May 12, 1936. C. M. SLACK ET AL 2,040,156

SHOCKPROOF X-RAY TUBE

Filed Nov. 30, 1934 3 Sheets-Sheet 1

Fig. 1.

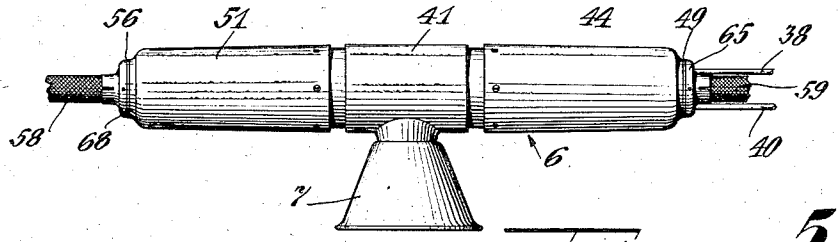


Fig. 5.

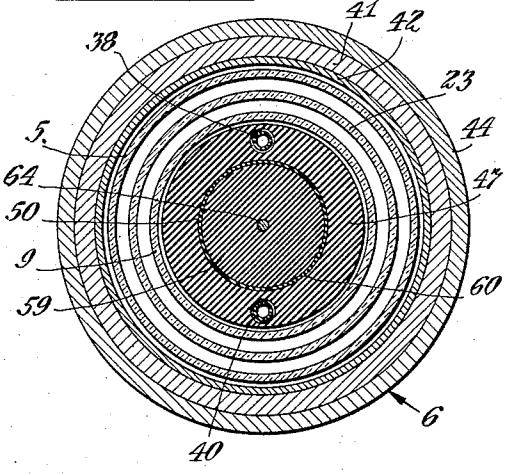


Fig. 4.

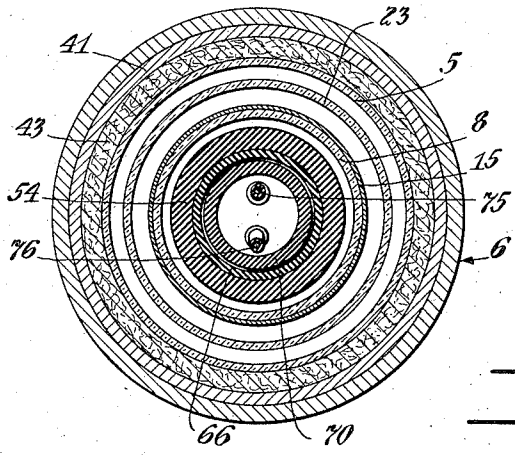


Fig. 9.

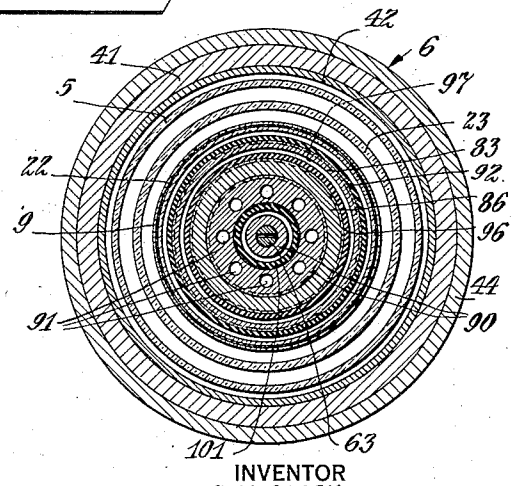
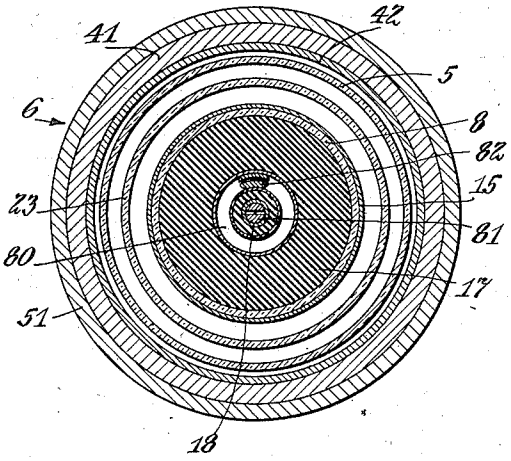


Fig. 8.

