July 6, 1937. O. H. PIEPER 2,086,045

X-RAY APPARATUS

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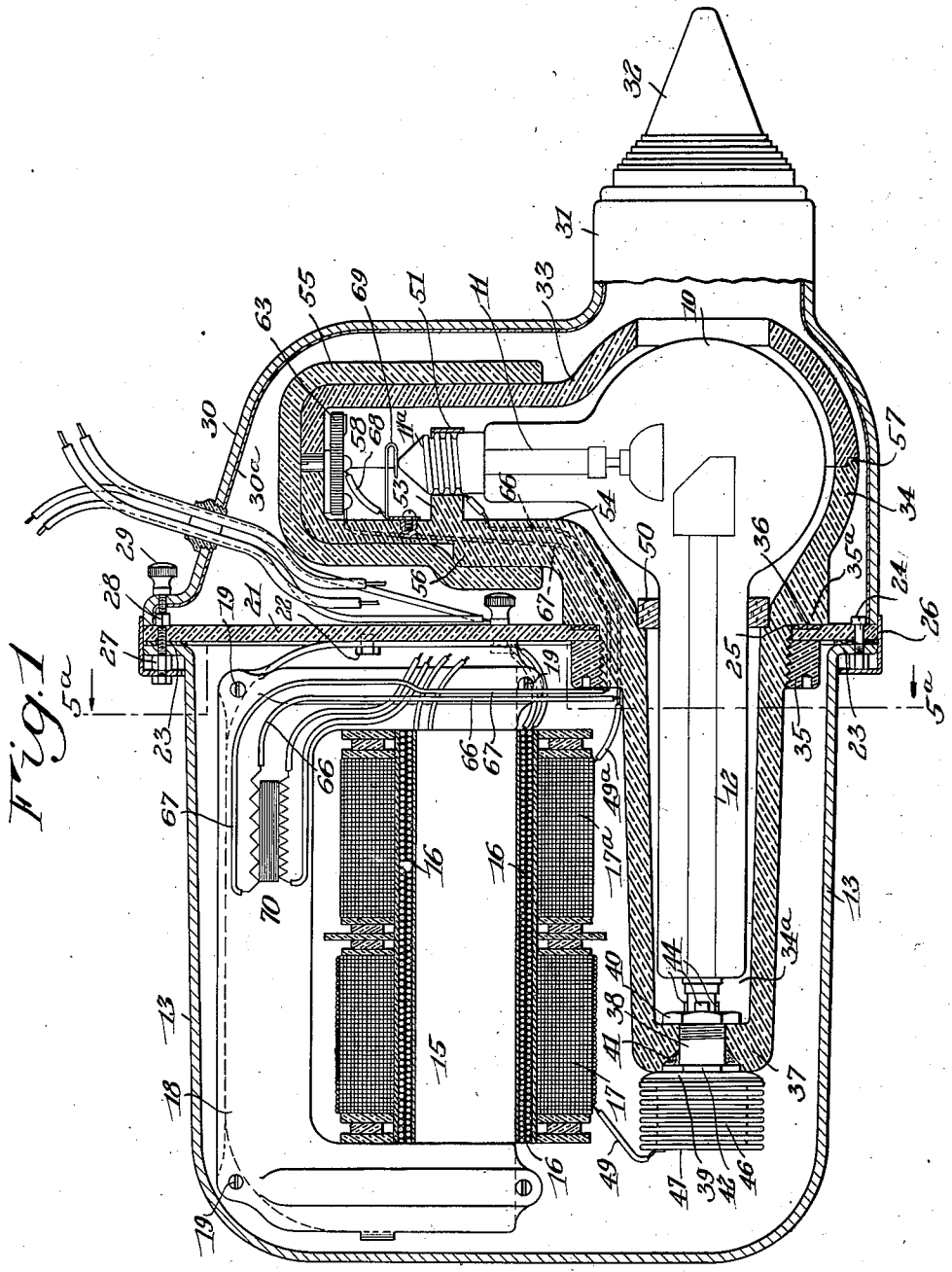

