Dec. 26, 1950 J. J. VLACH 2,535,708

X-RAY GENERATOR

Filed April 10, 1948 2 Sheets-Sheet 1

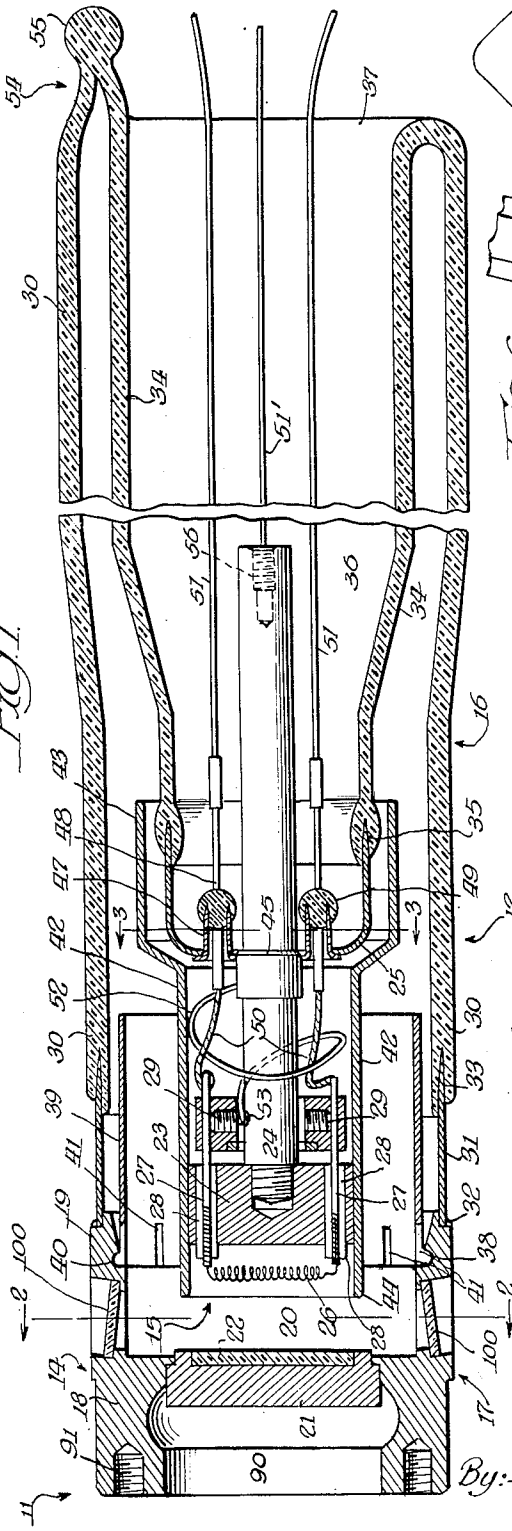

FIG. 1

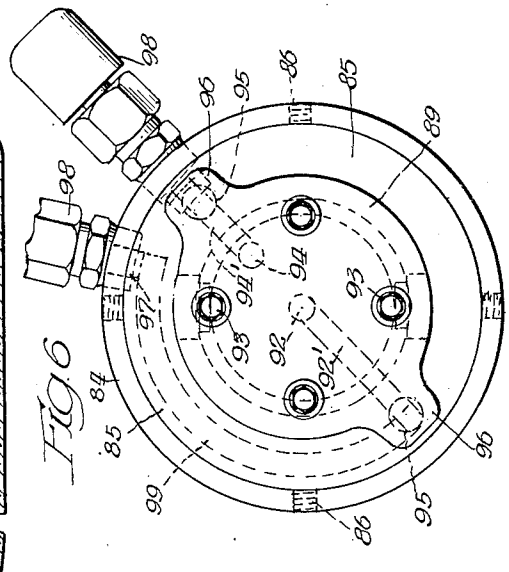

FIG. 6

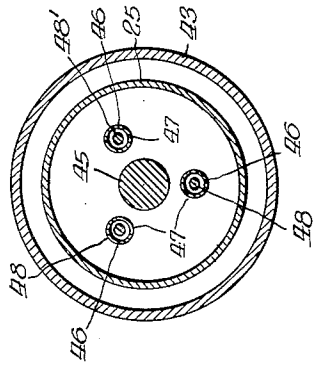