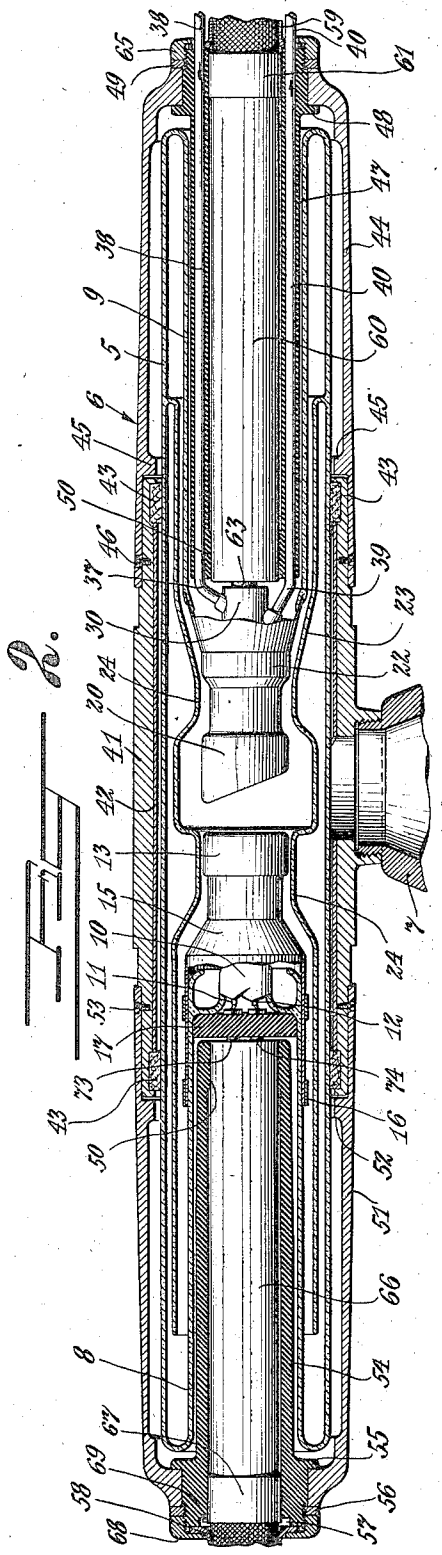


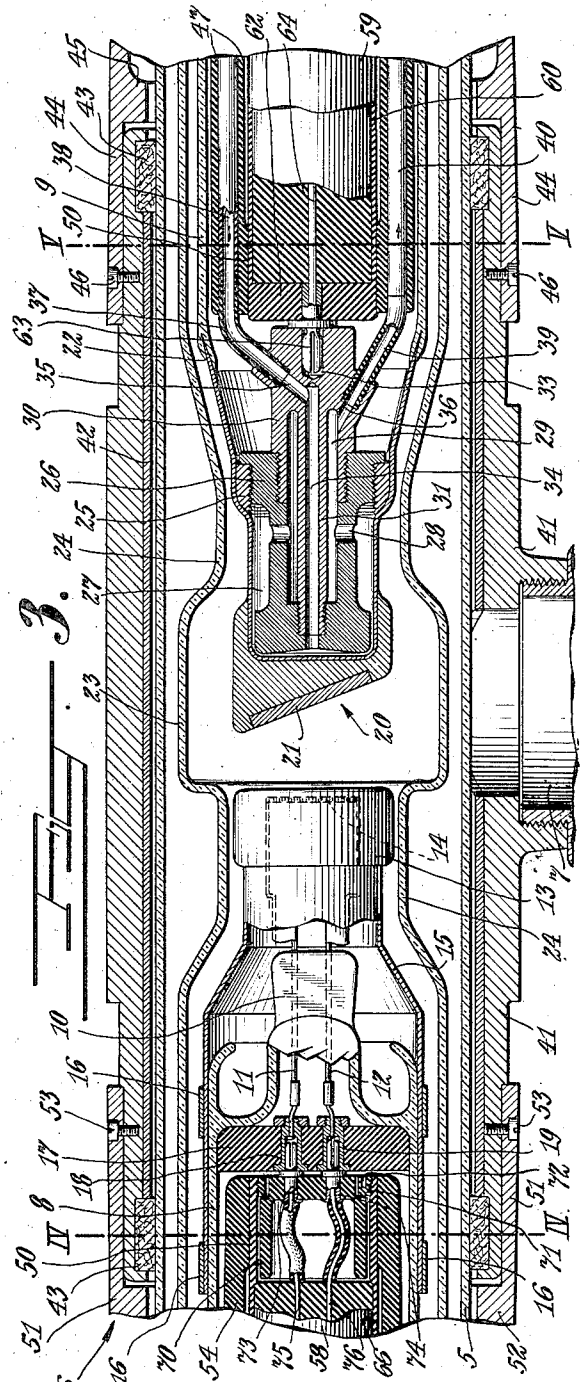
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SHOCKPROOF X-RAY TUBE

