Dec. 28, 1937. H. F. MESICK, JR., ET AL 2,103,335

X-RAY TUBE

Filed May 28, 1932 2 Sheets-Sheet 1

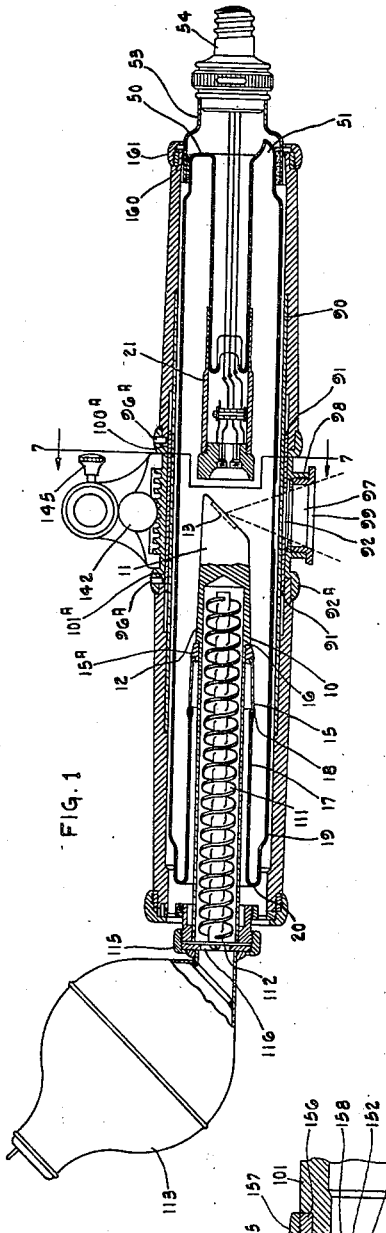

FIG. 1

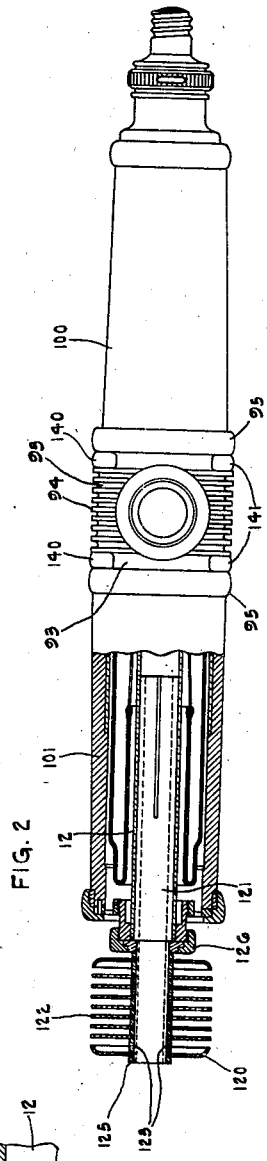

FIG. 2

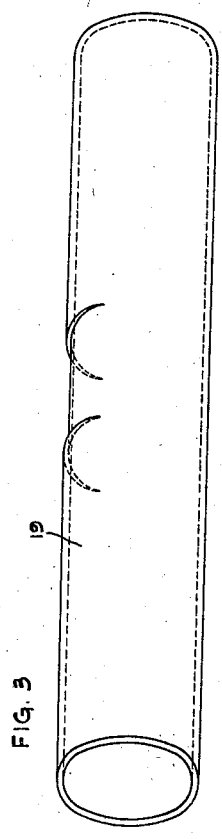

FIG. 3

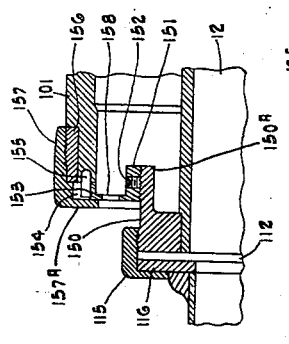

FIG. 8

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X-RAY TUBE

Filed May 28, 1932 2 Sheets-Sheet 2

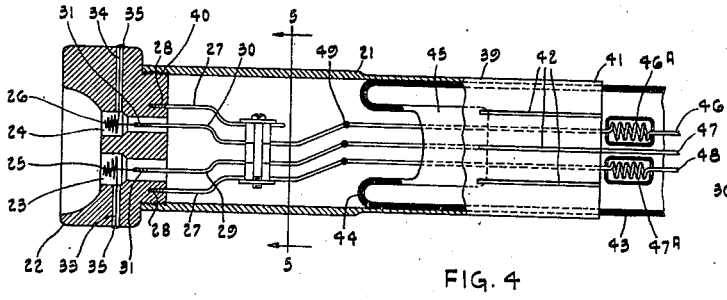

FIG. 4

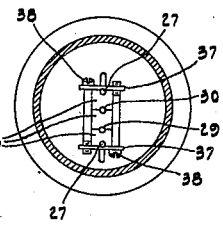

FIG. 5

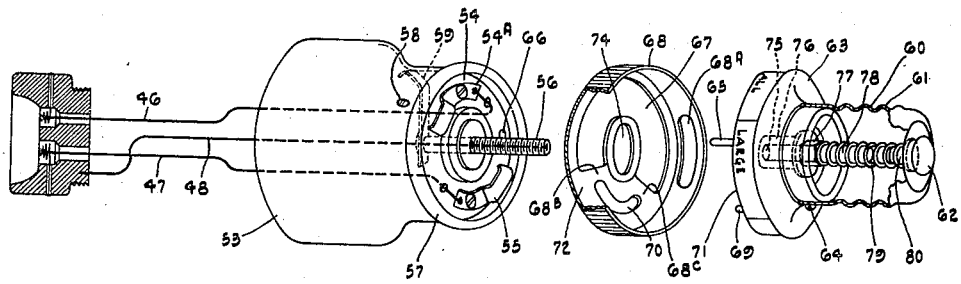

FIG. 6

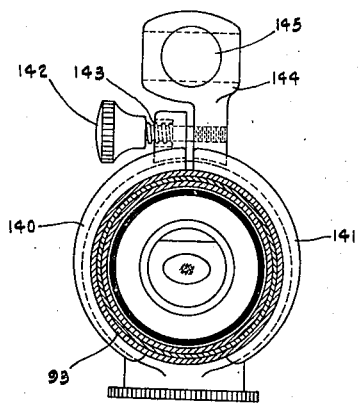

FIG. 7

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UNITED STATES PATENT OFFICE

2,103,335

X-RAY TUBE

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Application May 28, 1932, Serial No. 614,124

24 Claims. (Cl. 250—34)

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.

Attention is first directed to Figures 1 and 2 and particularly to an anode 10 having a head 11 at the inner end of a hollow shank 12. Upon the diagonal face of the head 11 is a tungsten target 13.

A sleeve 15, preferably made of nickel steel, is copper brazed or otherwise suitably secured to an auxiliary ring 15a 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 15a 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 forty-two 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 15a 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 15a 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 unwieldy 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 tapped 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 46a and 47a which may be made in any desired fashion as by using coils of resistance wires suitably insulated. In the particular construction illustrated, the resistances 46a and 47a are open coils of relatively stiff resistance wire such as an alloy of nickel and chromium and are covered by a glass tube. These coils 46a and 47a 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. Contact is then made between the disc 63 and the contact cup 68 by engagement of their two opposing surfaces 71 and 72 when the two members are in assembled position.