FIG. 3

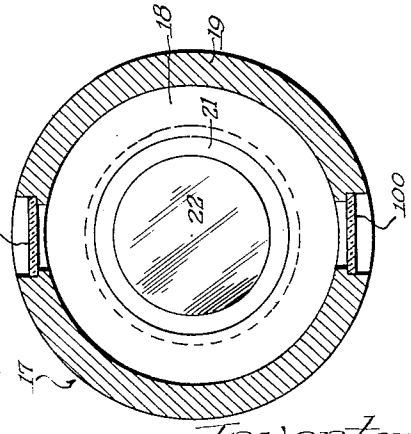

FIG. 2

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X-RAY GENERATOR

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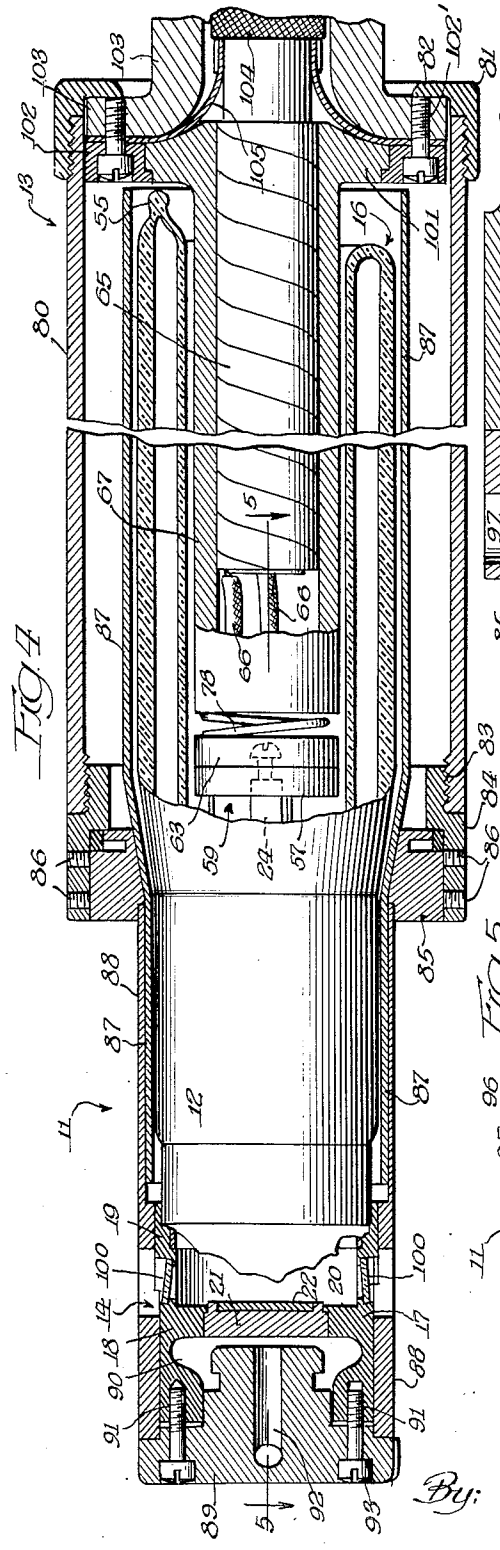