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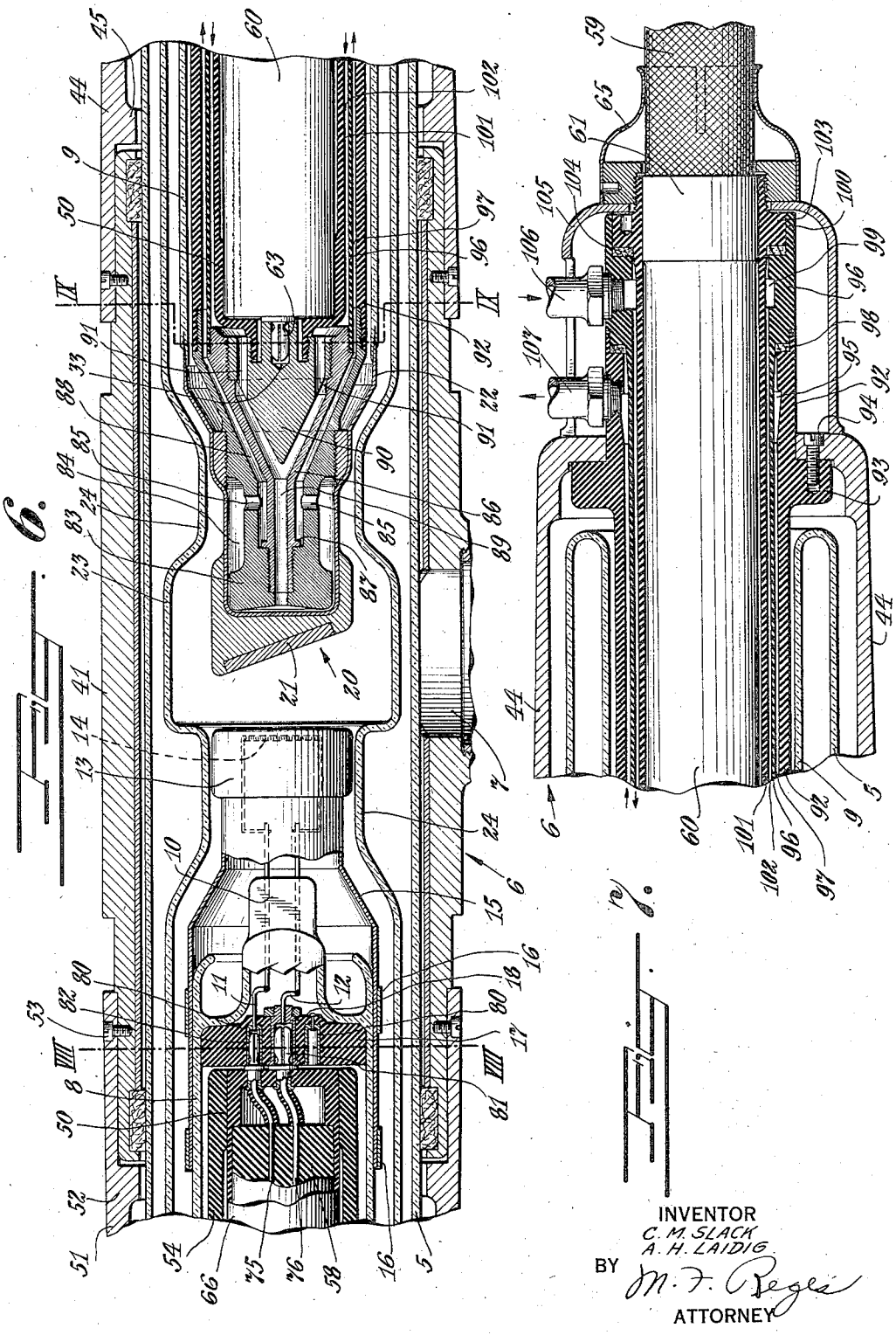


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SHOCKPROOF X-RAY TUBE

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UNITED STATES PATENT OFFICE

2,040,156

SHOCKPROOF X-RAY TUBE

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Application November 30, 1934, Serial No. 755,332

6 Claims. (Cl. 250—35)

Our invention relates to X-ray apparatus and has particular reference to shockproof X-ray apparatus wherein the danger of accidental shocks resulting to a patient or operator are entirely eliminated and constitutes an improvement on the apparatus shown and described in the copending application of C. M. Slack, Serial No. 750,760, filed October 31, 1934.

The most common type of shockproof X-ray apparatus at present utilized in the art is that of the so-called oil immersed type wherein the X-ray tube and the high tension transformer for supplying the energy thereto are immersed in a cooling and insulating material and encased in a metallic housing.

Such oil immersed apparatus, however, has several inherent objectionable features which it is preferable to eliminate. For example, the entire weight thereof renders it exceedingly unwieldy and difficult to manipulate and the insulating material acts as a filter for the generated X-rays. Accordingly a shockproof unit obviating the undesirable features of the oil immersed type is shown and described in the above noted copending application. This apparatus comprises an X-ray tube having a foreshortened length than that normally required for a tube operating in air at the same applied voltage, and the energy for the tube is supplied by grounded metallic sheathed cables, which are connected to recessed electrode terminals carried by the envelope in such manner, as to insulate the same and prevent spark over to grounded metallic parts of the apparatus at the maximum operating voltages of the tubes.

Our present invention is concerned primarily with the provision of a similar type of shockproof unit wherein the energy is supplied through grounded metallic sheathed cables which in addition to supplying the energy so support the tube that the same may be rotated to various inclinations for the purpose of treating or radiographing various parts of the anatomy.

It is accordingly an object of our present invention to provide a cable connected shockproof unit wherein the X-ray tube is of a foreshortened length than that normally required for a tube operating in air at the same applied voltage and the unit is rotatable about its longitudinal axis with the high tension cables which supply the electrical energy functioning as bearings for the rotation thereof.

Another object of our present invention is the provision of a cable connected shockproof unit wherein the X-ray tube is of a foreshortened length than that normally required for a tube operating in air at the same applied voltage with the energy for the tube being supplied through grounded metallic sheathed cables and the unit being rotatable about its horizontal axis to allow directing of the radiations at various inclinations of the unit.

Another object of our present invention is the provision of a cable connected shockproof unit wherein the X-ray tube is of a foreshortened length than that operating in air at the same applied voltage with the energy for the tube being supplied through grounded metallic sheathed cables which enter the ray proof housing and are so connected to the terminals of the X-ray tube as to reduce the spacing normally required between the tube terminals and the grounded housing, and wherein the unit is rotatable to various inclinations about the cables which function as bearings for rotation thereof.

Another object of our present invention is the provision of a cable connected shockproof unit wherein the energy for the tube is supplied through grounded metallic sheathed cables connected to the ray proof metallic housing and the X-ray tube terminals in such manner as to ground the housing and form a support for the tube about which the tube and housing may rotate as a unit, as well as to form sufficient insulation for the tube terminals so that the actual air gap spacing between the latter and the grounded housing may be reduced, to enable the utilization of a tube of foreshortened length than that normally required for a tube operated in air at the same applied voltage.

A further object of our present invention is the provision of a cable connected shockproof unit wherein the X-ray tube is of a foreshortened length than that normally required for a tube operating in air at the same applied voltage, with the energy for the tube being supplied through grounded metallic sheathed cables connected to the ray proof metallic housing and extending into the tube, so as to insulate the electrode terminals to prevent spark-over to the grounded housing and forming a longitudinal axis about which the tube and housing may be rotated to various inclinations, and a circulatory system is provided for the cooling of the anode of the X-ray tube in all inclinations of the latter about the longitudinal axis formed by the cables.