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 63 is an oblong aperture 63*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 63*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 63*a* is at this time over a different indicia denoting the energized filament.

To the outer end of the anode 18 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 important 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 insulating sleeve 90 in any desired fashion as by means of an insulating varnish. A metallic member 92*a* surrounds the sleeve 91 and is secured to it by insulating varnish or other suitable material. The member 92*a* includes a sleeve 93, the center portion of which is ribbed as shown at 94 for heat dissipation in a manner to be later described. Said central member 93 has two flanges 95.

A passage for the useful beam of X-rays is pro-

vided 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 to the ring 157. The flange 157a reacts 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 inner 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 cooling of the tube is further assisted by the sleeve 93, which has a ribbed section 94 as previously described, to promote the dissipation of heat into the surrounding air.

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 a patent to Jesse L. Worden, No. 1,972,414, issued September 4, 1934. 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, is deflected in the same manner as the X-rays and strikes 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 be-

cause 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. The combination with an X-ray tube, of a demountable casing comprising an inner continuous, imperforate sleeve of insulating material transparent to X-light, a centrally disposed housing member of X-ray absorbing material about said transparent insulating sleeve, and end housing sleeves of insulating X-ray absorbing material engaging said centrally disposed member, there being a window for a beam of X-light in said centrally disposed housing member.