FIG 4

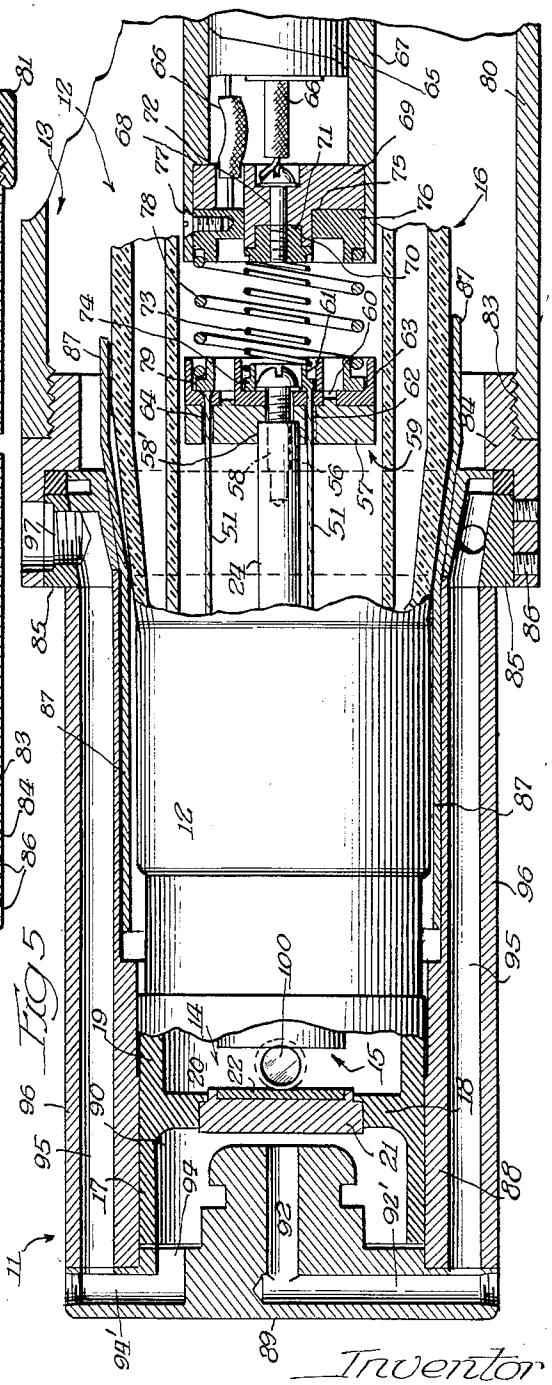

FIG 5

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2,535,708

X-RAY GENERATOR

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Application April 10, 1948, Serial No. 20,199

6 Claims. (Cl. 250—143)

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The present invention relates in general to electronics, and has more particular reference to an X-ray generator of improved construction and particularly well suited for use in the diffraction analysis of materials, although, of course, useful for other and general purposes, as well.

An important object of the present invention is to provide an X-ray generator structure of compact arrangement and small overall dimensions, thereby facilitating manipulation of the same; a further object being to provide novel and improved means rendering the apparatus substantially shockproof for the protection of the user.

Another important object is to provide an X-ray generating unit adapted for operation at relatively high intensity, yet safely insulated for the protection of the user, the generating unit embodying an X-ray tube having an envelope comprising an insulator formed to embrace and thus aid in insulating a high tension power supply cable used for energizing the tube; a further object being to provide an improved commutator construction for electrically connecting the power supply cable with the operating elements of the tube within the cable insulating portions of the tube envelope.

Another important object of the invention is to provide an X-ray tube having an envelope comprising an insulator, such as glass, and forming a relatively deep re-entrant pocket for the reception of a power cable, including improved commutator means for electrically connecting the cable with an interior operating element of the tube upon insertion of the cable in the pocket; a further object being to form the commutator as a plate of insulating material mounted on a conducting stem extending within and outwardly of the envelope, the commutator including electrical contact shoes in position to engage and electrically connect with cable conductors, outwardly of the envelope, upon insertion of the cable in its mounting pocket, whereby to permit said stem to be used for the operation of gettering means within the envelope, during the fabrication of the tube, and for short-circuiting and thus inactivating the gettering means when the tube is placed in service.

Another important object is to provide improved means for circulating a cooling liquid in heat exchange relation with the anode element of the tube; a further object being to incorporate the fluid circulating facilities in a shockproof housing in which the tube is mounted.

Another important object is to provide an improved shockproof housing of relatively simple and inexpensive construction for enclosing an X-ray tube of the character described, in order to provide an X-ray generating unit, the housing and tube, when in assembled relationship, having interconnecting ducts for the circulation of a cooling fluid through the housing and in heat exchange relation with an operating element of the tube.

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Another important object is to provide an X-ray generator unit of the character described, having an improved X-ray outlet window arrangement affording minimum absorption of X-rays, and wherein the window is disposed closely and immediately adjacent the X-ray generating source of the tube, whereby rays of maximum intensity may be delivered from the unit when in operation.

Another important object is to provide an X-ray tube in which the anode portion of the tube comprises a unitary, preferably metal base fitted with anode target and closely adjacent X-ray window openings, said base being sealed in the end of a sleevelike envelope member of insulating material, such as glass, to form the anode end of the tube; a further object being to form the anode as a generally cup-shaped element, with means for sealing the edge or lip of the cup-shaped element with the facing end of the sleevelike envelope member; a still further object being to provide a novel guard sleeve adapted to be interlockingly fitted in the cup-shaped element in position to shield the seal against electron impingement thereon during the operation of the tube as an X-ray generator.

Another important object is to provide an X-ray tube having an anode structure of the character mentioned mounted at an end of a sleevelike envelope member of insulating material, such as glass, wherein said envelope member comprises an outer sleeve portion carrying said anode member at one end and a deeply re-entrant envelope portion secured to the outer sleeve portion at the end thereof remote from said anode member, said deeply re-entrant portion having an inner end terminating within and adjacent the anode carrying end of the outer sleeve portion, and carrying sealed thereon a cathode structure embodying an electron emitting element disposed adjacent and in alinement with an anode target formed on said anode member, whereby said envelope portions provide a relatively deep pocket at the cathode end of the tube for receiving, enclosing, and insulating a

cable for delivering tube operating power to the cathode.

Another important object is to form the electron emitting element of the tube as a filament and to provide improved commutator means within the cable pocket, outwardly of the envelope and adjacent the cathode supporting end of the re-entrant envelope portion, for electrically interconnecting the cable with the filament, said means including a member for operating gettering means within the envelope and for rendering the gettering means inactive when the cable is in mounted position in contact with the commutator means.