Still further objects of our present invention will become obvious to those skilled in the art by reference to the accompanying drawings, wherein:

Figure 1 is a side view of a shockproof unit constructed in accordance with our present invention.

Fig. 2 is a side view in cross section and on an enlarged scale of the apparatus shown in Fig. 1.

Fig. 3 is a sectional view on a still further enlarged scale of a portion of the unit as shown in Fig. 2.

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 3.

Fig. 5 is a sectional view taken on the line V—V of Fig. 3.

Fig. 6 is a sectional view showing a portion of a modification of the unit as shown in Fig. 2 with parts thereof broken away to better illustrate the unit.

Fig. 7 is a sectional view of a still further portion of the modification shown in Fig. 6 and constitutes the right hand end of the unit which is broken away in the preceding figure.

Fig. 8 is a sectional view taken on the line VIII—VIII of Fig. 6, and

Fig. 9 is a sectional view taken on the line IX—IX of Fig. 6.

Referring now to the drawings in detail and particularly to Figs. 1 and 2 thereof we have shown an X-ray tube comprising an elongated evacuated vitreous envelope 5 of a foreshortened length than that normally required for a tube operating in air at the same applied voltage. A metallic or other suitable ray opaque housing, shown generally at 6, surrounds the X-ray tube for preventing the egress of X-rays except through a pervious window 7 provided in the housing as hereinafter more fully set forth.

This envelope is provided with reentrant stems 8 and 9 extending well into the envelope as can be more readily seen in Fig. 2 with the innermost portion of the reentrant sleeve 8 being formed into a press 10 through which a pair of conductors 11 and 12 pass to the cathode electrode shown generally at 13.

This latter electrode comprises the usual filament 14 (Fig. 3) which is recessed within a focusing cup or shield 15, in turn fitting over the press portion of the reentrant sleeve 8, and held in place by means of metallic rings or the like 16. An insulated disc 17 is suitably secured to the inner periphery of the reentrant stem 8, at the innermost extremity thereof and is provided with a pair of recessed metallic sleeves 18 and 19 which are connected to the filament 14 by the conductors 11 and 12 passing through the press and thus constitutes the cathode terminal for the tube.

A hollow anode electrode 20 formed of a material of good electrical and thermal conductivity, such as copper or the like, and provided with the usual target 21 of refractory metal embedded in the head thereof, is sealed by a feather edge copper annulus 22 to the reentrant portion 9 of the envelope 5. A vitreous glass sleeve 23 fused to the envelope is disposed interiorly thereof and extends longitudinally from well in back of the point of seal of the anode to the envelope to considerably beyond the press 10 formed in the reentrant stem 8. This sleeve is provided with constrictions 24 adjacent the anode and cathode for a purpose shown and described more in detail in the copending application of C. M. Slack, Serial No. 750,633 filed October 30, 1934, but as the same per se forms no part of our present invention further description thereof is deemed unnecessary.

The hollow anode 20 is threaded at the outer end 25 as shown in Fig. 3, and is arranged to be engaged by a metallic member 26 forming an oil tight connection. This latter member 26 is provided with a portion of reduced diameter intermediate its ends which forms an annular passage 27 communicating through a plurality of radial openings 28 with a longitudinal passage 29 interiorly of the member 26.

A further metallic member 30, having an elongated portion 31 of reduced diameter, is arranged to threadedly engage the member 26 at its outer extremity as well as interiorly thereof in an oil tight manner, to form an integral member having the annular passageway 29 interiorly thereof, between the portion 31 of the member 30 and the greater portion of the interior of the member 26. This latter member 30 is provided with a recess 33 forming an anode terminal for the X-ray tube similar to the cathode terminal which comprises the insulated disc 17 and sleeves 18 and 19.

A longitudinal passage 34 is provided interiorly of the member 30 which extends through the portion 31 of reduced diameter and registers with a portion of the passage 29 adjacent the rear surface of the anode head. A pair of angularly extending passageways 35 and 36 are provided in the member 30 one of which, 35, aligns with the longitudinally disposed passage 34 and the other, 36, communicating with the annular passage 29. A suitable fitting, such as an elbow 37 of insulating material, threadedly engages the anode terminal member 30 in alignment with the angular passageway 35.

An inlet conduit 38 also of suitable insulating material extends from an appropriate reservoir (not shown) which in turn engages the elbow 37 thus forming a continuous inlet passage from the reservoir to the interior of the hollow anode 20 for the ingress of a cooling and insulating material, such as oil, with the insulation characteristics of this oil being augmented by the insulated elbow 37 and the conduit 38 so that the potential applied to the anode will not be transmitted to other parts of the apparatus by the cooling system.

In a similar manner an insulated elbow 39 threadedly engages the anode terminal member 30 in alignment with the angular passageway 36 and an outlet conduit 40 extends from this elbow back to the reservoir. Accordingly during operation of the tube the oil or other suitable insulating material will flow from the reservoir through the inlet conduit 38, elbow 37, passageways 35 and 34, and a small portion of the passageway 29 which is closed by the extension 31 from the annular formed portion thereof, to immediately in back of the target 21 at the point of greatest heat concentration. The oil then flows around the member 26 through the annular passage 27 and radial openings 28 to the annular passageway 29 formed by the union of the members 26 and 30. As the angular passageway 36 communicates with the passageway 29 the oil flows therethrough and returns to the reservoir through the insulated elbow 39 and return or outlet conduit 40.

