May 17, 1927. 1,628,699

F. H. WAPPLER ET AL

X-RAY APPARATUS

Filed Dec. 7, 1923 3 Sheets-Sheet 1

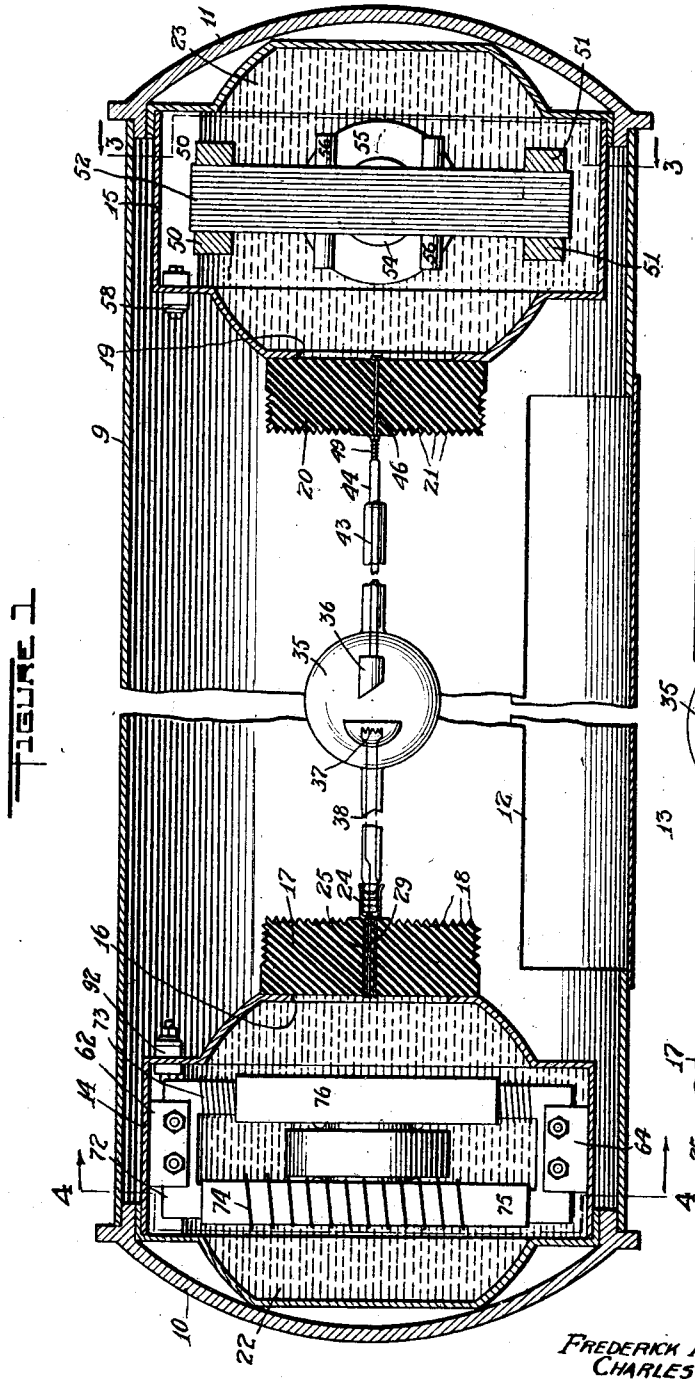


FIGURE 1

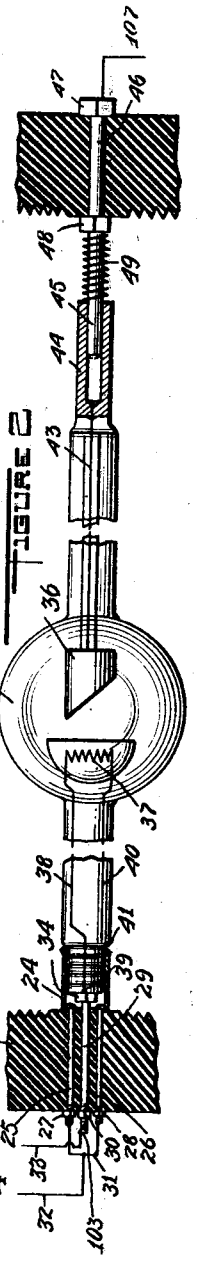


FIGURE 2

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FIGURE 7

