be attached either a water reservoir or a cooler of the radiator type for the purpose of cooling the tube anode.

Another object of the present invention is to provide a casing for an X-ray tube and from which the tube is capable of delivering X-rays of a relatively low penetrating power.

Another object of the present invention is to provide a cathode in an X-ray tube having a multiplicity of filaments suitable for independent energization whereby different intensities and fields of usefulness may be obtained.

Another object of the present invention is the provision within the structure of a casing for an X-ray tube, of means for insulating from exposed metallic parts of the tube and casing the electrical charges which accumulate upon the tube walls.

Still another object of the present invention is to provide within the structure of a detachable X-ray tube casing a sleeve of high dielectric strength and of low X-ray absorption qualities whereby to insulate any metallic supporting means from the tube and to permit of the ready passage of the useful field of X-rays therethrough without an aperture being formed in the casing.

Other objects of the present invention are the provision of:

A metallic supporting member within a casing for an X-ray tube and having flanges for the radiation of heat as a means for prolonging the useful period of an insulating sleeve in heat conductive relation thereto.

An anode of novel coniform structure especially adapted for use in X-ray tubes of the truly cylindrical type.

Means interposed within the filament circuits of an X-ray tube for standardizing filament excitation characteristics.

An electrical conductive sleeve within the structure of a casing for an X-ray tube for distributing electrical charges inherently accumulated by such a tube and for improving the operation of the tube.

These, and other desirable objects which are obtained by the novel construction, unique arrangement, and improved combination of the parts comprising the invention, will be made apparent in the following description when read in conjunction with the accompanying drawings, hereby made a part of this specification, disclosing one embodiment of the invention, and wherein like reference characters indicate similar parts and in which:—

Figure 1 is a longitudinal section of an X-ray tube and casing incorporating the invention, the tube having water cooling means;

Figure 2 is an elevation, partly in longitudinal section, of a tube similar to that shown in Figure 1 but with air cooling;

Figure 3 is a perspective view of the glass portion of a tube to be enclosed by the casings illustrated in Figures 1 and 2;

Figure 4 is an enlarged sectional view of the

cathode end of an X-ray tube showing in detail parts of the structure;

Figure 5 is a sectional view of an X-ray tube incorporating the invention and taken on the line 5—5 of Figure 4;

Figure 6 is a perspective view of the unassembled parts comprising the cathode end of the tube;

Figure 7 is a diametric section of a tube taken on the broken line 7—7 of Figure 1; and

Figure 8 is an enlarged fragmentary sectional view of the tube casing shown in Figures 1 and 2.

This application is a division of an application of Harry F. Mesick, Jr., and Malvern J. Gross, filed on May 28, 1932 and designated as Serial No. 614,124.

Attention is first directed to Figures 1 and 2 and particularly to an anode 10 having a stem provided with a head 11 at the inner end of a hollow shank 12. Upon the diagonal face of the head 11 is the usual tungsten target, shown in dotted lines.

A sleeve 15, preferably made of nickel steel, is copper brazed or otherwise suitably secured to an auxiliary ring 15*a* which is soldered or otherwise attached to the anode as indicated at 16. The left end of the sleeve 15, Figure 1, is turned down and a glass cylinder 17 is attached at 18, in accordance with modern practice. The anode and cylinder 17 are then sealed into a cylindrical outer tube 19, shown in perspective in Figure 3, the seal being indicated at 20.

Ring 15*a* is preferably made of steel, but any metal which can be brazed and soldered may be substituted therefor. The sleeve 15 is an alloy of steel and nickel, with approximately 42 per cent nickel. If this sleeve 15 be secured directly to the copper anode by silver-copper solder, the sleeve is attacked by the solder when heated to high temperatures. Small cracks are thereby effected in the sleeve where this solder of high melting point comes in contact therewith. Consequently, a tube so constructed is defective due to these cracks and soon becomes useless.