Fig. 1

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Fig. 3

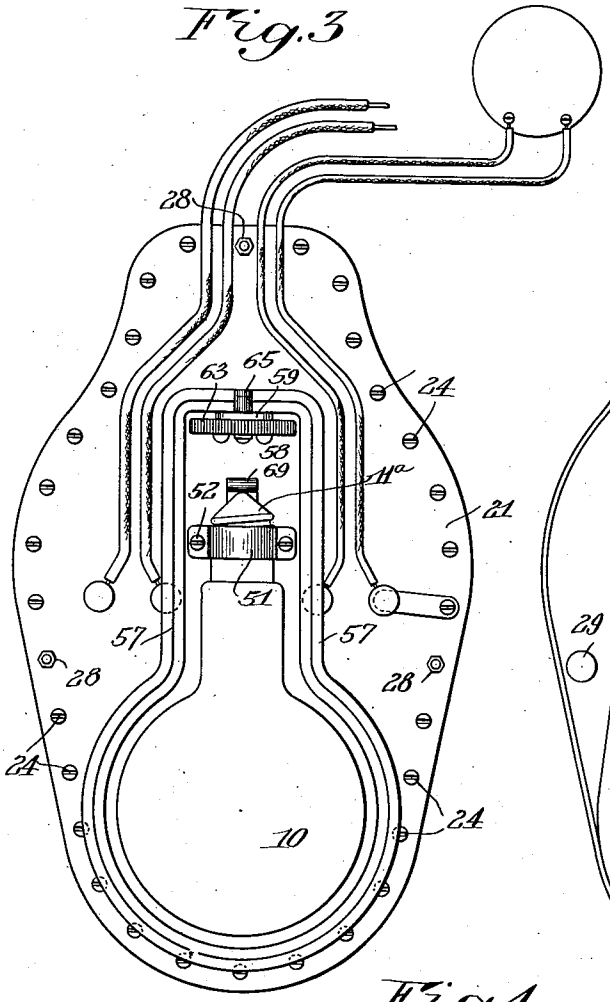

Fig. 2

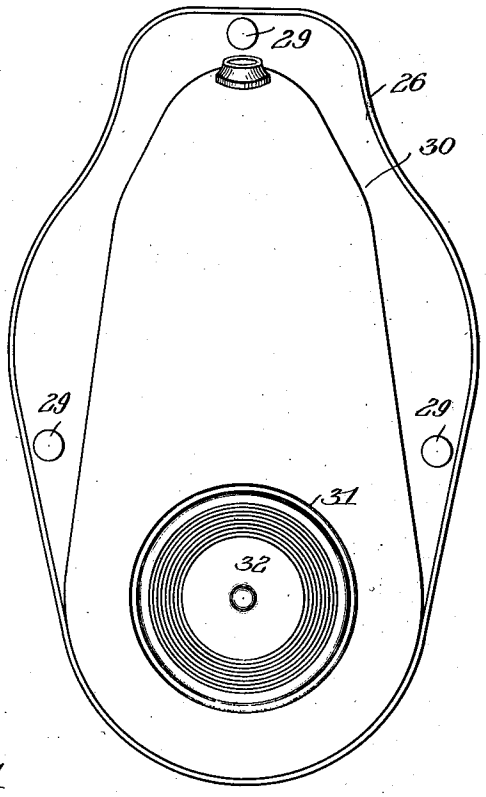

Fig. 4

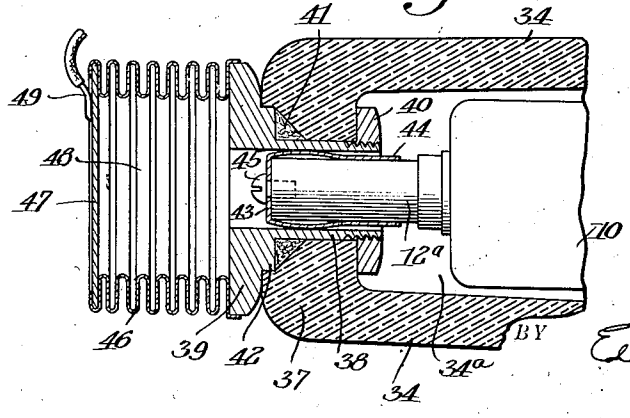

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Fig. 8

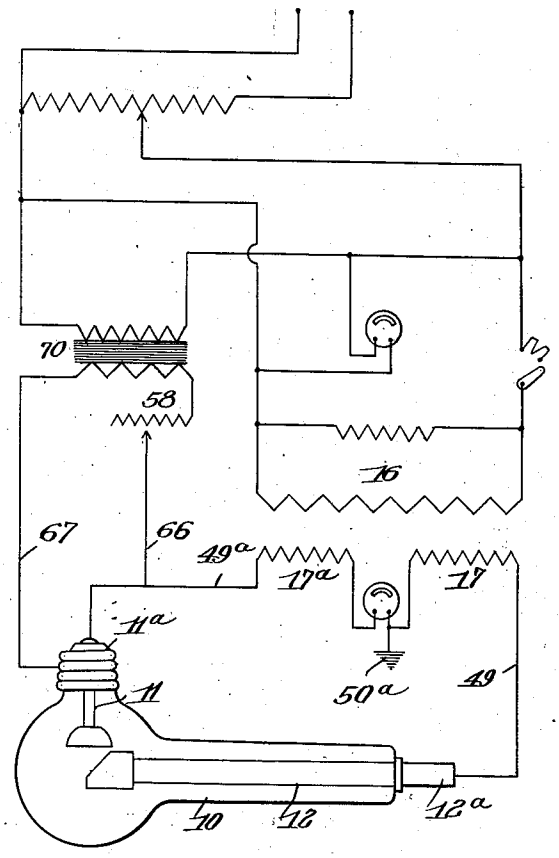


Fig. 5

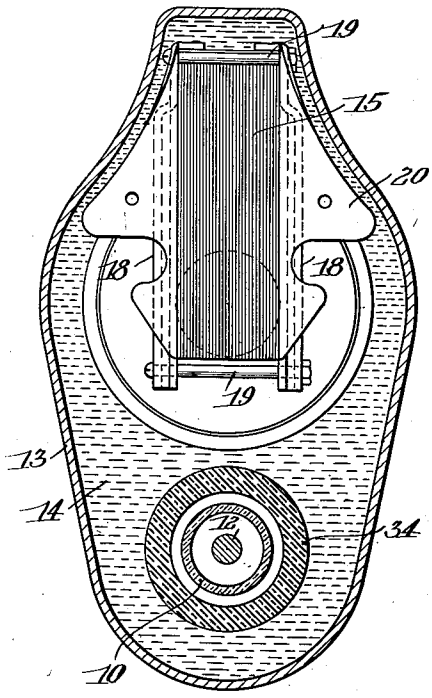


Fig. 7

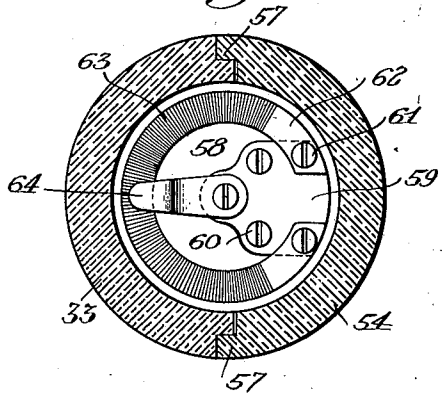
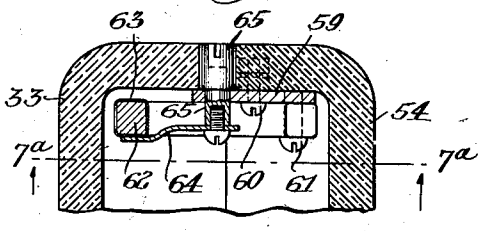


Fig. 6



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UNITED STATES PATENT OFFICE

2,086,045

X-RAY APPARATUS

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Application May 12, 1930, Serial No. 451,640

20 Claims. (Cl. 250—34)

The present invention relates to X-ray apparatus of the type employed in making anatomical examinations as required, for example, in the practice of dentistry, one object of the invention being to provide improvements in apparatus of this class affording a compact dependable and self-contained X-ray tube unit which can be handled with safety under all conditions of operation.

A further object of the invention is to provide in apparatus of this class means by which to effectively insulate the high tension portions of the apparatus in order to eliminate any danger from electric shock by contact with said portions.

A further object of the invention is to provide improved means by which to intercept unemployed rays generated by the tube in order to prevent injurious effects resulting from exposure thereto.