2. An X-ray tube having an envelope and provided with an anode and cathode, there being a fitting at one end of said tube, in combination with a casing for said tube held in demountable assembly with respect to said fitting and having a window providing an outlet for X-light in juxtaposition to the bombarded area of the anode, said casing comprising an inner sleeve of insulating material transparent to X-light and surrounding the envelope of said tube, an outer sleeve of X-ray absorbing material about the central section of the inner sleeve, and end jackets of X-ray absorbing and insulating material about and extending beyond the ends of said inner and outer sleeves.

3. An X-ray tube having an anode, a cathode, and an enclosing envelope and provided with a fitting at each end of the envelope, in combination with a casing held in demountable assembly with respect to one of said fittings and said envelope, said casing comprising a jacket of insulating material surrounding the tube approximate the anode and cathode thereof to add dielectric strength to the envelope, a second jacket of metallic X-ray absorbing material of less longitudinal extent than and disposed about said insulating sleeve, there being a window in said metallic sleeve for the escape of a beam of useful X-light, and end members intermediate said metallic sleeve and said end fittings and of an insulating material impregnated with a salt of high molecular weight.

4. The X-ray tube and housing described in claim 3, and in which said metallic sleeve is surrounded by a second metallic sleeve to which the end members are attached, there being a window in said second metallic sleeve registering with the window in said first referred to metallic sleeve.

5. An X-ray tube comprising a generally cylindrical envelope having an anode and a cathode disposed therein away from its ends, in combination with a sleeve of insulating material transparent to X-light completely encircling said envelope and extending from the median line toward the ends a distance greater than the space between the anode and cathode, a metallic sleeve surrounding said insulating sleeve and having a window in juxtaposition to said anode for the passage of a beam of useful X-light, said metallic sleeve being of less longitudinal extent in respect to said envelope than said insulating sleeve, a second metallic sleeve about said first named metallic sleeve and having a window registering with the window in said first mentioned metallic sleeve, and insulating end members opaque to X-light extending from said second mentioned metallic sleeve to the ends of said envelope.

6. In an X-ray tube, an anode having a flange selectively positioned longitudinally thereof, there being a guide means on said flange and said flange being rotatably adjustable on said anode to position said guide means radially of said tube, a cathode in said tube, a casing including a window and having guide means at one end thereof cooperating with the guide means on said flange, said casing being adapted to fit around said tube with the end thereof in abutment with said flange for selectively disposing said window longitudinally with respect to a useful beam of X-light from said tube, and with said guide means in alignment to fix the position of said window radially of such useful X-ray beam.

7. For use with an X-ray tube having an envelope and an anode and a cathode therein, a casing adapted to telescope longitudinally thereof and comprising a portion of electrically conducting material opaque to X-light for equalizing electrostatic charges induced on the envelope by the potentials of the anode and cathode, said casing having a window therethrough for the passage of a beam of useful X-light, and a sleeve of electrical insulating material of great dielectric strength and transparent to X-light, said sleeve being within said opaque portion and in axial alignment therewith, and being wider than the diameter of said window and across said window.

8. The combination with an X-ray tube having an anode extending outwardly of the tube, of a demountable casing comprising an inner continuous sleeve of insulating material transparent to X-light, a centrally disposed housing member of X-ray absorbing material about the insulating sleeve, said housing member having a window through which a beam of X-light may be projected outwardly of said casing, and end closures for said casing comprising sleeves of insulating and X-ray absorbing material secured to the centrally disposed member, one of said sleeves having a closure at its end through which said anode may extend out of the casing.

9. The combination with an X-ray tube having an anode extending outwardly of the tube, of a demountable casing comprising an inner continuous sleeve of insulating material transparent to X-light, a centrally disposed housing member of X-ray absorbing material about the insulating sleeve, said housing member having a window through which a beam of X-light may be projected outwardly of said housing, end closures for said housing comprising sleeves of insulating and X-ray absorbing material secured to the centrally disposed member, one of said sleeves having a closure at its end through which said anode may extend out of the casing, said anode having a cavity opening outwardly of said casing and means connected on the projecting end of the anode for circulating a cooling medium within said cavity.