When solder of a lower melting temperature is used, the zinc or similar metal which forms a part of the solder distills at the operating temperature of the anode and collects upon the glass walls of the tube in the form of a thin metal coating to affect the operating characteristics of the tube. The steel ring 15*a* is not attacked by the silver-copper solder and thus provides a serviceable coupling between the sleeve 15 and the solder of high melting point, the latter not having the tendency to vaporize, due to the absence of zinc or similar material, as does a solder of lower melting point. There is no action, therefore, to form a deposit upon the tube walls. The structure thus described permits the use of a solder of high melting point which permits the anode to be run at higher temperature thus increasing the normal energy capacity of the tube. Consequently, since the solder does not come into contact with the nickel-steel sleeve 15, the objectionable formation of cracks in the sleeve is precluded.

One of the requirements within the structure of an X-ray tube for prolonging its life and stabilizing its operating characteristics is the provision of a greater distance between the walls of the tube adjacent to the bombarded end of the anode than at a position near the supported end thereof. This structure is to prevent stray and reflected electrons from the anode from getting back onto the glass in the anode arm thereby unbalancing the voltage distribution along the glass and causing excessive bombardment thereof, with the resultant heat and fluorescence of the glass. The conventional glass shell for an X-ray tube has an enlarged portion about the bombarded end of the anode to meet this desired requirement.

In the case of the present tube which has a truly cylindrical wall, the shape of the anode 10 is altered to provide the desired space relationship between the anode and the wall. It will be observed in Figure 1 that the anode 10 increases in diameter as the point of seal with the ring 15*a* is approached from the extended end of the head 11.

This tapering configuration of the anode makes the present form of tube with the cylindrical wall equivalent in operation and life to that of the more complicated form of wall with an enlarged central portion. Even if a cylindrical tube, which is made as effective as the ordinary shaped tube by the tapering of the anode, was not especially desirable because adaptable to a removable sleeve casing to be described later in this specification, the cylindrical tube has still another advantage of being less unwieldly than the ordinary tube.

A cathode 21, shown in detail in Figures 4 and 5 consists of a focusing cup 22 having two apertures 23 and 24. Two leads 27, preferably of molybdenum, are screwed into tapered holes 28 in the base of cup 22. The filaments 25 and 26 are attached to center leads 29 and 30, respectively, in any desired fashion as by binding with wire 31 and arc welding. The outer ends of the filaments extend as leads 33 and 34 and are carried through holes in the focusing cup and attached to the outer edge of the focusing cup as indicated at 35. Nickel brazing has proven to be a satisfactory method of making the connection at 35. The two center leads 29 and 30 are suspended by the support leads 27 and are held in insulated spaced relationship by means of insulator blocks 36.

The blocks 36 are held together by means of the clamps 37 and lock screws 38 (see Figure 5). A sleeve 39 for supporting the cathode is attached at one end to the cathode cup 22 by means of screw threads 40. The other end 41 of the sleeve is provided with slits 42 and is reduced in thickness so that it may yieldingly engage the glass cylinder 43 for support.

Attached to the glass cylinder 43 and sealed thereto, as at 44, so as to extend therewithin is a pinch seal 45, sealing three wires 46, 47, and 48 in a manner well known in the art. One end of the wire 46 is attached to the free end of the wire 30, preferably by spot welding, as shown at 49. In the same fashion the free ends of the wires 27 and 29 are attached to wires 48 and 47.

Interposed between sections of the wires 46 and 48 are two standardizing resistances 46*a* and 47*a* which may be made in any desired fashion as by using coils of resistance wires suitably insulated. In the particular construction illustrated, the resistances 46*a* and 47*a* are open coils of relatively stiff resistance wire such as an alloy nickel and chromium and are covered by a glass tube. These coils 46*a* and 47*a* are used to compensate for inherent differences in different types of cathode filaments to permit their excitation from a source of power of standard characteristics.