The foregoing and numerous other important objects, advantages, and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment of the invention.

Referring to the drawings:

Fig. 1 is a sectional view taken through an X-ray tube embodying the present invention, the tube being shown as manufactured and ready for assembly in operating position in its enclosing casing;

Figs. 2 and 3, respectively, are sectional views taken substantially along the lines 2—2 and 3—3 in Fig. 1;

Fig. 4 is a sectional view taken through an X-ray generator unit embodying the present invention and incorporating the tube shown in Fig. 1; and

Figs. 5 and 6 are enlarged sectional views, respectively, taken substantially along the lines 5—5 and 6—6 in Fig. 4.

To illustrate the invention the drawings show an X-ray generator unit 11 comprising an X-ray tube 12 and a casing or housing 13 in which the tube is mounted and enclosed in service.

The tube 12, as shown more particularly in Figs. 1–3 of the drawings, comprises an anode structure 14, and a cooperating cathode structure 15 enclosed in sealed and evacuated envelope means 16. As shown, the anode structure 14 preferably comprises a frame or base 17, as of metal, forming a generally cup-shaped element sealed to the envelope means and forming a part thereof. The cup-shaped member has a bottom 18 and cylindrical walls 19 enclosing a cavity 20, an anode target element or button 21 being mounted preferably centrally on the bottom of the cup-shaped element, with a target surface 22 facing into the cavity 20.

The cathode assembly preferably comprises a head 23 forming a disk of metal supported in spaced apart facing alinement with respect to the anode target surface 21. To this end, the head 23 may be supported on a stem 24 which, in turn, extends through and is mounted centrally in the bottom of a seal member 25, by means of which the member 24 and the cathode structure supported thereon is sealed to and supported on the envelope structure 16. The cathode structure also comprises an electron emitting element, shown as a filament 26, mounted on, extending between, and electrically connected with conductor stems 27 supported on the head 23, the filament 26 being thus carried in spaced registration with respect to the target surface 22. The stems 27 are supported on, insulated from, and extend through the head 23, as by means of insulating sleeves 28 mounted in channels formed through the head, and by insulated clamps 29 supported on the head 23 or the stem 24 behind the head, that is to say, the side thereof facing away from the anode target surface 21.

The envelope means 16 preferably comprises a member of insulating material, such as glass, having an outer sleevelike portion 30, to one end of which the anode member 14 is sealed, as by means of a sealing sleeve 31 of metal adapted to seal with glass. The sleeve 31 at one end is sealingly secured to the lip or rim of the cup-shaped anode member, as by a welded or brazed seal 32, the opposite end edge of the sleeve 31 forming a glass-to-metal seal 33 with the end of the outer sleeve portion 30 of the envelope member. The envelope member 16 also preferably includes an inner re-entrant sleeve portion 34, integral with and secured to the outer sleeve portion 30 at the end thereof remote from the anode member 17, said re-entrant or inner portion 34 extending within the outer portion 30 adjacent the anode connected end of said outer portion, the terminal edges of the inner portion forming a glass-to-metal seal 35 with the rim of the cup-shaped cathode supporting member 25, which preferably comprises metal readily sealable with glass.

It will be seen from the foregoing that the envelope means 16 comprises the glass member having outer and inner portions 30 and 34, the cup-shaped anode member 17 sealed to the end of the outer envelope portion 30, and the cup-shaped cathode supporting and sealing member 25, sealed in the end of the inner envelope portion 34. The envelope portions 30 and 34 also form a deep, cylindrical, double wall pocket 36, the bottom of which is defined by the cathode support member 25, said cylindrical pocket 36 opening at the anode and cathode remote ends 37 of the glass envelope member.

If desired, the walls 19 of the anode member 17 may be formed with an annular groove 38 inwardly of and adjacent the seal 32, and a sleevelike shield 39, having a locking bead 40 at one end and longitudinal slits 41 extending from said beaded end in the material of the sleevelike member, may be mounted on the anode member by interlocking the beaded end 40 thereof in the locking groove 38, whereby the sleeve member 39 may be mounted in position to screen the glass-to-metal seal 30 from the stray electrons and other energized particles emitted by the anode or cathode when the device is in operation. The cathode, likewise, may embody a sleevelike element 42 mounted on and carried by the cathode head 23, encircling the same and enclosing the space between said head and the cathode mounting element 25, said sleevelike element 42 having a terminal skirt 43 embracing and enclosing the cup-shaped member 25 and the glass-to-metal seal 35, in order to protect said seal against the deleterious action of stray electrons or other energy particles. If desired, the sleevelike member 42 may be extended beyond the head 23 in the direction of the anode target 22 in order to provide a focusing cup 44 for the electron emitting element 26.