The metallic housing, shown generally at 6 as before stated, may be formed in sections to facilitate assembly of the tube therein and may comprise a center section 41 having the ray pervious window 7 and a lining 42 of a metal of high atomic weight, such as lead, for shielding purposes, and in order to prevent undue shocks to the tube a pair of cushion rings or the like 43 may be carried by the section 41 which bear lightly against the envelope 5. An end section 44 is arranged to overlap the center section 41 and is provided

with an annular shoulder portion 45 bearing against the end of the center section for longitudinally positioning the same, and is held in place in any suitable manner, such as by cap screws or the like 46. This end housing section 44 has an insulating sleeve 47 extending longitudinally thereof to well within the reentrant sleeve 9 of the envelope and is made an integral part of the housing by the provision of an annular shoulder 48 bearing against the end of the metallic portion of the section 44 with this sleeve being rigidly secured to the latter, such as by means of a locknut or ring 49. At the inner end thereof the internal diameter of this sleeve is slightly reduced, as shown more clearly at 50 in Figs. 2, 3, 5 and 6, to form a bearing for a purpose to be hereinafter explained. Accordingly this sleeve 47 of insulating material, by extending well into the reentrant sleeve 9 of the tube, reduces the normal air gap spacing required to prevent sparkover between the anode terminal 30 and the metallic portion of the housing 44 at the maximum operating voltages of the tube, and is also provided with longitudinal passages through which the insulated conduits 38 and 40 pass to the exterior of the housing to the reservoir.

A further end housing section 51 overlaps the center section 41 and is secured thereto in the same manner as just described relative to the section 44, namely, by the provision of a shoulder 52 and cap screws or the like 53. This section 51 is likewise provided with an insulating sleeve 54 extending well into the reentrant sleeve 8 of the envelope having the bearing portion 50, and is made an integral part of this housing section 51, by being rigidly secured thereto through a shoulder 55 and locking ring 56 constructed in the identical manner as above noted with respect to the section 44, the only difference between the two sections 44 and 51 residing in the provision of an annular groove 57 at the end of the sleeve 54 which extends substantially around the inner edge thereof for a purpose to be hereinafter more fully described.

In order to support the tube and housing as well as supply high potential electrical energy to the tube a pair of grounded metallic sheathed high tension cables 58 and 59 extend from a suitable source, such as a high voltage transformer (not shown) having the midpoint of its secondary winding grounded, to the X-ray tube.

The cable 59 has the metallic sheathing removed therefrom a distance corresponding to that from substantially the outside of the housing to the recessed anode electrode terminal 30 which is disposed at the innermost extremity of the reentrant sleeve 9. A sleeve of insulating material 60 fits snugly the unsheated portion of the cable 59 and accordingly forms an integral part thereof. This sleeve 60 slidably engages the insulated sleeve 47 at the bearing portion 50 provided therein and also at the outer extremity, by an increased diameter portion 61 again forming a second bearing thus enabling rotation of the tube and housing about the cable 59.

For the purpose of supplying electrical energy to the anode electrode terminal 30 as well as to form a further bearing for rotatively supporting the unit, the sleeve 60 is closed at its inner end by an insulated disc 62 provided with a metallic pin 63 which is connected to the electrical conductors 64 of the cable 59 and arranged to slidably engage the recess 33 of the anode electrode terminal 30. A flange 65 frictionally contacts the metallic sheathed portion of the cable and threadedly engages the insulated sleeve portion 47 of the housing yet when completely screwed in place establishes an electrical contact with the locking ring 49 for the purpose of effectively grounding the metallic housing and maintaining the cable in place within the reentrant sleeve 9 of the tube, as well as supporting one end of the tube and housing.

In a similar manner the cable 58 is provided with an insulated sleeve 66 forming an integral part thereof, which slidably engages the housing sleeve 54 at its bearing portion 50, and it is likewise provided with an additional bearing 67 formed by an increased diameter portion in the same manner as just described relative to the sleeve 60, with the cable being held in place by a flange 68 identical to that of the flange 65 for effecting the ground connection to the metallic housing. The sleeve 66 has a laterally extending pin 69 projecting into the annular groove 57 so as to limit the rotation of the tube and housing about the longitudinal axis formed by the respective cables 58 and 59 to slightly less than 360 degrees.

The inner end of this sleeve 66 is provided with a loose fitting insulated thimble 70 (Fig. 3) which constitutes an integral part of the sleeve 66 and cable 58 and is held in place by a locknut or the like 71 having openings 72 adapted to be engaged by a suitable tool for inserting the nut in position. This thimble 70 in turn is provided with a pair of metallic pins 73 and 74 connected to the electrical conductors 75 and 76 of the cable 58, and slidably engaging the metallic sleeves 18 and 19 for the purpose of supplying low tension heating current to the filamentary cathode 14 as well as one side of the high potential energy thereto.

In the assembling of our unit the tube may be placed in the center housing section resting upon the cushion rings 43 with the conduits 38 and 40 protruding therefrom. The right hand end section 44 is then slid on, with the conduits 38 and 40 passing through the openings provided in the insulated sleeve 47, and this section secured to the center section of the housing after the shoulder 45 abuts the same by the screws 46. The left hand end section 51 is then slid over the tube until the shoulder portion 52 contacts the center section 41 after which it is secured in place by the set screws 53. This accordingly positions the insulated sleeves 47 and 54, which form an integral part of the respective end sections 44 and 51, well into the reentrant sleeves 8 and 9 of the envelope and, as before stated, form sufficient insulation between the recessed electrode terminals 17 and 30 and the grounded metallic housing to enable the spacing therebetween to be reduced below that normally required for a tube operating in air at the same applied voltage thus resulting in the utilization of an X-ray tube 5 of foreshortened length.