A definite order of operation is followed in the assembly of the cathode. The two filaments after

being roughly positioned are accurately adjusted by means of a depth gauge and the screws 38 locked up tightly to keep them in a selected position. After this, joints 49 are made and the sleeve 41 is screwed into place on the focusing cup 22, the focusing cup being held stationary and the sleeve 39 revolved until the desired position is obtained. The cathode structure is then sealed into the cylinder 19 at circular joinder 50. At this end, a protruding section 51 is formed pursuant to the process of evacuating the tube.

After having been given certain tests, the tube, as assembled to this stage, is supplied with a cap 53 on its cathode end. The cap 53 is attached to the glass in any desired manner, as by means of litharge and glycerin, by plaster of Paris, or by a "Bakelite" compound.

Attached to the cap 53 is a selector switch 54 shown more in detail in Figure 6. The three leads 46, 47, and 48 are carried back to this selector switch to make contact respectively with contact 54*a*, contact 55 and center stud 56, the latter named parts being carried by an insulating disc 57.

The disc 57 is secured to the sleeve 53 by a plurality of screws 58. Center stud 56 is electrically connected to the sleeve 53 by means of a contact strip 59 shown in dotted outline. The contact 59 is for the purpose only of preventing static discharges from the stud 56 and across the edge of the insulating disc 57 to the sleeve 53. A cup-shaped contact member 68 serves as a medium for connecting either spring 54*a* or spring 55 to one side of the circuit for energizing the filament in the manner hereinafter described.

The circuit for energizing the filament is connected to the X-ray tube by means of a plug 60. One side of the circuit is carried on a shell 61 and the other side is carried by a center contact 62. The shell 61 is mechanically and electrically connected to a metal disc 63 (an electrical conductor), by means of screws 64. This metal disc 63 carries an indexing stud 65 which engages a hole 66 in the dielectric disc 57 for the purpose of holding discs 63 and 57 in a selected fixed relationship.

Stud 65 passes through an aperture 67 in a contact member 68. A second stud 69 projects into a slot 70 to limit the rotative movement of the contact cup 68 to the curvilinear dimensions of the slot 70. When the members 63 and 68 are in assembled position contact is made between the inner surface of the member 68 and the surface 71 of the member 63.

The contact member 68 is then at the same potential as the side of the electric circuit connected to the shell 61, and when it is in a position so that stud 69 is at one end of the slot 70, it electrically connects the shell 61 to the contact 55. When in the other position, it connects the shell to the contact 54*a* and hence to the inner end of filaments 25 or 26 by means of the wires 46 and 47.

The outer ends of the filaments are grounded to the cup 22 and thus are electrically connected to the support wires 27 and the lead 48 which is connected to center stud 56 as previously described. The stud 56 passes through a hole 74 in the contact plate 68 and through a center hole 75 in the disc 63 from which it is insulated by means of an insulating bushing 76. A nut 77 coacts with threads upon the stud 56 and the end of the bushing 76 to hold the disc 63 in assembly with the cap 53. Nut 77 is provided with a boss 78 onto which contact spring 79 seats. The other end of spring 79 is attached about a boss 80, which forms a part of the center contact 62. In this manner, the electric circuit is completed from stud 56 to contact 62 to form the return circuit from the outer ends of both filaments.

After the sleeve 53 has been attached to the end of the cylindrical tube, the wires 46, 47, and 48 are drawn through suitable apertures in the insulating disc 57 and secured respectively to the contacts 54*a* and 55 and to the center stud 56. When the plug 60 is screwed into a proper socket for supplying electrical energy to the tube, the metal cup 68 will be at one potential and the center stud 56, the focusing cup 22, the filaments 25 and 26, and the contacts 54*a* and 55 will be at a potential different than that of the cup 68.