The cathode mounting stem 24 extends through and is sealed, as at 45, in a preferably central opening in the member 25. Outwardly of said central opening, the member 25 is formed with openings 46 disposed about the central opening and sealingly fitted each with a sleeve 47 of material readily sealable with glass. Conductor members 48 and 48' of metal readily sealable with glass are mounted coaxially within the sleeves 47,

sealed therein, and insulated therefrom by sealing globules 49 of glass surrounding and sealed to the stems 48 and 48', within and sealed to the sleeves 47. The conductor stems 48 and 48' thus extend inwardly and outwardly of the sealed envelope means 16. The inner ends of a pair of stems 48 are electrically connected, respectively, with the filament stems 27, as by means of flexible connecting conductors 50. Outwardly of the envelope, said pair of stems 48 are each connected with a corresponding conductor wire 51. The inner end of another of said stems 48' may be electrically connected with one end of a gettering member 52, comprising a hollow conductor containing evaporable gettering material, such as barium or the like, said gettering member extending in the space enclosed by the sleeve 42 between the head 23 and the cathode mounting and sealing member 25, the remote end of said gettering member being electrically connected with the stem 24, as at 53. The outer end of the stem 48' may be electrically connected with a flexible conductor 51'.

It will, of course, be understood that X-ray tubes function to produce X-rays in response to the activation of the anode member by impingement thereon of electrons emitted by the cathode. Operation of the tube as an X-ray generator, including electron impingement upon the anode, results in the generation of large quantities of heat within the envelope, and particularly at the anode. In conditioning an X-ray generator for operation, it is necessary to remove not only all of the gas that may be present within the envelope, but also all occluded gas contained in the anode and cathode and in the material of the envelope itself. If such occluded gases are not entirely removed, they will be gradually released within the envelope and impair the exhausted condition at which the generator is designed to operate. Removal of occluded gases may be accomplished by baking or otherwise heat treating the entire tube at a temperature short of the softening point of the glass portions thereof, while maintaining the interior of the envelope under vacuum conditions, and also by heating the electrode elements of the tube to a high temperature, either by operating the cathode for electron bombardment of the anode, or by placing the electrodes in a magnetic field fluctuating at radio frequency.

The envelope, for tube conditioning purposes, may be connected with a suitable molecular exhaust pump, as by connecting the envelope with the pump by means of a connection, as at 54, at the junction 37 of the outer and inner envelope portions 30 and 34.

After all of the occluded gases and impurities have thus been removed from the envelope, the exhaust connection may be sealed off to form a globular seal 55. As a final step of the tube conditioning process, the gettering means 52 may be operated by passing an electric current therethrough to heat the same, in order to volatilize or flash the gettering material and release it in vapor form in the space within the sleeve 42, between the cathode head 23 and the cathode mounting element 45. This space, it will be noted, communicates with the interior of the envelope through the annular channel defined between the skirt 43 and the seal 35. The vaporization of gettering material, such as barium, within the sleeve 42 will form innocuous end products through the combination of any gases, remaining within the envelope, with the metallic gettering vapor which, after combining with any residual gases, becomes deposited as a permanent film upon the interior of the sleeve 42.

Operation of the electron emitting filament 26, in conditioning the tube for service, may be accomplished by applying filament energizing power between the conductors 51. Operation of the gettering element 52 may be accomplished by applying an electrical potential between the conductor 51' and the portions of the stem 24 which project outwardly of the envelope, within the cavity 36. The outwardly projecting end of the stem 24 may be provided with an axially extending, internally threaded opening 56 in its end to facilitate the attachment and electrical connection thereto of a suitable conductor for power application during the gettering operation.

After the tube has been completely conditioned for service, the conductors 51 and 51' may be cut off approximately opposite the outwardly projecting end of the stem 24, and the gettering connection with said outer end of the stem may be removed and discarded, and a connecting commutator 59 may be assembled on the outwardly projecting end of the stem. This commutator, as shown more particularly in Fig. 5 of the drawings, preferably comprises a plate or disk 57 adapted to be mounted on the outwardly projecting end of the stem 24, as by means of a headed screw 58 adapted to be secured in the threaded opening 56. The plate 57 preferably comprises insulating material having a centrally disposed socket 58' opening on one side for receiving the end of the stem 24. On its other side, the plate is preferably formed with an annular rib 60 disposed concentric with respect to the axis of the socket 58', said rib defining a central seat adapted for the reception of a preferably cup-shaped commutator member 61, which may be held in place by the head of the screw 58.