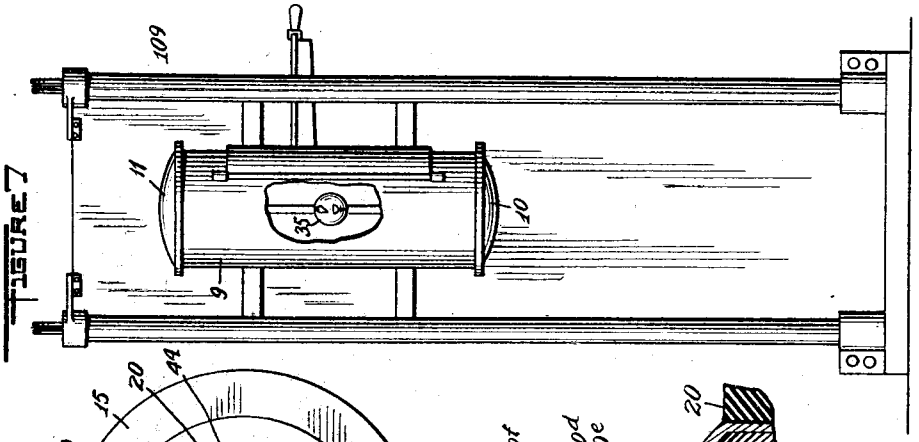


FIGURE 6

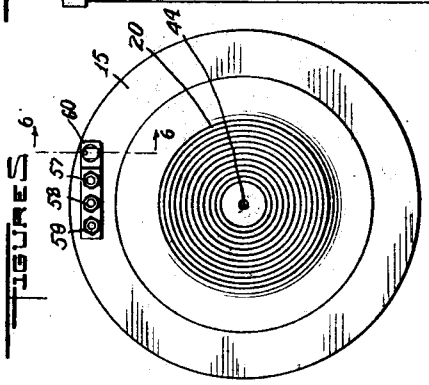


FIGURE 5

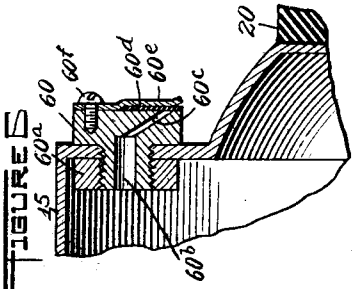


FIGURE 3

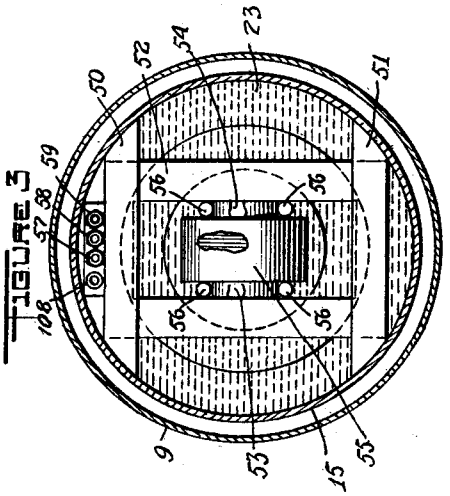
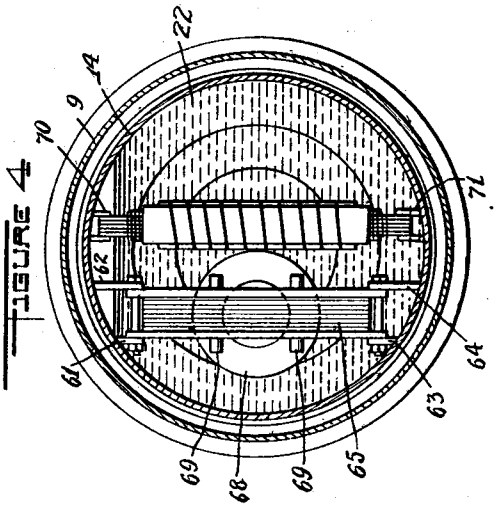