The cables 58 and 59, having their respective integral sleeves 66 and 60 secured thereto, are then slid into the sleeves 54 and 47, respectively, with the pins 73 and 74 engaging the metallic sleeves 18 and 19, and the pin 63 slidably engaging the recess 33 in the anode terminal 30. This accordingly connects the cables to the anode and cathode electrode terminals of the X-ray tube 5 and at the same time supports the tube at these electrodes as well as the housing at the bearing portions 50, 61 and 67. The respective flanges 65 and 68 are then tightened thus establishing a metallic connection between the grounded metallic sheathed portion of the cables 58 and 59 and the housing, shown generally at 6 in Fig. 1, and

the conduits 38 and 40 are connected to the reservoir in any suitable manner to allow a slight flexibility thereof.

During a radiographic examination or a therapeutic treatment the operator may desire to alter the angle at which the X-rays strike the patient. In this event it is only necessary to rotate the unit until the ray pervious window 7 is at the desired inclination as the cables 58 and 59 remain stationary. The housing will, accordingly, rotate about the cables 58 and 59 at the point of contact of the frictionally engaged flanges 65 and 58 with the metallic sheathing of the cables, and at the bearings 50 formed by reduced diameter portions of the sleeves 47 and 54, as well as at the points 61 and 67. At the same time the X-ray tube will likewise rotate with the housing about its respective electrode terminals which function as bearings therefor due to the slight friction exerted by the cushion rings 43 and the engagement of the conduits 38 and 40 with the insulated sleeve 47.

However, the metallic pins 73 and 74, which engage the cathode terminal sleeves 18 and 19, will also cause the thimble 70 to rotate with the X-ray tube, thus tending to twist the cathode heating conductors 75 and 72 as well as the cooling system conduits 38 and 40 if the unit is rotated completely 360 degrees. Such result is prevented by the pin 69 projecting into the annular groove 57 because this latter groove does not extend completely around the end of the insulated sleeve 54 and accordingly forms a stop limiting rotation of the entire unit, as before stated, to slightly less than 360 degrees.

In Figures 6 to 9 inclusive we have shown a modification of the structure just described which enables unlimited rotation of the unit in either direction of rotation without interfering in any way with the circulating system for cooling of the anode or causing a twisting of the cathode heating conductors 75 and 76. The unit in this particular embodiment is in most respects identical to that previously described with the exception of the construction of the electrode terminals and the circulatory system. The insulated disc 17 in this particular modification is again provided with the recessed metallic sleeve 18 which in this instance is disposed concentric with the longitudinal axis of the X-ray tube 5 and metallic ray proof housing 6. In lieu of the recessed sleeve 19 as in the preceding construction, we provide a recessed metallic ring 80, shown more clearly in Figs. 6 and 8, which, like the metallic sleeve 18, is electrically connected to the filamentary cathode 14 by the conductors 11 and 12 passing through the press portion 10 of the reentrant sleeve 8.

The insulated sleeve 66 forming an integral part of the cable 58, is provided with metallic pins 81 and 82 rigidly secured thereto and connected to the conductors 75 and 76 of the cable 58. The pin 81 slidably engages the recessed concentric metallic sleeve 18 and the pin 82 which is of a distorted ellipsoidal configuration, slidably engages the recessed metallic ring 80 so that upon rotation of the X-ray tube and housing about the stationary cable 58 the pin 81 functions as a concentric bearing and the pin 82, while not concentrically disposed, nevertheless also functions as a bearing enabling rotary motion of the ring 80 without destroying the electrical contact therebetween. Hence, upon rotation of the unit the entire cable 58, including the metallic pins 81 and 82, remains stationary thus precluding any possibility of twisting of the conductors 75 and 76.

Also in this modification, as shown particularly in Fig. 6, the hollow anode 20 is again threaded at the outer end and is arranged to be engaged by a metallic member 83 of substantially frustoconical configuration having a portion of reduced diameter intermediate its ends which forms an annular passage 84. This passage 84 communicates through a plurality of radial openings 85 with the hollow interior of the member 83. A hollow metallic member 86, having substantially the same configuration as the member 83 but of slightly reduced size than the hollow interior of the latter member, threadedly engages the same until a shoulder 87 carried by the member 86 bears firmly against the member 83 and forms an oil-tight seal therebetween. This accordingly forms an annular passage 88 between the interior surface of the member 83 and the exterior surface of the member 86 while at the same time completing a passageway 89 communicating from the interior of the hollow member 86 to the end of the member 83 immediately in back of the anode head carrying the target 21.

A third metallic member 90 of substantially conical form in turn is secured to the member 86 in an oil-tight manner thus closing the open end of the member 86 and converting the hollow passageway 89 of the member 86 into annular form for a portion of its length. In order to establish a communication to the passageway 89 the member 90 is provided with a series of longitudinally extending openings 91, as can be more readily seen in Figs. 6 and 9, which align with the annular formed portion of the passageway 89, and this member 90 is provided with the recess 33 which forms the anode terminal in the same manner as just described relative to the preceding embodiment of our invention. Moreover, while we have described the members 83, 86 and 90 as separate parts, it is to be understood that when the same are assembled they constitute an integral unit forming the anode terminal for the tube and having passages therethrough for the circulation of a cooling and insulating material in the same manner as previously described relative to Figs. 1 to 5 inclusive.