A further object of the invention is to provide improved means for effectively cooling the heated portions of the X-ray tube together with pressure compensating means for relieving pressure due to the heating and expansion of the insulating liquid in the transformer container.

A further object of the invention is to provide an improved insulating housing for the X-ray tube whereby to afford protection from the relatively high voltage of the terminals within the housing and also to provide improved means for preventing discharges from the tube terminals and connections to a casing or other adjacent object.

A further object of the invention is to provide improved variable resistance means for the filament circuit for regulating the operation of the tube.

A still further object of the invention is to provide in apparatus of the present type, certain advantageous structural features affording economy in manufacture and operation and also to provide a unitary arrangement of parts which can be readily assembled and disconnected in case repairs are required from time to time.

To these and other ends the invention resides in certain improvements and combinations of parts, all as will be hereinafter more fully described, the novel features being pointed out in the claims at the end of the specification.

In the drawings:

Fig. 1 is a longitudinal sectional elevation of an X-ray apparatus embodying the invention;

Fig. 2 is a front elevation of the same;

Fig. 3 is an elevation as viewed from the right of Fig. 1 with the front casing and one section of the tube housing removed;

Fig. 4 is an enlarged fragmentary section through the rear end of the housing for the high tension terminal showing the manner of attaching the combined cooling and pressure compensating units which operate within the oil filled container for supporting the transformer;

Fig. 5 is a transverse sectional elevation taken substantially on line 5*a*—5*a* of Fig. 1;

Fig. 6 is an enlarged fragmentary sectional elevation through the filament current regulator located in the housing for the X-ray tube;

Fig. 7 is a transverse section taken substantially on line 7*a*—7*a* of Fig. 6; and

Fig. 8 is a diagrammatic view showing the electrical connections for the tube unit.

Similar reference numerals throughout the several views indicate the same parts.

The present invention embodies generally a compact self-contained unit comprising a container, an X-ray tube, and a transformer, the container having a body of insulating, heat dissipating fluid therein, in which the high tension terminals of the transformer are disposed, the container also having a closed reentrant portion in which one terminal of the tube is extended. The other terminal of the tube is disposed externally of the container and protected by a detachable casing carrying an extension or cone for indicating the direction of discharge of the rays from the tube. The complete unit is adapted to be mounted upon a suitable support, not shown, designed to permit of universal adjustment of the unit to various operating positions.

In the present embodiment of the invention the X-ray tube comprises a bulb 10 in which is sealed a cathode, indicated generally at 11 and comprising the usual or any suitable filament. Also sealed within the tube is the anode 12 disposed at right angles to the cathode whereby to afford a tube of angular construction to reduce to a minimum the overall length of the unit. With this type of tube the ray projecting portion is located externally of the container 13, which latter is preferably constructed of metal and within which one terminal portion of the tube, preferably the anode is extended and provided with heat dissipating means located in oil or other insulating fluid of high dielectric strength with which the container is provided as indicated at 14, Fig. 5.

Disposed within the container and surrounded by the oil is the high voltage transformer comprising generally a core 15, a primary coil or winding 16 and a secondary coil or winding which

is preferably divided into two sections, 17 and 17a. The transformer is supported within the container by oppositely disposed frame-like members 18 clamped upon the core by the transversely extending bolts 19, the frame-like members having flanged portions 20 at their forward ends which are suitably connected to the front wall 21 of the container as by means of the stud bolts 22, Fig. 1. The wall 21 is formed of a suitable insulating material and is connected with the flange 23 of the container by the bolts 24 as shown in Figs. 1 and 3. A gasket or washer 25 is interposed between the flange and wall 21 to afford a liquid tight joint for preventing leakage of the oil from the container. A flanged ring 26, Fig. 1, serves to cover the joint to afford proper finish at this point, the ring being held in position by the bolts 27 which extend through the flange 23 and wall 21, the heads 28 of the bolts being seated on said wall and threaded to receive the inner ends of the thumb screws 29 which serve to clamp upon the wall a conductive grounded casing 30 for enclosing the X-ray tube and its housing externally of the container, said casing being electrically connected with the conductive grounded container 13 by means of the bolts and thumb screws 27 and 29 respectively. The casing is provided with an angularly disposed tubular extension 31 through which the rays are projected, the extension being closed by the usual detachable cone 32, said parts constituting means for aiding the operator in adjusting the unit to properly direct the rays when operating the machine.