FIGURE 4



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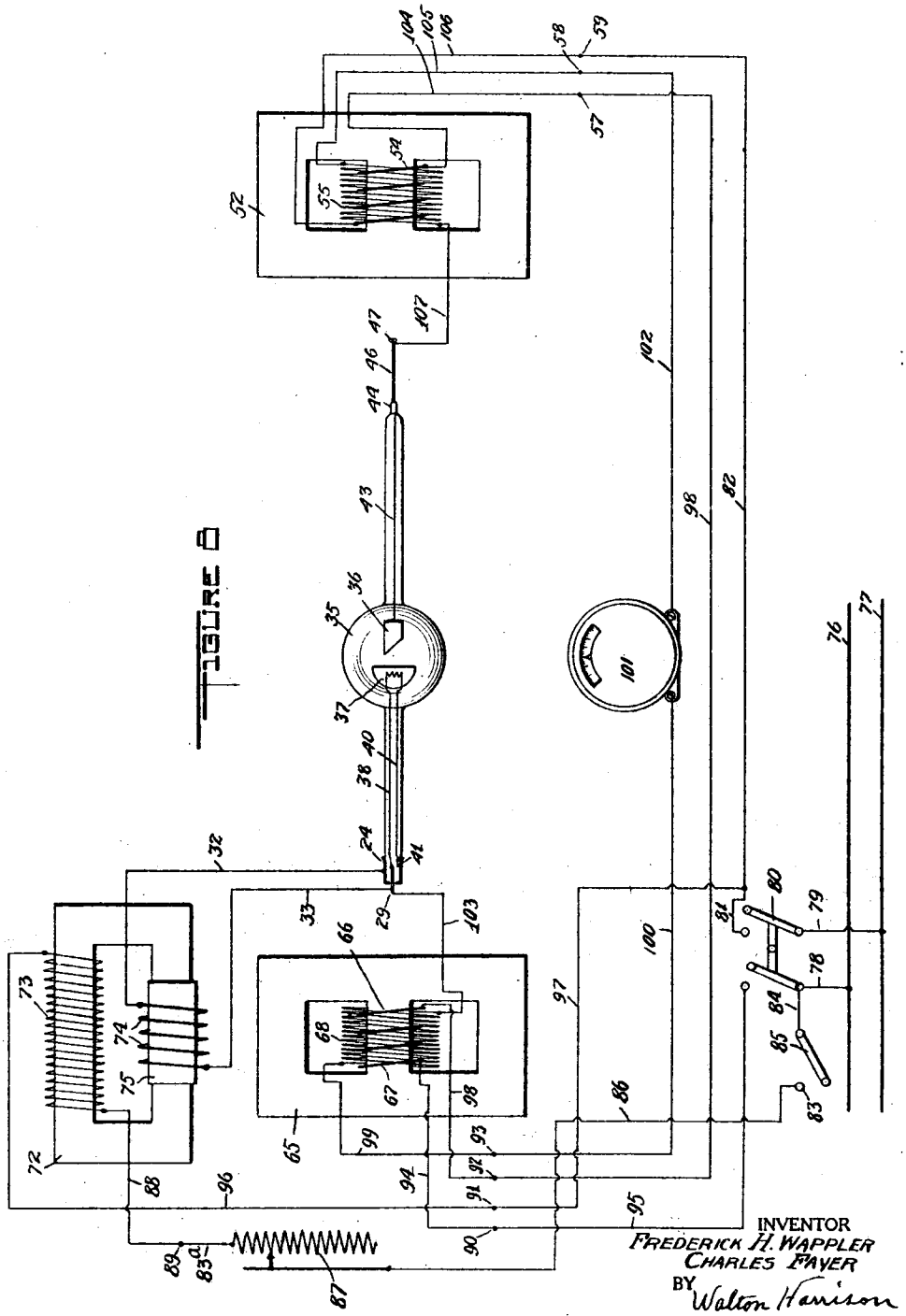


FIGURE 6

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UNITED STATES PATENT OFFICE.

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X-RAY APPARATUS.

Application filed December 7, 1923. Serial No. 679,081.

Our invention relates to the style of apparatus in which the transformers for energizing the X-ray tube are located as nearly as practicable at the ends of the tube, and also to apparatus in which the X-ray tube is housed within a hollow shield in order to protect operators and bystanders from the deleterious effects of stray X-rays.