An insulated sleeve 92 threadedly engages the metallic member 83, which extends longitudinally of the reentrant sleeve 9 of the envelope 5 in a similar manner to the sleeve 47 in Fig. 2, and adjacent its free end is provided with an annular shoulder 93 to which the right hand metallic end section 44 of the housing is secured in a suitable manner such as by set screws 94, thus enabling this sleeve to protrude slightly beyond the housing section 44 where its internal diameter may be slightly increased, as shown at 95. Another insulated sleeve 96 concentric with the sleeve 92, but of slightly less diameter than the latter for the greater part of its length, threadedly engages the metallic member 86 thus forming an annular passage 97 therebetween which communicates with the passage 88 between the metallic members 83 and 86.

This sleeve 96 projects slightly beyond the free end of the sleeve 92 where its outer diameter increases in steps to that of the sleeve 92 thus forming, with the provision of a gasket 98, an oil-tight connection as well as enabling the sleeve 92 to slightly overlap this sleeve 96 and support the same. A portion 99 of increased internal diameter is provided in this sleeve 96 and its free end is provided with an annular groove 100 for purposes hereinafter noted. A still further sleeve

101 is secured to the metallic member 90 which is also concentrically disposed relative to the aforenoted sleeves 92 and 96 but of lesser diameter than the latter, thus again forming an annular passageway 102 between the respective sleeves 96 and 101 which communicates with the openings 91 in the metallic member 90. Like the other sleeves, this sleeve 101 is of increased diameter near its outer end to form a shoulder portion 103, which fits into the annular groove 100 provided in the sleeve 96 and together with a suitable gasket 104 renders this connection oil tight. This latter sleeve 101 is provided with the bearing portion 50 (Fig. 6), in the same manner as described relative to the sleeve 47 in the embodiment shown in Fig. 2, and its free end projects slightly beyond the shoulder portion 103 where it is threadedly engaged by the flange member 65 frictionally contacting the grounded metallic sheathing of the cable 59. Inasmuch as the flange 65 threadedly engages the insulated sleeve 101, in order to establish a ground connection between the metallic sheathing of the cable 59 and the metal housing section 44, we provide a metallic hood or the like 105 which fits over the threaded end of the sleeve 101 and upon connection of the flange 65 thereto this hood is forced into frictional contact with the metallic end section 44 of the housing 6.

A suitable bushing or the like 106 is secured to the sleeve 96 in alignment with the annular groove formed by the increased diameter portion 99 thereof, and this bushing is arranged to be connected to the reservoir (not shown) in the same manner as the inlet conduit 38 of Figs. 2 and 3. A similar bushing 107 forms an oil-tight connection with the sleeve 92 in alignment with its annular groove 95 which is likewise arranged to be connected to the reservoir to complete the return thereto similar to that of the conduit 40. During operation of this latter modification of our invention the cooling and insulating oil flows from the reservoir through the connecting duct (not shown) to the bushing 106, thence around the annular groove 99 and along the annular passageway 102, through the longitudinal openings 91, to the passageway 89 where it then contacts the rear surface of the anode head at the point of greatest heat concentration immediately in back of the target 21.

The heated oil will flow around the metallic member 83 to the annular passageway 84, and thence find its way through the openings 85 to the passage 88, from which it flows along the passageway 96 to the annular groove 95, and back through the bushing 107 and return duct to the reservoir. Accordingly with the cables 58 and 59 in place and connected to the electrode terminals and housing, as before explained, the entire unit can be rotated. The pins 81 and 82 forming bearings for rotation of the cathode end of the tube while the pin 63 engaging the recess 33 provided in the metallic anode terminal portion 90 functions as a bearing for the anode end of the X-ray tube 5.

At the same time the insulated sleeves 54 and 101 will rotate about the bearings formed by their respective portions 50 and the enlarged portions 67, 61 of the cables 58 and 59 while these latter cables remain stationary. These sleeves being an integral portion of the housing naturally cause rotary movement of the outer sections thereof so that the ray pervious window always aligns with the ray projecting portion of the tube 5, and the housing 6 might be said to be further journalled at the points of frictional engagement between the flanges 65 and 68 with the respective cables 58 and 59. Due to the construction of this embodiment of our invention the entire unit may be rotated as a whole about its longitudinal axis formed by the cables 58 and 59 and is not restricted to movement of slightly less than 360 degrees as in the modification shown in Figs. 1 to 5 inclusive. Hence twisting of the cathode conductors 75 and 76 is prevented as well as that of the cooling conduits 38 and 40 for the modification of Figs. 6 to 9 inclusive the bushings 106 and 107 follow movement of the housing without imposing a stress upon the portions of the connecting ducts (not shown) to the reservoir. Moreover, these latter ducts may constitute rubber hose, as is common in the art, which in both modifications allows considerable flexibility, although as before stated relative to Figs. 1 to 5, they would be twisted to such an extent as to perhaps be destroyed or shut off the oil supply if the unit were rotated 360 degrees or more.

It thus becomes obvious to those skilled in the art that we have provided a cable connected shockproof X-ray unit wherein an X-ray tube of a foreshortened length than that normally required for a tube operating in air at the same applied voltage may be utilized.

Moreover, the unit is supported upon high tension cables which so enter the grounded metallic ray proof housing as to reduce the air gap spacing normally required to prevent spark over and the formation of corona at the maximum operating voltages of the tube, and which form a longitudinal axis about which the unit may be rotated to various inclinations without in any way interfering with the circulatory system for the cooling of the anode in all inclinations of the unit.