One of the conductors 51 and, if desired, the conductor 51', also, may extend through a duct 62 formed in the disk 57 and electrically connected, as by soldering or otherwise, with the cup-shaped commutator member 61. Outwardly of the rib 60, the disk 57 forms a seat for an outer annular commutator ring 63 which may be secured to the head 57 as by means of screws or other suitable fastening means. The other conductor 51 may extend through a duct 64 and be electrically connected, as by soldering or otherwise, with the commutator member 63. The head 57 of insulating material thus electrically isolates the commutator ring 63 and the conductor 51 connected therewith from the inner commutator member 61 and the conductors electrically connected therewith.

It should be noted that, since the gettering member 52 is electrically connected at 53 with the stem 24, the connection of the conductor 51' with the inner commutator member 61, which is electrically connected with the stem 24 by the screw 58, serves to connect the other end of the gettering element with the stem 24 and thus completely inactivate the gettering member. If, during the service life of the tube, it should become necessary to operate the gettering member, the conductor 51' may be disconnected from the commutator member 61 and the gettering operation may be performed by applying electrical potential between the conductor 51' and the commutator member 61, which is electrically connected with the stem 24.

It will be seen that the commutator assembly

59 affords means for making electrical connection with the filament 26, and that it is disposed within and substantially at the bottom of the envelope cavity or pocket 36. The walls of the pocket 36 are preferably cylindrical and of uniform internal diameter from the commutator 59 to the open end 37 of the pocket; and the pocket is adapted to receive and enclose a power cable 65 for supplying operating power to the cathode. This cable preferably comprises at least a pair of conductors 66 enclosed in suitable insulation and adapted, respectively, to be electrically connected with the filament conductors 51. To this end, the cable 65 is preferably enclosed in an insulating sleeve 67 of relatively rigid material, which may comprise ceramic, plastic, or other self-supporting insulation material, the external dimension of the sleeve 67 being such as to allow free insertion thereof within the pocket 36.

At its distal end, the sleeve 67 is formed with a cavity providing a seat 68 in which is mounted a disk 69, preferably of insulating material having a central portion forming a seat 70 for a preferably metal nut 71, which, as shown, is secured in the seat 70 as by means of a holding screw 72, to which one of the cable conductors 66 is electrically connected. This nut 71 forms a mounting for one end of a preferably helical spring member 73, the other end of which supports and electrically contacts with a ring forming a contact shoe 74. The disk member 69 also forms a seat 75 concentrically around the seat 70, in which seat is mounted a support ring 76, which is secured in place as by means of one or more set screws 77 mounted through the cable sleeve 67 and taking radially into the ring 76, thereby holding the ring and the disk 69 in the distal end of the cable sleeve 67. The ring 76 is electrically connected with the other of the cable conductors 66 and forms a mounting for one end of a preferably helical spring 78, the other end of which supports and electrically connects with a ring 79 forming a contact shoe.

The springs 73 and 78 are disposed concentrically the one within the other, and project from the distal end of the cable sleeve 67 in position supporting the annular shoes 74 and 79 yieldingly in coaxial alinement and equal spacement from the distal end of the cable sleeve 67. The contact shoes 74 and 79 are of electrically conducting material, and are thus electrically connected through the springs 73 and 78 and the mounting members 71 and 76, respectively, with the conductors 66 of the cable. Upon insertion of the cable sleeve 67 into the cavity 36, the shoes 74 and 79, respectively, will be brought into contact and yieldingly held, respectively, against the commutator members 61 and 63, whereby, as the result of inserting the cable sleeve in the pocket 36, the cable conductors 66 will become electrically connected with the conductors 51 and hence with the filament 26.

As shown more particularly in Figs. 4–6 of the drawings, the housing 13 comprises an outer, preferably cylindrical shell 80 of metal, having external screw threads at one end for threaded engagement with a ring 81 forming a retaining gland, having a cylindrical internally threaded portion for engagement with the threaded end of the housing member 80 and an inturned annular retaining flange 82. At its opposite end, the cylindrical shell 80 is provided with internal screw threads 83 for threaded connection with a mounting collar 84. Said collar is adapted to receive and support a mounting ring 85 therein in concentric alinement with the end of the tubular member 80, set screws 86 being provided for securing the ring 85 in the collar 84. The ring 85 carries a sleeve 87 shaped substantially in conformity with the external shape of the outer glass portion of the envelope of the X-ray tube, said sleeve extending within the member 80 to entirely enclose the envelope portions 30 within the casing member 80. The ring 85 also supports a sleeve 88, which extends axially outwardly thereof and encloses the outwardly projecting portions of the sleeve 87. This sleeve 88 also encloses the entire anode end of the X-ray tube, and carries a cover cap member 89 at the terminal end of the sleeve 88.