In the flange of the member 68 is an oblong aperture 68*a* through which indicating figures upon the periphery of the disc 63 may be viewed. By turning the cup 68 in a clockwise direction with reference from the cathode end of the tube, and as limited by the pin 69 abutting an end of the aperture 70, the piece 68*b* within the cup 68 will be carried into contact with the electrode 54*a* to close the electric circuit through the filament 26. Concurrently the aperture 68*a* is carried over the indicia upon the periphery of the disc 63 corresponding to the energized filament. To energize the filament 25, the cup 68 is rotated in the opposite direction to place the piece 68*c* against the contact 55. The aperture 68*a* is at this time over a different indicia denoting the energized filament.

To the outer end of the anode 10 is securely anchored a collar 150. The threaded shoulder 150*a* projects longitudinally of the tube from the collar 150. A second and complemental collar 151 screws upon the threaded shoulder 150*a*. The collar 151 is drilled and tapped for receiving a set screw 152. There is a flange 153 projecting from the collar 151 provided with a radial slot 154 and apertures 158.

The description up to this point covers the vacuum tube proper and the parts permanently attached thereto. Where tube replacements are necessary, the outer casing, now to be described is retained by the user and only the above described parts are sent to the manufacturer for repair.

If a tube is beyond the state of practical repair, an entirely new tube may be obtained by the owner of the worn out tube to fit into the outer sleeve or casing which he still possesses. In this way, i. e., by the use of interchangeable and replaceable vacuum tubes in a single outer casing, the cost of replacements is substantially reduced, as only one portion of the assembly need be replaced, the other portion of the assembly being retained by the user.

The casing proper consists of an insulating sleeve 90, which is immediately about the center of the glass cylinder 19. Sleeve 90 can be made of any desired insulating material having low X-ray absorption. It has been found that a phenol condensation product is a suitable insulating material. This sleeve is a very imporant part of the casing as will be made apparent from a subsequent disclosure of its functions. About the sleeve is secured a lead protective cylinder 91 suitably apertured to permit of the passage of a useful beam of X-rays, as indicated by the diverging lines in Figure 1.

The lead sleeve 91 can be secured to the insu-

lating sleeve 90 in any desired fashion as by means of an insulating varnish. A metallic member 92a surrounds the sleeve 91 and is secured to it by insulating varnish or other suitable material. The member 92a includes a sleeve 93, the center portion of which is ribbed as shown at 94 for a purpose to be later described. Said central member 93 has two flanges 95.

A passage for the useful beam of X-rays is provided by a window aperture 97 bounded by an internally threaded cylinder 98 into which various devices, such as diaphragms, and the like, may be secured by a nut 99. It will be noted that there is no window in the sleeve 90.

Two tapered insulating sleeves or sections, 100 and 101, are suitably chamfered and notched to fit snugly over the sleeves 90 and 91 and beneath the respective flanges 95. Pins 96a anchored within the flanges 95 project into notches 100a and 101a within the ends of the sections 100 and 101 so that the sections will be definitely arranged axially with reference to the window 97. An insulating varnish or shellac may be used for attaching the sleeves 100 and 101 to the sleeves 90 and 91 to assist the tight fit used to hold the parts in place.

The sections 100 and 101 are made of an insulating material, such as a phenol condensation product, glass, hard rubber, or a similar product which has been impregnated with a salt of high molecular weight for the purpose of rendering the combination impervious to the passage of indirect X-rays from within the tube.

Projecting from the end of the piece 101 is a pin 155 which is to be seated within the notch 154 of the flange 153. A threaded band 156 encircles the end of the sleeve 101 to be securely fixed thereto. A ring 157 is threaded to screw upon the band 156 to draw the casing toward the anode end of the tube. There is a flange 157a integral with the ring 157. The flange 157a is forced against the flange 153 so that the casing will be displaced along the tube instead of the ring 157 being so displaced while it is being screwed upon the band or threaded ring 156.

Mounted on the end of sleeve 100 is a ring 160 provided with threads for the advancement of a flanged collar 161 thereon. The flange upon the collar 161 is free to slide upon the cap 53 but is arranged to fit closely enough to said cap to prevent lateral movement between the two members.