10. An X-ray tube comprising a cylindrical envelope of material relatively transparent to X-light and of substantially uniform diameter and wall thickness throughout its extent, an anode having a portion forming a substantially point source of X-light for projection through the walls of said envelope, a demountable casing around said envelope comprising an inner continuous, imperforate sleeve of insulating material transparent to X-light, a centrally disposed housing member of X-ray absorbing material about the insulating sleeve, said housing member having a window, end housing sleeves of insulating, X-ray absorbing material secured to said housing member in position enclosing the opposed ends of the envelope, the walls of said envelope being

ground to produce a thin spot opposite said housing member, the remaining walls of the envelope being relatively thick in order to impede the passage of X-light therethrough except at said thin spot at which minimum impedance to the passage of X-light is afforded.

11. The combination with an X-ray tube, of a demountable casing comprising an inner continuous, imperforate sleeve of insulating material transparent to X-light and a housing comprising a centrally disposed housing member of X-ray absorbing material about said insulating sleeve, said housing member having a window through which X-light may be projected from the X-ray tube and fin-like heat dissipating means on the outer surface of said housing member, and said casing comprising end housing sleeves of insulating X-ray absorbing material secured to said centrally disposed member.

12. The combination with an X-ray tube adapted when energized to provide a substantially point source of X-light, of a demountable casing for said tube comprising an inner continuous, imperforate sleeve of insulating material transparent to X-light and a sectional housing comprising a centrally disposed housing member of X-ray absorbent material disposed about the transparent insulating sleeve, and having a window through which X-light from said point source may be projected, and end housing sleeves of insulating X-ray absorbent material secured to said centrally disposed housing member and extending oppositely to enclose the opposed ends of said X-ray tube, said X-ray tube and casing being formed with co-operating means affording an index for registering said point source with said window as and when the X-ray tube is assembled in the casing.

13. The combination as set forth in claim 1 wherein the sleeve of insulating material extends at its opposite ends outwardly of said centrally disposed housing member and within the end housing sleeves.

14. The combination of an X-ray tube having an anode and a cathode in a suitable envelope from which a beam of useful X-rays is projected from said anode in a direction normal to the axis of the envelope, an inner sleeve of insulating material transparent to said X-rays encircling the tube between said anode and cathode and extending longitudinally thereof toward the ends of the tube, an outer sleeve of X-ray absorbing material extending over said inner sleeve and to the ends of the tube, said outer sleeve comprising a section of X-ray absorbent metal at the median portion of the envelope having an opening therein, a metallic sleeve enclosing this median section and being provided with an X-ray transmitting window in registry with the opening in said section, and X-ray absorbing end members extending from the outer sleeve toward the ends of the tube and cap members cooperating with said end members to enclose the ends of the tube.

15. In an X-ray apparatus the combination of an X-ray tube having an envelope with an anode and cathode therein, adjustable guide means on the anode, a casing for said tube, said casing having a window therein adapted to be disposed adjacent said anode for transmitting a beam of X-rays, index means on said casing for cooperating with the guide means on the anode to aline the window in said casing with said anode when said casing and tube are assembled.

16. In an X-ray apparatus, the combination of an X-ray tube having an envelope with an anode and cathode therein, and a unitary casing adapted to telescope thereover, said casing comprising a metallic sleeve for equalizing electrostatic charges induced on the envelope by the potentials of the anode and cathode, an electrical insulating sleeve intermediate the metallic sleeve and the envelope for fortifying the dielectric strength of said tube, said metallic sleeve being of an X-ray absorptive material and having a window for the passage of useful X-rays and said insulating sleeve being of X-ray transparent material and extending entirely across said window.

17. An X-ray apparatus comprising in combination an X-ray tube having an envelope with an anode and a cathode therein, a casing of material opaque to X-rays and having a window therein enclosing said tube, an adjustable guide means on said envelope abutting an end of said casing, said guide means being adapted to be adjusted axially of the tube to a distance from the face of the anode equal to the distance between said abutting end of the casing and said window, an indexing means on the abutting end of said casing and cooperating with said guide means to selectively position the window of said casing in respect to the anode of said tube whereby tubes having envelopes of slightly different dimensions may be interchanged within the casing.

18. An X-ray tube comprising a cylindrical envelope of material relatively transparent to X-light and of substantially uniform diameter and wall thickness throughout its extent, an anode having a portion forming a substantially point source of X-light for projection through the wall of said envelope, a demountable casing around said envelope comprising an inner continuous sleeve of insulating material transparent to X-light, a centrally disposed housing member of X-ray absorbing material about the insulating sleeve, said housing member having a window and end housing sleeves of insulating, X-ray absorbing material secured to said housing member in position enclosing the opposed ends of the envelope, the wall of said envelope having a thin spot opposite said housing member, said thin spot being formed by removing a curved portion of the cylindrical envelope from the outer surface thereof, said removed portion having a crescent-like cross sectional configuration in a plane normal to the axis of the cylindrical envelope and the remaining portion of the wall of the envelope being relatively thick in order to impede the passage of X-rays therethrough except at said thin spot at which minimum impedance to the passage of said rays is afforded.