The anode member 17 is provided with a cavity 90 communicating with the side of the anode member 21 opposite from the target surface 22, said cavity 90 opening at the bottom of the member 17 in a direction away from the target member. The anode member 17 also is provided with preferably threaded bolt openings 91 disposed around the cavity 90. The cover cap member 89 includes a portion adapted to seat upon the end of the anode member 17, and a portion adapted to extend into the cavity 90 behind the target member 21, said portion being provided with a duct 92 adapted to open upon the back of the target member 21. Suitable cap screws 93 may be provided in the cap member 89 in position to threadingly engage in the bolt holes 91 in order to secure the cap member 89 upon the end of the anode member 17.

The cap member is also provided with a duct 94 opening therein upon the cavity 90 at one side thereof. These ducts 92 and 94 communicate, respectively, with radially extending channels 92' and 94' formed in the cap member 89, said radial ducts, respectively, communicating with longitudinal ducts 95 disposed in ribs 96 formed on opposite sides of and along the sleeve 88 from the head 89 to the collar 85. These ducts 95 communicate each with an outwardly opening seat 97 formed in the ring 85 to receive inlet and outlet fittings 98 for connection with a suitable supply of cooling fluid, the collar 86 surrounding the ring 85 being provided with openings opposite the seats 97 to allow for the assembly of the fittings 98 therein through the collar 86.

Cooling liquid may thus be introduced through one of the fittings 98, thence through a semicircular duct 99, in the ring 85, and through one of the ducts 95 to and through the ducts 92 and 92', and delivered in the space immediately behind the target member 21, to thereby cool the same. Cooling liquid may thence circulate from the chamber 90, through the connected ducts 94 and 94', and one of the ducts 95, to the outlet fitting 98.

The cooling arrangement thus is exceedingly simple and readily demountable for access to the anode end of the tube, this facility, in part at least, resulting from the novel arrangement of the entire anode end of the tube as a sleevelike member having the partition wall 18 carrying the target member 21 and dividing the anode member into the generating and cooling chambers 20 and 90 on opposite sides of the integral partition 18. When the tube is in operation as an X-ray generator, electrons emitted by the cathode element 26 will impinge at high velocity upon the target surface 22 and constitute the same as a source of X-rays, in accordance with well known principles. X-rays thus generated at the target surface 22 will be transmitted radially of the

tube and may pass outwardly thereof through windows 100, which may comprise panes of any suitable X-ray pervious material set into and sealed in openings formed in the sleevelike walls of the anode member 17, said windows being disposed closely adjacent the peripheral edges of the target member 21, preferably on opposite sides thereof as shown.

Electron impact upon the target member results in the generation of excessive heat whereby the temperature of the target element, particularly at the target surface 22, may approach the melting temperature of the material at the target surface, the higher the intensity of electron bombardment of the target surface, the higher the temperature to which it will be raised when the device is in operation. The present invention affords most efficient yet simple means for maintaining the temperature of the target member within limits preventing or minimizing the destructive action of electron bombardment on the surface 21, by providing for the delivery and circulation of a cooling fluid immediately behind and in direct heat exchange contact with the target element 21. As a consequence, the X-ray generator may be operated at much higher electrical pressure for the generation of high intensity X-rays without destroying the target.

As shown more particularly in Fig. 4 of the drawings, the cable 65 is secured in place within the socket or cavity 36 by mounting it on the housing 13. To this end, the sleeve 67, within which the end of the cable is mounted, preferably comprises insulating material and is formed with an outstanding rim 101 at its end remote from the connecting commutator 59, said rim extending outwardly of the end 37 and seal 55 of the tube envelope when the same are in mounted position within the housing 13. The marginal edge of the rim 101 may be fitted with a collar 102 of electrical conducting material sized to slidingly fit within the end of the sleeve portion 39 of the housing. This rim provides means for clampingly securing a preferably cylindrical bushing 103 of any suitable insulating material to and in concentric alinement with the member 67, in position extending outwardly of the housing 13 through the clamping gland 81, the bushing 103 embracing and encircling the cable 65 outwardly of the housing. To this end, the bushing 103 has an outstanding flange 103' to which the collar 102 may be clampingly secured, as by means of bolts 102'. The bushing 103 thus may be used as a convenient handle for manipulating the end of the cable when inserting it in the cavity 36.

The cable preferably includes an outer sheath 104 of electrical conducting material, such as woven wire, an extension 105 of which is preferably clamped between the bushing flange 103' and the rim collar 102 in electrical contact therewith through the bolts 102', making contact with the clamping gland 81, whereby said cable sheath 104 is electrically connected with and grounded upon the housing 13. The entire cable end assembly may be held in the housing 13 by means of the removable clamping gland 81, the resilience of the springs 73 and 76 of the commutator assembly serving to yieldingly press the cable end assembly in one direction against the inturned flange 82 of the clamping gland, while at the same time urging the contact shoes 74 and 79 in the opposite direction against the contact members 61 and 63.