In the manufacture of the tube proper which includes the anode, cathode, the glass cylinder 19, the cap 53 and switch assembly attached thereto, the collar 150 and the index ring 151, it is not always possible to make the cylinder 19 of exact standard length. Variation occurs where the end of the tube is sealed off at 51. Therefore, it becomes necessary to make the means for attaching the casing and tube one to another of an adjustable nature for the casing is of a standard size and length.

The anode and cathode are set within the tube with the cathode filament and the target 13 of the anode in a definite standard spaced relationship with reference to each other. Later, the cap 53, collar 150 and ring 151 are set upon the ends of the tube. The ring 151 is advanced upon the collar 150 until its innner face is a selected distance from the anode target.

The ring 151, in addition to being spaced at a definite predetermined distance from the anode target, is also selectively alined with the anode axially. Tightening the set screw 152 insures the maintenance of the desired position of the ring 151. The ring as held by the set screw 152 is in such a position that the pin 155 when inserted into the slot 154 will position the window 97 of the casing in radial alinement with the useful field of X-rays as deflected from the anode target.

The sleeves 93, 100 and 101 are of a standard length and the notches 100a and 101a are of a depth to receive the pins 96a in a manner allowing the ends of the outer sleeves to abut solidly against the ends of the intermediate sleeve 93. It follows that the overall longitudinal dimension of the casing is definitely fixed. There is no telescopic motion relative any of the parts forming the casing. Instead, the casing is a rigid accurately fabricated member.

There is a standard known distance between the left end of the sleeve 101, Figure 1, and the center of the window 97. The collar 151 is advanced upon the collar 150 until the distance between the inner face of the flange 153 and the center of the anode target is equal to the distance between the left end of the sleeve 101 and the center of the window 97. By screwing the flanged ring 157 to draw the said end of the sleeve 101 against the inner face of the flange 153 with the pin 155 seated in the notch 154, the window 97 will be squarely alined with the conical X-ray field to emanate from the target 13.

Adjustment to accommodate the slight discrepancy in tube lengths is had at the cathode end of the tube after the casing has been thus accurately fitted to the tube from the anode end. It will be recalled that the flanged ring 161 slidingly engages the cap 53. The ring, therefore, can with equal efficacy engage the cap at any section along the part of greater diameter. Never is there such a disparity of dimensions in the tube that the ring 161 will fail to register some place upon the enlarged section of the cap 53.

An examination of the flange 153 will reveal that said flange has a thinned section. The material of the flange 153 is resilient so that there may be a slight axial movement of the tube relative to the casing, the cap 53 being free to slide within the flanged ring 161 to accommodate such a movement. This flexible mounting for the tube is added protection therefor, and cushions the effect of any accidental blows which might without such cushioning be detrimental to the tube.

In the above described manner, a certain and simple method is provided for the assembly of a vacuum tube in the casing and for the alinement of the focal spot, both axially and radially of the casing for the passage of useful X-rays through an opening in the outer casing, in combination with cushioning means for absorbing shocks due to rough handling. Apertures 158 provide for ventilation within the casing and assist to cool the tube.

The simplicity of the casing makes it practical for a user to retain an outer casing in the event of damage to the vacuum tube and for the manufacturer of the tube to ship to the user for replacement only a vacuum tube. Hence, a highly economical and practical method of tube repair is possible.

To further provide a greater possible flexibility of the present X-ray tube the anode has been designed so that it can be cooled either by water or air at the option of the user. As noted, the anode of the tube is hollow and projects beyond the end of the casing. The collar 150 is

threaded near its outer end to render it applicable for the coupling thereto of a cooling unit.

When the anode is to be cooled by means of water, the connections are made as shown in Figures 1 and 8, in which the member **111** is a baffle the operation of which is more fully described in Letters Patent of the United States No. 1,972,414, issued September 4, 1934, in response to the application of Jesse L. Worden for patent on "Electron discharge device", Serial No. 571,701. The baffle is held in position by means of a multi-apertured plate **112**, which commonly abuts the end of the anode and the collar **150**. The water reservoir **113** is attached by means of a free running nut **115** which engages the flange **116** thereon and the threads on the member **150**.