We seek to produce an X-ray apparatus including a hollow metal X-ray shield and a plurality of transformers housed therein for controlling the main discharge and also for controlling an electron discharge if one be used, the transformers being submerged in oil, the X-ray tube being so mounted and spaced within the hollow shield as to be insulated by the air or gases therein contained, and to be easily removed and replaced.

More particularly stated, our invention contemplates a number of improvements in X-ray apparatus of the type above mentioned, among which are the following:

I. To generate the high potential currents for the main discharge of the X-ray tube by means of powerful but light and compact transformers, submerged in oil contained in metal casings, these casings each being detachably mounted within the cylindrical X-ray shield.

II. To so mount the X-ray tube within the cylindrical X-ray shield that the X-ray tube is at all times insulated from the X-ray shield and parts therein contained, by means of air or such other gaseous medium as may be contained within the X-ray shield.

III. To provide improved mountings for the X-ray tube, in order to facilitate its easy removal and replacement relatively to the X-ray shield and the various parts contained therein.

IV. To improve the insulation of the X-ray tube relatively to surrounding objects within the X-ray shield, independently of the insulation afforded by the oil transformers.

V. To improve the construction and arrangement of the transformers and the casings in which they are contained with oil, in order to facilitate detachably mounting these parts within the cylindrical X-ray shield.

VI. To so mount the oil transformer casings detachably within the hollow X-ray shield as to enable them to be removed or replaced independently of each other.

VII. To avoid the development of excessive potential strains by using, for purposes of the main discharge, a plurality of separate transformers housed within separate casings and yet connected in series.

VIII. To provide the X-ray shield with improved mountings, so constructed and arranged that, by merely mounting the X-ray tube within the hollow X-ray shield, various contact members are automatically fitted together so as to establish the various electrical connections used for energizing the X-ray tube.

IX. To provide an improved value mechanism for each transformer casing in order to permit egress therefrom of air or gases driven out whenever the tranformer becomes heated from use, but without permitting atmospheric air to pass through the valve mechanism and into the X-ray shield.

X. To provide mountings for supporting the transformers within the oil casings.

Reference is made to the accompanying drawing forming a part of this specification, and in which like reference characters indicate like parts throughout the several figures.

Figure 1 is a central longitudinal section through a hollow X-ray shield of substantially cylindrical form, provided with our invention.

Figure 2 is a central fragmentary section through the X-ray tube and its mountings, whereby it is detachably supported as contemplated by Figure 1.

Figure 3 is a section on the line 3—3 of Figure 1, looking in the direction indicated by the arrows.

Figure 4 is a section on the line 4—4 of Figure 1, looking in the direction indicated by the arrows.

Figure 5 is an end elevation of one of the transformer casings.

Figure 6 is a section on the line 6—6 of Figure 5, looking in the direction indicated by the arrows.

Figure 7 is a front elevation of an X-ray shield like that appearing in Figure 1, but showing the same as supported vertically upon a tube stand.

Figure 8 is a diagram of the wiring and various electrical connections.

An X-ray shield appears at 9, and has the general form of a cylinder. It is made of metal and is provided at its ends with a pair of end caps 10 and 11, each detachably fitted into position. The shield is further provided with an opening 12, and with a door 13 for closing this opening.

Mounted within the ends of the cylinder just described, and carried by the end caps 10 and 11, are a pair of transformer casings 14 and 15, alike in construction, and appearing in cross section as indicated in Figure 1.

These casings 14 and 15 are each made of sheet metal and circular in cross section, as may be understood from Figures 3 and 4.

The casing 14 is mounted within and carried by the end cap 10, the casing 15 being similarly mounted within and carried by the end cap 11. By this arrangement either end cap when removed carries with it one of the transformer casings.

The casing 14 is provided with an opening 16, closed by a block 17 of insulating material, such as hard rubber, or porcelain, having the general form of a massive disk and provided with corrugations 18 for improving its insulating qualities.

The casing 15 is provided with an opening 19 closed by a block 20, this block being provided with corrugations 21 and having substantially the same form as the block 17.