It will be seen from the foregoing that the apparatus of the present invention is adapted for easy assembly and disassembly. The cable may be mounted and removed merely by inserting or withdrawing the same and manipulating the clamping gland 81 to secure the cable end in place or to permit of its removal from mounted position in the housing. The cable thus may be applied or removed without disturbing the rest of the assembly. After the cable has been removed, it is likewise possible to dismount the X-ray tube from the housing merely by removing the bolts 93 and withdrawing the tube axially from the housing through its open end which normally carries the clamping gland 81. Removal of the X-ray tube thus may be accomplished without disturbing the assembly otherwise than by removal of the cable and the clamping gland 81. The structure of the X-ray tube itself, including the novel anode structure and also the structure and arrangement of the commutator assembly 59, greatly facilitates the fabrication of the generator.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. The combination of an X-ray tube including a sealed envelope having a metal anode head forming an end of said envelope, said head comprising a sleeve-like side wall and a medial partition, integral with said side wall, means sealing said side wall in said envelope, at one end of said head, said partition having a central opening therein providing a seat facing the opposite end of the head, a target block sealed in said seat and closing said opening, said block forming an electron target facing into said envelope, an electron emitting cathode in said envelope in position facing said target, and means forming an X-ray pervious window in said side wall at the junction thereof with said partition, a housing for receiving said X-ray tube, said housing having a sleeve-like portion snugly enclosing the side walls of said anode head, said sleeve-like portion being formed with fluid inlet and outlet channels extending longitudinally therein, and a removable cover sealed on the envelope remote end of said head to form a cavity therein, in which cavity the back of said target block is directly exposed, said removable cover being formed with ducts therein for connecting said cavity with said channels for the circulation of target cooling fluid into and out of said cavity.

2. The combination as set forth in claim 1, including removable fastening means for securing said cover on said head, said cover and housing having interengaging means for anchoring the tube in said housing when said cover is secured on said head.

3. In an X-ray tube, a sealed envelope having a sleeve-like glass portion and a metal anode head forming an end of said envelope, said head comprising a sleeve-like side wall, in alinement with said sleeve-like glass portion, and a bottom wall forming an anode target facing into the envelope, an electron emitting cathode, in said envelope, in position facing said target, said side wall of said anode head having an X-ray pervious

window formed therein at the juncture thereof with said bottom wall, means forming a peripheral glass-metal seal sealingly connecting said sleeve-like side wall with the end of said sleeve-like glass portion, and a shield for said seal comprising a metal sleeve having an end secured on and within said sleeve-like wall of said anode head, between said window and said seal, and extending thence outwardly of said head, within the sealed end of said sleeve-like glass portion, in position underlying said peripheral seal and extending between said seal and said anode.

4. An X-ray tube, as set forth in claim 3, wherein said shield is formed with spring fastening means at one end thereof and the side wall of the anode head is formed with an inwardly opening keeper notch to latchingly interfit with said fastening means to hold said shield in place on said head in seal shielding position.

5. An X-ray tube, as set forth in claim 3, wherein said shield is formed with spring fastening means at one end thereof and the side wall of the anode head is formed with an inwardly opening keeper notch to latchingly interfit with said fastening means to hold said shield in place on said head in seal shielding position, said side wall of the anode head being formed also with an inclined cam surface over which said fastening means may ride to depress same for entry into said notch.

6. An X-ray tube comprising sealed envelope means, including a glass member having an outer and a re-entrant inner sleeve portion, sealed together at one end of the member and presenting concentrically disposed sealing ends at the opposite end of the member, an anode comprising a metal cup member having a rim sealed to the sealing end of said outer sleeve member, means forming an anode target on the bottom of said cup member, a cup-shaped metal seal member having sleeve-like walls and sealed to the sealing end of the re-entrant sleeve portion, said metal seal member having a bottom formed with a central opening, said inner sleeve portion of the envelope forming a pocket having a bottom at said metal seal member and opening at the remote end of said inner sleeve portion, a cathode structure embodying an electron emitter, a mounting stem supporting the cathode structure in the envelope with the emitter in position facing said target, said stem extending through said central opening in the bottom of said metal seal member and being mounted and sealed on said metal seal member at said opening, and extending into said pocket, a terminal block supported on said stem in said pocket, and emitter leads connected with the emitter within the envelope and extending into said pocket, through glass seals formed in the bottom of said seal member, in position for connection with contact means on said terminal block.

JOHN J. VLACH.

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