The operation of the cooler is based on the natural circulation of heated water in a system of this type.

A radiator device for use when the tube is to be air cooled is illustrated in Figure 2. The radiator consists of a stud **121** which is slidably engaged within the hollow cylindrical tube **12** and a plurality of fins **122** held apart by washers **123**. The washers **123** and fins **122** are held in assembly by means of a ring **125** which may be pressed or screwed onto the stud **121**. A free running nut **126** is also provided for securing the radiator, just described, in position, or for acting as a thrust device for removing the radiator from the anode recess.

Surrounding the metal cylinder **93** is a clamping device illustrated more particularly in Figure 7. This device consists of pairs of spaced fingers **140** and **141**.

The fingers rest in the circumferential grooves in the casing so that a tube may be rotated axially as desired. A lock screw **142** provided with a spring washer **143** locks the clamping fingers to the casing. The fingers **141** extend from a common shank **144** by means of which the tube appurtenances are adapted to be supported on any standard frame apparatus. A lock nut **145** may be employed for locking the tube in any desired position of support.

Hereinabove, the physical properties of the insulating sleeve **90** have been set forth. The following part of this description relates to the application of those properties.

Due to the electron discharge from the cathode filaments in an X-ray tube, there is a negative electric charge gradually accumulated upon the inner wall of the glass tube **19**. Most of the electrons are attracted to the positively charged anode. A portion of the electrons, however, are deflected in the same manner as the X-rays and strike the tube wall adjacent to the window **97**. Such deflected electrons and other electrons, emitted directly from the cathode filaments, collect upon the inner tube wall at the central section to there build up a negative charge. This charge approaches the potential of the cathode and is slowly dissipated along the walls of the glass tube to the anode. While the inner surface of the wall of the tube is so charged, if the adjacent outer wall surface be accidentally contacted or approached by an object not charged, or one positively charged, there is danger of puncturing the tube wall **19** by an electric discharge to such object.

The insulating material **90** extends entirely over the area of the tube wall which is likely to be reached by an appreciable negative potential. Since the sleeve **90** covers the tube at the window **97** there can be no contact with the tube with a foreign object by way of the window. The type of insulation used at present in the sleeve **90** is but one-eighth as averse to the passage of X-rays as is the same thickness of glass comprising the tube wall. The dielectric strength of the material of the sleeve **90** is greater than that of glass so that said sleeve may be of such a thin structure as not to appreciably affect the intensity of the X-ray field and at the same time provide ample insulating protection for the tube.

In addition to providing protection to the tube wall, the insulating sleeve **90** reduces the likelihood of an operator of a tube receiving an electric shock. The negative charge accumulated upon the inner side of the tube wall gradually penetrates the tube wall to reach the outer surface. Should anyone come in contact with the charged outer wall he would suffer an unpleasant sensation, to say the least, and might be caused to do an unintentional injurious act because of a sudden nervous reaction due to the shock.

The sleeve **91** is three-fold functional. This sleeve absorbs the X-ray beam in directions other than that in which the useful X-rays flow. Another important part played by sleeve **91** has to do with minimizing the danger of electric shock. The sleeve **91** is used in conjunction with the insulating sleeve **90**, the latter being for insulating electric charges from the sleeve. Sleeve **91** may be grounded to further insure that there will be no accumulation of an electric charge thereon.

The third function of the sleeve **91** is to act as a condenser plate in combination with electric charges which collect upon the glass tube wall. Without the presence of the sleeve **91** there is a steep voltage gradient over that narrow portion of the glass tube wall between the anode and the cathode. In effect there are two condensers, one condenser being formed between the anode electrode and the glass wall opposite to the anode as condenser plates, and the other condenser being effected by the cathode electrode and the glass wall opposite thereto as condenser plates. Because of the insulating character of the glass wall, there is an appreciable capacity between the two above-mentioned portions of the glass wall serving as parts of the two different condensers, so that the said wall portions may acquire quite different potentials. Especially is there an appreciable voltage built up between the two condenser portions of the glass wall when the tube is operated by an unrectified alternating voltage.