The casings 14 and 15 respectively act as receptacles and each normally holds a volume of oil, as indicated at 22 and 23.

The block 17 of insulating material carries a sleeve 24 of conducting material, held upon it by a pair of metallic bolts 25, 26, these bolts extending through it and being fitted with nuts 27 and 28, as shown in Figure 2. Another bolt 29 extends through the block 19, and is fitted with a nut 30. This bolt serves as a contact member. A wire 31 extends from the bolt 26 to the bolt 25, and connected with this wire 31 is another wire 32. A wire 33 is connected with the bolt 29. The wires 32 and 33 are located within the transformer casing 13 and are used in energizing the X-ray tube, as hereinafter described.

A nut 34 is fitted upon the outer end of the bolt 29, and is used as a contact member.

The X-ray tube is shown at 35, and contains an anode 36 and a cathode 37. The cathode is in this instance a so-called glower cathode and consists of a wire or filament, adapted to be heated. Connected with the cathode 37 is a wire 38, which leads to a contact member 39. Another wire 40 is connected with the cathode at 37, and leads therefrom to a contact sleeve 41, carried by the X-ray tube. The contact sleeve 41 is proportioned, adapted and arranged to be detachably fitted into the contact sleeve 24 carried by the block 17 of insulating material; and the contact member 39, also carried by the X-ray tube, is adapted for detachable engagement with the nut 34, which as above described serves as a contact member.

A wire 43 extends from the anode 36 to the adjacent end of the X-ray tube, and is there connected with a contact member 44, made of metal and having the form of a tubular sleeve. Detachably fitting into this tubular sleeve is a contact bolt 45, which extends through the block 20 of insulating material, and is provided with a head 47 and fitted with a nut 48. Encircling the contact bolt 45 is a spiral spring 49; which, with the parts in position as indicated in Figures 1 and 2, presses in one direction against the nut 48 and in the opposite direction against the tubular contact sleeve 44.

We will now describe the transformer mechanism located within the casing 15, and shown in Figure 3 and at the right in Figure 1. Cross bars 50 and 51 are mounted within the casing 15, and supported by these cross bars is an H-type transformer core 52. This transformer core is provided with a middle bar 53, and carried by this bar is a primary winding 54. A secondary winding 55 encircles the primary winding 54. Insulating pins 56 are wedged in between the secondary winding 55 and the core 52, as indicated in Figures 1 and 3, so as to hold the secondary winding firmly in position and to properly maintain the spacing between the secondary winding and the core.

Binding posts 57, 58 and 59, carried by the casing 15 and properly insulated, are used in making various electrical connections.

A valve 60, having the form shown more particularly in Figure 6, is mounted upon the casing 15. The purpose of this valve is to permit egress of any vapors or gases formed within the casing in consequence of the heating of the oil 23, by action of the transformer. The valve 60 has the form of a short bolt, and is threaded and fitted with a nut 60^a. The valve is further provided with a passage 60^b, this passage having a portion 60^c extending outwardly as shown in Figure 6, and covered with a leaf 60^d of soft rubber. Fitted over the leaf 60^d is a leaf spring 60^e, serving as a clamp for holding the leaf and for pressing it against the face of the valve, thus normally closing the passage thereof. A screw 60^f holds the spring in position.

While the valve readily permits the outer passage of any gases or vapors formed within the casing, it does not permit the entrance of air into the casing.

The casing 14 is in many respects similar to the casing 15 just described.

The casing 14 is provided with a number

of lugs 61, 62, 63, 64, and supported upon these lugs is an H-type transformer core 65, provided with a middle bar 66. This middle bar carries a primary winding 67 and a secondary winding 68, these windings and the H-type core together constituting a high tension step-up transformer.

A number of insulating pins 69 are used for the purpose of holding the secondary winding 68 firmly in position, and of spacing it from the adjacent portions of the transformer core.

The casing 14 is further provided with lugs 70 and 71, and mounted upon these lugs is a closed transformer core 72, carrying a primary winding 73 and a secondary winding 74. The secondary winding is wound around a sleeve 75 of rubber or other good insulating material, this sleeve encircling a portion of the transformer core. The parts just mentioned constitute a small step-down transformer, used for supplying currents to heat the filament of the X-ray tube as hereinafter described. This transformer is usually designated as the heating transformer.