The casing is provided with a lining 30a of a material impervious to the rays projected by the tube, such for example as lead which is applied in any preferred manner. By this means the operator and patient are protected from the unemployed rays generated and discharged by the tube, the effective rays being discharged through the extended portion 31 of the casing.

An important feature of the invention resides in the manner of constructing and mounting the support or housing for the tube which is disposed both internally and externally of the container. The housing comprises front and rear sections 33 and 34 respectively, the latter affording a reentrant wall portion forming in effect a continuation of the housing wall 21. The reentrant portion extends beneath the transformer and is surrounded by the fluid as shown in Fig. 1, both sections being formed of a suitable insulating material. The reentrant section 34 is threaded to receive a nut 35 which serves to clamp it upon the front wall of the container, a washer or gasket 36 being employed between the shoulder portion 35a of the section and said wall to prevent leakage of the oil from the container. From this construction it will be noted that the anode terminal of the tube is extended inwardly of the walls of the container which affords a more compact disposition of the parts, while the cathode or filament end of the tube is disposed externally of the container at right angles to the anode. Thus the ray projecting portions are located in advance of the container which is desirable for various reasons including accessibility and convenience in operation. The rear end wall 37 of the reentrant or housing section 34 has projecting therein a conductive sleeve-like member 38 on which is formed at its rear end an annular head 39 abutting the end of the housing on which it is clamped by a nut 40 screwed on the front end of the sleeve to engage the inner face of the end wall 37, Fig. 4. The end wall is recessed to receive a suitable packing 41 for preventing leakage of the oil past the sleeve into the chamber 34a occupied by the anode terminal of the tube. The packing is tightly compressed within the recess by a reduced portion 42 on the head, which is preferably in the form of a nut, and which projects into the recess. The rear end of the anode rod is detachably and yieldably supported within the sleeve by suitable spring means comprising in the present instance a member 43 telescoped upon the extended portion 12a of the rod, said member having a plurality of bowed spring-like fingers 44 extending forwardly on said portion and serving also as heat conducting means between the anode and sleeve 38. The member 43 is detachably secured upon the anode rod, preferably by a screw 45 threaded into the end portion 12a of the rod.

The anode terminal is provided with means serving to both dissipate the heat developed in the tube and to relieve or compensate for any undue increase of pressure within the container resulting from the heating and expansion of the oil or other insulating fluid therein. This means preferably comprises a flexible or expansible hollow diaphragm 46, suitably connected with and supported by the head 39 of the sleeve 38. This construction affords a fluid tight joint, and the free end of the diaphragm is sealed by a closure member 47, whereby a chamber 48 is provided in the diaphragm which is in constant communication with the housing chamber 34a, in which the anode end of the tube is disposed. Communication between these chambers is afforded by reason of the spacings between the spring fingers 44 of the conductive member 43 on the extension 12a of the anode rod, the spacings extending longitudinally to points relatively close to the extremity of said extension. The combined radiator and pressure compensating element 46 may be constructed of any suitable heat conducting material and due to its convolutions the diaphragm will readily expand and contract as well as dissipate the heat generated by the anode terminal. The heat thus radiated is subjected to the cooling action of the oil and is carried away and dissipated by the latter. When the temperature of the oil rises above a certain degree, the increased pressure is relieved by a reduction in the capacity of the pressure compensating diaphragm, the flexible walls moving closer together under the higher pressures and expanding as the temperature decreases. It is apparent from Fig. 4 that the anode terminal of the tube is electrically connected with the closure 47 of the diaphragm by means of the intervening parts all of which, including the closure are formed of current conducting material. Connected with the closure 47 is a conductor 49 which extends to one of the secondary or high tension coils of the transformer, as best shown in Fig. 1. It will be understood however that if preferred the conductor may extend directly to the anode rod or to any suitable conductive part connected therewith.