As a result of the two potentials being built up upon the tube wall at wall sections opposite to the anode and cathode, respectively, there is an electrical surface leakage across that section of the tube wall intermediate the two charged portions. Such surface leakage is both audible and visible. Operation of the tube is effected more pronouncedly if there is a slight deposit of tungsten, copper, or some other material on the glass wall. With such a deposit on the tube wall, the likeliness of audible flashing and resulting surging of the tube is augmented.

Introduction of the sleeve **91** gives an appreciable capacity coupling between the above mentioned condenser portions of the glass wall, and therefore reduces the voltage difference between them and has a tendency to evenly spread the charges over the wall. The audible and visible sparking along the glass wall is substantially eliminated by the use of the lead sleeve **91** within the tube casing and the maximum voltage at

which the tube can be operated is substantially increased.

Grounding of the sleeve **91** is conveniently accomplished by an electrical connection between said sleeve and the sleeve **93**. The clamping and supporting device comprising metallic fingers **140** may complete the ground circuit. With the X-ray tube so insulated and grounded with the clamping and supporting devices there can be no injury either to the tube or to an operator thereof because of the electric charges inherent to such a tube.

What is claimed as new and is desired to be secured by Letters Patent of the United States is:

1. In an X-ray tube, an anode, a glass support for said anode, a cup shaped sleeve sealed to said glass support, and a metal ring having a cross section thick in relation to said sleeve and brazed thereto, said ring being soldered to said anode with solder having a relatively high melting point.

2. An X-ray tube comprising an envelope having a cathode and an anode therein, said anode comprising a stem having a longitudinal recess therein greater in longitudinal extent than one-half the length of the stem and opening directly to the atmosphere, and a threaded collar on the outer end of said anode, in combination with a heat radiating device having a stud adapted to be fitted into said recess at one end and having radiating fins at its other end, said radiating device being adapted to be secured to the tube by telescoping said stud into the recess in said anode, a collar on said stud, and a free running nut about said stud and said collar and adapted to cooperate with said threaded portion and said collar to hold said stud in place.

3. An X-ray tube comprising an envelope, an anode in one end of the envelope, a cathode in the other end of the envelope, a cap at the cathode end of said envelope, said cathode comprising a cup having a plurality of recesses therein, a filament substantially within each of the recesses in said cup, conduits to said filaments, and a selective switch within said cap at the cathode end of said envelope and in electrical connection with said filament conduits to close the circuits to one or another of said filaments.

4. The device described in claim 3, and in which said filament conduits to said switch include selected resistances.

5. An X-ray tube having a reentrant glass support for an anode, a cup shaped sleeve of nickel steel sealed to said glass support, a ring of steel brazed to said sleeve, and a copper anode, said ring of steel being attached to said anode with solder of high melting point.

6. In an X-ray tube comprising a glass envelope having a cathode and an anode therein, said envelope having a re-entrant anode-carrying portion of glass, a cup-shaped sleeve sealed to said glass anode support, a metal ring having a cross-section relatively thick with respect to said sleeve and brazed thereto, solder, having a relatively high melting temperature, securing said ring to said anode, said anode comprising a stem extending within said re-entrant anode supporting portion of the envelope and having a longitudinal recess in said anode opening outwardly of said envelope and extending in said anode inwardly beyond the point at which the ring is attached on the anode, a collar on said anode outwardly of said re-entrant envelope portion, and means secured in said longitudinal recess by said collar for dissipating heat from the anode when the tube is in operation, said means serving to dissipate heat at a rate sufficient to maintain the anode and the ring soldered thereon at a temperature below the melting temperature of said solder.