A pair of mains or other conductors used for supplying alternating current are shown at 76 and 77. From these mains two wires 78 and 79 lead to a double-pole switch 80. Connected with this switch is a wire 81, and connected with this wire is a wire 82, leading to the binding post 59, carried by the casing 14 as above described.

A wire 84 is connected with the wire 78, and leads therefrom to a switch 85. Connected with this switch is a wire 86 which leads to a variable resistance 87, serving the purpose of a regulator for controlling the current supply to the heating transformer. From the variable resistance 87 a wire 83^a leads to a binding post 89, and from the latter a wire 99 leads to the primary winding 73 of the step-down transformer used in connection with the heating of the filament of the X-ray tube, as elsewhere described.

The casing 14 is provided with binding posts 90, 91, 92, 93, properly insulated from it, and used in making various electrical connections. The wire 94 leads from the binding post 90 to the primary winding 67, and a wire 95 leads from the binding post 90 to the double switch 80.

A wire 96 leads from the binding post 91 to the primary winding 73 of the heating transformer. A wire 97 leads from the binding post 91 to the wires 81 and 82. Connected with the binding post 92 is a wire 98, which leads therefrom to the primary winding 67. A wire 98 is also connected with the binding post 92, and leads across to the other casing 15 and is connected with the binding post 57 carried thereby. A wire 99 leads from the secondary winding 68 to the binding post 93, and from the latter a wire 100 leads to a meter 101, used for measuring the secondary currents of the main discharge. From this meter a wire 102 leads to the binding post 58. A wire 103 is connected with the secondary winding 68 of the main transformer, and leads therefrom to the contact bolt 29 above described.

A wire 104 leads from the binding post 57 to the primary winding 54. A wire 105 is connected with the binding post 58, and leads therefrom to the secondary winding 55. A wire 106 leads from the binding post 59 to the primary winding 54.

The casing 14 is provided with a valve 108, similar to the valve 60 above described, and shown more particularly in Figure 6.

As may be noted from the foregoing description, the high potential currents for maintaining the main discharge through the X-ray tube are produced by transformers which, though powerful and submerged in oil, are nevertheless light and compact; and that the separate casings containing the transformers and the oil for insulating the same are each detachably mounted within the X-ray shield.

Although the X-ray tube, when in position and ready for active use, is located between the pair of oil transformers mounted within the X-ray shield, the insulation enveloping the tube is merely air or such gases or vapors as may be contained within the hollow X-ray shield.

To remove or replace the X-ray tube is a very easy matter, offering as a rule little or no more complication than would be required to fit an electric lamp bulb into a socket or to remove the same therefrom.

The mountings from the X-ray tube are so arranged that when the X-ray tube is in position it is insulated relatively to surrounding objects located within the X-ray shield, its insulation for this purpose being due to the spacing of the tube from the other parts and thus being independent of the insulation afforded by the oil in connection with the transformer.

The form, construction, and arrangement of the transformers and of the casings containing the same are such as to facilitate the mounting of these parts detachably within the cylindrical X-ray shield.

The transformer casings, because mounted upon the end caps of the X-ray shield, may each as a unit be quickly and easily replaced independently of the other.

We avoid the development of excessive potential strains by separating the main transformers and housing them separately within different portions of the X-ray shield, and thus at opposite ends of the X-ray tube. With the transformers thus arranged but connected in series through the tube, we obtain a potential adequate for purposes of

the X-ray tube, and yet we so localize and distribute this potential as to render it harmless.

The various contact members carried by the X-ray tube and other contact members carried by the X-ray shield are so arranged that the operator, in order to properly establish all of the connections necessary for energizing the X-ray tube, need do nothing more than merely place the X-ray tube in position, by hand, within the X-ray shield; and in order to properly undo various connections, he simply removes the X-ray tube from its mountings.

It will be observed in addition that by means of the valves used upon the transformer casings, provision is made for the escape therefrom of air, vapors or gases, arising from the action of the transformers.

It is clear, therefore, that for the reasons above stated the efficiency of our device is very great in proportion to its size, weight and mechanical strength.