The tube in addition to being supported at its rear end as described is also supported at a point adjacent the target portion of the anode by a ring or collar 50, Fig. 1, which is preferably formed of somewhat elastic or yieldable material, such for example, as cork. This collar may be frictionally or otherwise held within the wall of the housing section 34 and permits the tube to be readily withdrawn when the necessary parts have been removed. The tube is further supported

within the housing by the use of a clamping member 51 engaging the terminal portion 11a of the tube, the clamping member being secured by screws 52 threaded into a forwardly extending lug or projection 53 on the vertically disposed wall 54 of the rear housing section 34, Fig. 1.

Means has been provided for more effectively insulating the terminal portions of the cathode end of the tube to prevent discharges across the air gap between said portions and the wall of the casing 30 opposite thereto. This means comprises an inverted boot or hood 55 inserted over and surrounding that portion of the housing containing the cathode end of the tube and the portions of the circuit connections therein. The hood is formed of a material suitable for intercepting any discharges tending to bridge the gap between the casing 30 and the terminal or terminal portions of the tube within the housing. The hood is formed of a suitable insulating material such as a phenol condensation product, and is forced over the cylindrical-like end of the housing and caused to engage and hold the removable outer section 33 of the housing in position upon the rear section 34. It will be seen therefore that the hood functions both as retaining means for the housing section 33 and as an insulating element to prevent the discharge of current across the air gap between the housing and the casing 30.

The upstanding wall 54 of the housing is provided with a reinforcing portion 56 to increase its thickness at the point in which portions of the terminal connections leading to the filament are imbedded. It will be noted that the lower extremity of the hood, at its rear side, is offset and extended downwardly in engagement with the reinforcing portion 56 of the housing. The hood as stated above serves to retain the section 33 of the housing in position and can be readily removed when desired. The front end of the rear housing section 34 is provided with a portion 57 forming a supporting shoulder for the front section 33 whereby the latter is held against vertical displacement upon the rear section.

By removing the thumb screws 29 the casing 30 which is attached independently of the housing, can be readily removed from the container to permit removal of the hood and the front section 33 of the tube housing. When this has been done and the tube clamping element 51 removed the X-ray tube can be readily withdrawn from the rear section of the housing without having to disconnect any other parts. This simplified method of removing and securing the parts is not only advantageous in assembling the various sections of the complete unit, but also in making repairs, as in case it may become necessary to remove a defective tube and to substitute a new one therefor. It will be seen therefore that removal of the tube can be readily effected without breaking any of the sealed joints of the oil container, the anode terminal being withdrawn from its sleeve-like socket 38, which is closed at all times by a diaphragm 46. The housing element 34 therefore affords a fluid tight receptacle extending inwardly of the container and sealed against the passage of the fluid surrounding the same.

Located within the upper extremity of the tube housing is a rheostat or current regulator 58 comprising a support 59 attached by screws 60 to the end wall of the fixed section 34 of the housing, Fig. 6. Connected with the support 59 as by means of screws 61 are the opposite ends of a split ring 62 on which is wound the resistance 63, Fig. 7. The movable element 64 of the rheostat is suitably connected to a post 65 journaled in the support 59 and having an operating head extending through the wall of the housing and slotted to receive a suitable tool for rotating the post and the adjustable contact thereon whereby to effect proper regulation of the current flowing to the filament. It will be understood from this construction that upon removal of the hood 55 the front section 33 of the tube housing can be withdrawn without disturbing the rheostat, all parts of which are supported by the upstanding wall 54 of the rear section of the housing.

Imbedded or molded within the upstanding wall 54 of the housing is a pair of conductors 66 and 67, the former being connected with the terminal portion 11a of the tube and the latter with one end of the resistance 63 of the rheostat. The connection between the rheostat 58 and the tube terminal 11a comprises a short conductor 68 connected with a spring-like contact 69 suitably secured to the wall 54 of the housing as best shown in Fig. 1 and yieldably engaging the terminal portion 11a of the tube.

A separate transformer 70 is provided for supplying current to the cathode filament as indicated in Figs. 1 and 8. The secondary coil of the transformer 70 is connected with the cathode terminal of the tube by the conductors 66 and 67, the current passing through the rheostat 58 by which it is regulated. The portion 17 of the secondary winding of the main transformer is connected with the portion 12a of the anode terminal of the tube, the portion 17a of the secondary winding being connected with conductor 66 by a short connection 49a. In the circuit arrangement shown in Fig. 8 the main transformer secondary has a ground connection 50a intermediate its terminals which in the present instance is disposed at the middle point of the transformer.