Although we have shown and described several embodiments of our present invention we do not desire to be limited to the precise structural details illustrated as various modifications of our present invention may be made without departing from the spirit and scope of the appended claims.

What is claimed:

1. A shockproof X-ray apparatus comprising an X-ray tube having an envelope provided with oppositely disposed reentrant stems, electrode terminals carried by said envelope at the innermost extremities of said reentrant stems, an X-ray opaque metallic housing surrounding said tube and provided with an X-ray pervious window in alignment with the ray projecting portion of said envelope, and means connected to said housing to ground the latter and provided with portions extending into said housing and connected to said electrode terminals for the purpose of supplying electrical energy thereto and for insulatingly supporting said X-ray tube and housing to enable rotation of said tube and housing as a unit to various inclinations about said means, and to prevent the formation of corona or a discharge between said electrode terminals during operation of said tube.

2. A shockproof X-ray apparatus comprising an X-ray tube having an envelope provided with a thermionic cathode and a hollow anode, electrode terminals carried by said envelope, an X-ray opaque metallic housing surrounding said tube and provided with an X-ray pervious window in alignment with the portion of said envelope through which the X-rays emerge, means connected to said housing to ground the latter and

provided with portions extending into said housing and connected to said electrode terminals for the purpose of supplying electrical energy thereto and for insulatingly supporting said X-ray tube and housing to enable rotation of said tube and housing as a unit to various inclinations about said means, and to prevent the formation of corona or a discharge between said electrode terminals at the maximum operating potential of said tube, and means connected to the electrode terminal for said hollow anode for circulating a cooling and insulating medium therethrough in all various inclinations of said X-ray tube and housing.

3. A shockproof X-ray apparatus comprising an X-ray tube having an envelope of foreshortened length than that normally required for a tube operating in air at the same applied voltage and provided with oppositely disposed reentrant stems extending a substantial distance longitudinally of said envelope, electrode terminals disposed at the innermost extremity of said reentrant stems, an X-ray opaque housing surrounding said X-ray tube and provided with a pervious window therein, and means for supporting said X-ray tube and housing to form a longitudinal axis about which said tube and housing may be rotated to various inclinations and for supplying electrical energy to said X-ray tube comprising grounded metallic sheathed cables having an insulated portion extending into said reentrant stems and connected to said electrode terminals, to form bearings for the rotation of said tube and housing and to provide sufficient insulation between said electrode terminals and grounded parts of said apparatus to enable the spacing therebetween to be reduced from that normally required for a tube operating in air at the same applied voltage without the formation of corona or spark-over resulting at the maximum operating voltage of said tube.

4. A shockproof X-ray apparatus comprising an X-ray tube having an envelope of foreshortened length than that normally required for a tube operating in air at the same applied voltage and provided with oppositely disposed reentrant stems extending a substantial distance longitudinally of said envelope, electrode terminals disposed at the innermost extremity of said reentrant stems, an X-ray opaque metallic housing surrounding said tube and provided with an X-ray pervious window therein, and means for supporting said X-ray tube and housing and for supplying electrical energy to said X-ray tube comprising grounded metallic sheathed cables connected to said housing to ground the latter and provided with an insulated portion extending into said reentrant stems for supplying electrical energy to said electrode terminals and forming an axis for said X-ray tube to enable rotation thereof and said housing as a unit to various inclinations.

5. A shockproof X-ray apparatus comprising an X-ray tube provided with a thermionic cathode and a hollow anode and having an envelope of foreshortened length than that normally required for a tube operating in air at the same applied voltage with oppositely disposed reentrant stems extending a substantial distance longitudinally thereof, electrode terminals for said anode and cathode disposed at the innermost extremity of said reentrant stems, an X-ray opaque housing surrounding said X-ray tube provided with a pervious window therein, means for supporting said X-ray tube and housing to form a longitudinal axis about which said tube and housing may be rotated to various inclinations and for supplying electrical energy to said electrode terminals comprising grounded metallic sheathed cables having an insulated portion extending into said reentrant stems to provide sufficient insulation between said electrode terminals and grounded parts of said apparatus to enable the spacing therebetween to be reduced from that of the normal air-gap equivalent for the same applied voltage, and means connected to the electrode terminal for said hollow anode for circulating a cooling and insulating medium therethrough and through said hollow anode in all various inclinations of said X-ray tube and housing during operation thereof and to prevent the potential impressed upon said anode from being transmitted to other portions of said apparatus.

6. A shockproof X-ray apparatus comprising an X-ray tube provided with a thermionic cathode and a hollow anode and having an envelope of foreshortened length than that normally required for a tube operating in air at the same applied voltage with oppositely disposed reentrant stems extending a substantial distance longitudinally thereof, electrode terminals disposed at the innermost extremity of said reentrant stems, an X-ray opaque metallic housing surrounding said tube and provided with an X-ray pervious window therein, means for supporting said tube and housing to form a longitudinal axis about which said tube and housing may be rotated as a unit to various inclinations and for supplying electrical energy to said electrode terminals comprising grounded metallic sheathed cables connected to said housing to ground the latter and provided with an insulated portion extending into said reentrant stems to provide sufficient insulation between said electrode terminals and grounded parts of said apparatus to enable the spacing therebetween to be reduced from that of the normal air-gap equivalent for the same applied voltage, and means connected to the electrode terminal for said hollow anode for circulating a cooling and insulating medium therethrough and through said hollow anode in all various inclinations of said unit during operation thereof and operable to prevent the potential impressed upon said anode from creating a potential stress between said means and grounded metallic portions of said apparatus.

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