7. In an X-ray tube comprising a glass envelope having a cathode and an anode therein, said envelope having a re-entrant anode-carrying portion of glass, a cup-shaped sleeve sealed to said glass anode support, a metal ring having a cross-section relatively thick with respect to said sleeve and brazed thereto, solder, having a relatively high melting temperature, securing said ring to said anode, said anode comprising a stem extending within said re-entrant anode supporting portion of the envelope and having a longitudinal recess in said anode opening outwardly of said envelope and extending in said anode inwardly beyond the point at which the ring is attached on the anode, and means secured in said recess for dissipating heat from the anode outwardly of said envelope at a rate sufficient to maintain the temperature of the anode, during the operation of the tube, substantially below the melting temperature of said solder.

8. An X-ray tube comprising a cylindrical envelope having an anode arm, an anode disposed within and spaced from the walls of said envelope and having a target at its end, a sleeve encircling a portion of said anode, means for sealing said sleeve to said anode and to said envelope, said anode comprising a stem increasing in diameter at and in a direction away from said target end of the anode to a point adjacent said sleeve whereby to minimize the number of stray or reflected electrons reaching the envelope portions in the anode arm during operation of the tubes and thereby unbalancing the voltage distribution of said envelope.

9. An X-ray tube comprising a cylindrical envelope providing an X-ray transmitting portion and an anode-receiving arm portion, said envelope being of uniform internal diameter in the arm and transmitting portion, an anode disposed within said arm and having a target in its end opposite said transmitting portion, said anode comprising a stem increasing in diameter from the target end thereof in order to reduce the number of stray electrons reaching the envelope portions in the anode arm during the operation of the tube.

10. An X-ray tube comprising a cylindrical envelope providing an X-ray transmitting portion and an anode-receiving arm forming a continuation of said transmitting portion, said envelope being of uniform internal diameter in said transmitting portion and the adjacent arm, an anode disposed within said arm and having an end forming a target disposed opposite said transmitting portion of the envelope, said anode comprising a conical stem having walls diverging toward the walls of said envelope away from the target end of the anode.

11. In an X-ray tube, a cylindrical glass envelope, a metallic anode, means for sealing the anode to the glass envelope, said anode having a target portion at one end and a stem portion extending therefrom, said stem portion being of minimum diameter at said target end portion and increasing in diameter from said end to said sealing means.

12. In an X-ray tube, a cylindrical glass envelope, a metallic anode, a metallic sleeve encircling a portion of said anode, means for sealing said sleeve to said anode and to said glass envelope, said anode comprising a target por-

tion at one end and a stem portion having a longitudinal recess extending from said target end portion, said stem portion being of minimum external diameter at said target end portion and gradually increasing in external diameter from said end portion to said sealing means.

13. In an X-ray tube, a cylindrical envelope, an anode axially disposed in said envelope, a sleeve encircling said anode, means for sealing said sleeve to said anode and to said glass envelope, said anode having a target end portion substantially equi-distant from the ends of said envelope and a stem portion, said stem portion being of minimum diameter at said target end portion and gradually increasing in diameter from said end portion to said sleeve.

14. In an X-ray tube having a plurality of cathodes, an envelope, a cap member mounted on the cathode end of said envelope, an insulating member secured to the outer end of said cap, angularly spaced contacts carried by said insulating member and connected to said cathodes, a terminal member non-rotatively secured to said insulating member and having a plurality of contact members adapted to be connected to a source of electric supply, a controlling member rotatively mounted between said terminal member and said insulating member for selectively connecting said last mentioned contact members to said spaced contacts.

15. In the combination of claim 14 wherein said terminal member comprises an outer end portion forming an electric plug for receiving said contact members and connecting the same to a source of supply and a cylindrical portion at its inner end, said cylindrical portion having indicia representative of each of said cathodes and said controlling member having an annular flange rotatably journaled on said cylindrical portion, said annular flange having a slot for permitting inspection of said indicia to determine which cathode is energized at a particular instant.

HARRY F. MESICK, JR.
MALVERN J. GROSS.