I claim:

1. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, said container having a hollow reentrant portion, a transformer in said fluid, an X-ray tube having one of its terminal portions disposed within said reentrant portion and connected with the transformer, and a hollow pressure compensating element within the fluid, said element having a conductive sleeve forming a socket for the last mentioned terminal portion of the tube, said sleeve establishing communication between said hollow element and said reentrant container portion.

2. In an X-ray apparatus, the combination of a container having therein fluid of high dielectric strength other than air, a transformer within the container, an X-ray tube having angularly disposed terminal portions one of which extends inwardly of the container and the other exteriorly thereof, a housing for the tube connected with the container and including separable sections, one of the sections detachably receiving and supporting the anode terminal of the tube within the container, means electrically connecting the anode terminal with the transformer, and a detachable casing on the container enclosing the housing section disposed exteriorly of the container, said casing being formed in part of material substantially impervious to the rays projected by the tube.

3. In an X-ray apparatus, the combination of a container having therein insulating fluid of high dielectric strength other than air, a transformer in said fluid, an X-ray tube having one of its terminals located exteriorly of the container and

the other extending inwardly thereof and connected with the transformer, supporting means for the tube connected with the container, and a detachable hood of insulating material on the supporting means substantially surrounding the terminal portion of the tube disposed exteriorly of the container.

4. In an X-ray apparatus, the combination of a container having therein fluid of high dielectric strength other than air, a transformer in said fluid, an X-ray tube having its cathode terminal located exteriorly of the container and its anode terminal extending inwardly thereof and connected with the transformer, supporting means on the container for the tube, a detachable insulating hood on the supporting means substantially surrounding said cathode terminal, and a conductive grounded casing enclosing the hood and that portion of the tube disposed exteriorly of the container.

5. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in the fluid, an X-ray tube having its ray projecting portion and one of its terminal portions disposed exteriorly of the container and the other extending inwardly thereof and connected with the transformer, a housing connected with the container and enclosing the ray projecting and cathode terminal portions of the tube, circuit connections leading to the cathode terminal through the housing, current regulating means interposed in said circuit connections, said means being located within the housing, and a detachable insulating hood enclosing that portion of the housing containing said current regulating means.

6. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer within the fluid, an X-ray tube connected with the transformer, a housing for the tube connected with the container and formed of separable sections one of which is detachably positioned upon the other, and a hood substantially surrounding that portion of the housing containing one of the terminals of the tube, said hood serving to secure the detachable housing section in position.

7. In an X-ray apparatus, the combination of a container having insulating fluid therein other than air, a transformer in the fluid, an X-ray tube having its anode terminal connected with the transformer, the cathode and ray projecting portions of the tube being located exteriorly of the container, a housing for the tube connected with the container, circuit connections extending to the cathode terminal of the tube, and current regulating means interposed in said connections, said regulating means being disposed within the housing and adjustable through the wall thereof from a point exteriorly of the container.

8. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer having its terminals in said fluid, an X-ray tube having its cathode terminal and ray projecting portion located exteriorly of the container and its anode terminal extending inwardly thereof and connected with one of the terminals of the transformer, a connection between the other transformer terminal and said cathode terminal, a housing for the tube projecting from and extending inwardly of the container, and a detachable hood of insulating material substantially surrounding that portion of the housing containing the cathode terminal of the tube.

9. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in the fluid, an X-ray tube having its cathode terminal located exteriorly of the container and its anode terminal extending inwardly thereof and connected with the transformer, a housing for the tube comprising a section fixed upon and projecting inwardly of the container and a detachable section mounted on the fixed section exteriorly of the container, and a hood formed of insulating material disposed upon that portion of the housing containing the cathode terminal of the tube and serving to secure said detachable section upon the fixed section.

10. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in the fluid, an X-ray tube having one terminal connected with the transformer, a housing for the tube connected with the container and including a section formed of insulating material, and circuit connections extending to the other terminal of the tube, said connections having portions thereof substantially paralleling and imbedded within and insulated by a wall of said housing section.

11. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer within the fluid, an X-ray tube having its cathode terminal and ray projecting portion located exteriorly of the container and its anode terminal extending inwardly of the container, current conducting means connecting said anode terminal with the transformer, a housing for the tube comprising detachably connected sections, one of the sections being formed of insulating material and fixed upon the container, and circuit connections extending to the cathode terminal of the tube, said connections being imbedded within and insulated by said fixed housing section.

12. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in said fluid, an X-ray tube having one of its terminals mounted exteriorly of the container and another extending therein, a housing for the last mentioned terminal lying within the container and having a rigidly secured sleeve-like bearing thereon in which said last mentioned terminal extends, and a combined heat dissipating and pressure compensating element disposed within the container and movable relative to said bearing and electrically connected in all of its positions with said transformer and one terminal of said tube.

13. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, said container having a wall portion forming a receptacle extending inwardly of the container, a transformer in said fluid, a sleeve-like bearing rigidly secured on the receptacle within the container, an X-ray tube having one of its terminal portions extending within said receptacle and projecting within said rigidly secured sleeve-like bearing, and a combined heat dissipating and pressure compensating element disposed within the container and serving as a seal for the receptacle independently of the tube.

14. In an X-ray apparatus, the combination of

a container having therein a fluid of high dielectric strength other than air, a transformer in said fluid, an X-ray tube having its anode terminal extending inwardly of the container, a hollow pressure compensating element within the fluid having a sleeve thereon receiving said anode terminal and electrically connected therewith, means rigidly securing the sleeve within the container, and means electrically connecting said element with the transformer.

15. In an X-ray apparatus, an X-ray tube, a housing formed of separate sections and in which the tube is detachably mounted, said housing being formed of molded insulating material, circuit connections for a terminal of the tube embedded within the wall of the housing, the material of the housing being molded about the connections to insulate the same, and a hood of insulating material surrounding portions of said sections and serving to secure one section upon another.

16. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in said fluid having its secondary winding grounded at a point intermediate the terminals thereof, said container having a re-entrant wall portion, an X-ray tube associated with the container and having one of its terminals extending within said re-entrant wall portion and having its other terminal connected with one of said secondary terminals, a rigidly secured supporting part on said re-entrant wall portion receiving the extremity of the tube terminal extending within said wall portion, a pressure responsive heat radiating part immersed within the fluid and connected with said rigidly secured part, and means within the fluid electrically connecting one of said parts with the other of said secondary terminals.

17. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in said fluid, an X-ray tube having one of its terminal portions extending inwardly of the container, a fixed housing within the container for said last mentioned terminal portion, and a combined radiator and pressure compensating variable capacity element located within the fluid and having its interior sealed against the passage of the fluid thereto by said housing, said element being electrically connected with the transformer and the terminal portion of the tube within the housing.

18. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in said fluid, said container being provided with a reentrant wall portion, an X-ray tube having its anode terminal extending within said reentrant wall portion, and a yieldable hollow pressure compensating element within the container sealed against the passage of the fluid to the interior thereof and formed of heat conducting material, said element having a supporting part on said wall in conductive relation with respect to said anode terminal and secured against movement relative to said reentrant wall portion and having another part electrically connected with the transformer through said fluid.

19. In an X-ray apparatus, the combination of a container having therein a fluid of high dielectric strength other than air, a transformer in said fluid, said container being provided with a reentrant wall portion, an X-ray tube having its anode terminal extending within said reentrant portion, and a hollow pressure compensating element within the container sealed against the passage of the fluid thereto and formed of heat conducting material and having a supporting portion on said wall in conductive relation with respect to said anode terminal and secured against movement by said compensating element, the latter having another portion conductively connected with the transformer through said fluid.

20. In an X-ray apparatus, the combination of a container having a body of insulating fluid therein, a transformer having its high tension terminals immersed in said fluid body, an X-ray tube having its cathode terminal arranged exteriorly of the container and connected with one of the high tension terminals of said transformer and having its anode terminal extending inwardly of said container, a hollow pressure compensating heat radiating element within the container having a metal sleeve thereon within which the inner end of said anode terminal is extended, and supporting means within the container for said anode terminal forming a closure for said sleeve, said sleeve being rigidly held by said means against movement by said compensating element, said element being electrically connected with the other high tension terminal of the transformer and with said sleeve.

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