19. An X-ray tube comprising a cylindrical envelope of material relatively transparent to X-light and of substantially uniform diameter and wall thickness throughout its extent, an anode having a portion forming a substantially point source of X-light for projection through the wall of said envelope, a demountable casing around said envelope comprising an inner continuous sleeve of insulating material transparent to X-light, a centrally disposed housing member of X-ray absorbing material about the insulating sleeve, said housing member having a window and end housing sleeves of insulating X-ray absorbing material secured to said housing member in position enclosing the opposed ends of the envelope, the wall of said envelope being ground to produce a thin spot opposite said housing member, the remaining portion of the wall of the envelope be-

ing relatively thick in order to impede the passage of X-light therethrough except at said thin spot at which minimum impedance to the passage of X-light is afforded, and said envelope and the casing being formed with cooperating means providing an index for registering a thin spot of the envelope with the window of said housing member as and when the parts are assembled.

20. An X-ray tube having a cylindrical envelope and a casing enclosing said envelope, said casing comprising laminations of electrically insulatory and non-insulatory material, certain of said laminations of the casing being opaque to X-light and having a window for the emission of a beam of useful X-light and another lamination being closely circumjacent said envelope and of a dielectric material transparent to X-light, said dielectric lamination having a continuous extension across the window formed in the opaque laminations through which extension the beam of useful X-light is projected.

21. X-ray apparatus comprising the combination of an X-ray tube having an envelope with an anode and a cathode therein, guiding and fastening means on said anode selectively adjustable radially and longitudinally of said tube, a casing telescoping the whole length of said tube and having parts complemental to said guiding and fastening means, said casing having a window transparent to X-light, said guiding and fastening means and the complemental parts of said casing being adapted to close one end of said tube and to be operatively connected one to the other only when said window is proximate the X-light emitting face of said anode and is disposed radially of said envelope to pass the most intense beam of X-light projected from said anode, and a cap member cooperating with the end of said casing opposite said guiding and fastening means to enclose the other end of said tube.

22. X-ray apparatus comprising in combination an X-ray tube having an envelope generally cylindrical in configuration with an anode and a cathode axially disposed therein, guiding and fastening means on said anode adjacent one end of said tube a predetermined distance from the focal spot of said anode and positioned in predetermined radial relationship to the emitting face of said anode, a cylindrical casing extending longitudinally of said tube, a cap cooperating with said casing to enclose the end of said tube opposite said guiding and fastening means, said casing having an X-ray transmitting window, and means on said casing adapted to cooperate with said guiding and fastening means to enclose the first mentioned end of said tube, said last mentioned means being adapted to engage said guiding and fastening means only when said X-ray transmitting window is proximate the emitting face of said anode and is disposed radially thereof to permit the passage of the most intense X-ray beams radiating from said anode face.

23. An X-ray tube having an envelope, a casing closely circumjacent said envelope, said casing comprising laminations of insulatory and non-insulatory material, certain of said laminations of the casing being opaque to X-light and having a window for emission of a beam of useful X-light and another lamination being of a dielectric material transparent to X-light and through which the beam of useful X-light is projected, clamping means having a pair of split collars encircling said casing proximate said window, means for controlling the frictional contact of said pair of split collars with said casing, and a support for said clamping means.

24. In X-ray apparatus, the combination of an X-ray tube having an anode and a cathode and a glass envelope in the form of a cylinder surrounding said anode and cathode and to which said anode and said cathode are sealed, and a casing adapted to surround said envelope, said casing comprising an insulating cylinder in close proximity to the glass envelope proximate the anode and the cathode of the tube for fortifying the dielectric strength of the envelope, a metallic sleeve surrounding a portion of the insulating cylinder for equalizing the electrostatic charges induced on the envelope by the potentials of the anode and the cathode, and a heat dissipating sleeve surrounding said metallic sleeve, said heat dissipating sleeve and said metallic sleeve having openings therethrough for the passage of a useful beam of X-rays, and said heat dissipating sleeve being of metal and comprising outwardly projecting spaced apart fins.

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