Assuming the switches 80 and 85 to be closed, the various circuits may be traced as hereinafter described.

A circuit may be traced through the primary windings of the main transformers, as follows:

Main 76, wire 78, left-hand portion of double switch 80, wire 93, binding post 90, wire 94, primary winding 67, wire 98, binding post 92, wire 98, binding post 57, wire 104, primary winding 54, wire 106, binding post 59, wire 82, wire 81, right hand portion of double switch 80, wire 79, main 77 to source of electrical supply (not shown), and thence back to the main 76.

This circuit energizes the primary windings 67 and 54 of the main transformers.

A circuit through the secondary windings of the transformers just mentioned may be traced as follows:

Secondary winding 68, wire 99, binding post 93, wire 100, meter 101, wire 102, binding post 58, wire 105, secondary winding 55, wire 107, bolt 46, sleeve 44, wire 43, anode 36 of X-ray tube 35, cathode 37, wire 38, contact bolt 29 and wire 103, back to secondary winding 68. The circuit thus traced is the circuit of the main discharge, through the X-ray tube.

A circuit may be traced through the primary winding of the heating transformer, as follows:

Main 76, wire 78, wire 84, switch 85, wire 86, variable resistance 87, wire 83, binding post 89, wire 88, primary winding 73, wire 96, binding posts 91, wire 97, wire 81, right-hand portion of double switch 80, wire 79, main 77, to source of electrical supply, thence back to main 76. The circuit just traced energizes the primary winding of the heating transformer.

The secondary circuit of the heating transformer may be traced as follows:

Secondary winding 74, wire 32, contact members 24 and 41, wire 40, cathode 37, wire 38, contact bolt 29, and wire 33, back to secondary winding 74.

In Figure 7 of the X-ray shield is shown as mounted upon a tube stand 109. However, the tube shield may be mounted either as here indicated or in any other manner known in this art for supporting an X-ray shield.

The operation of our device may be readily understood from the foregoing description.

The parts being constructed and arranged as shown and described, and the switches being closed the apparatus is thrown into action.

We do not limit ourselves to the particular mechanism shown and described, our invention being commensurate with our claims.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is as follows:

1. An apparatus of the character described comprising an X-ray shield having the form of an elongated hollow body impervious to X-rays, a pair of oil transformers mounted independently of each other within the ends of said X-ray shield and supported thereby, and supporting mechanism connected with said transformers and energized thereby for supporting an X-ray tube in a position intermediate said transformers and within said X-ray shield, said supporting mechanism being in two parts, each carried by one of said transformers.

2. An apparatus of the character described comprising an X-ray shield having the general form of an elongated hollow body, a pair of high tension transformers housed within the ends of said hollow body and supporting mechanism made in two parts each carried by one of said high tension transformers for supporting an X-ray tube within said hollow body and lengthwise between said transformers.

3. An apparatus of the character described comprising an X-ray shield having the general form of a hollow cylinder, a pair of end caps mounted upon said cylinder and closing the ends thereof, a pair of high tension transformers carried by said end caps and thus supported within the ends of said cylinder, and connections for supporting and energizing an X-ray tube extending lengthwise between said transformers and located within said cylinder.

4. An apparatus of the character described comprising a hollow X-ray shield provided with open ends, a pair of end caps detachably engaging said ends and thus

closing the same, a pair of oil tanks normally housed within the ends of said hollow X-ray shield, an oil transformer in each oil tank, and means for supporting an X-ray tube intermediate said oil transformers.

5. An apparatus of the character described comprising an X-ray shield having the general form of a hollow cylinder, a pair of high tension oil tanks separately housed within the ends of said cylinder, a separate transformer in each oil tank, and an X-ray tube located within said cylinder and connected with said transformers.

6. An apparatus of the character described comprising an X-ray shield having the general form of a hollow cylinder, a pair of oil tanks separate from each other and respectively housed within the ends of said cylinder, a high tension transformer mounted within each oil tank and insulated thereby, and an X-ray tube mounted within said cylinder and substantially co-axial therewith, said X-ray tube being at its ends detachably connected with said transformers.

7. An apparatus of the character described comprising an X-ray shield having the general form of a hollow cylinder, a pair of end caps closing the ends of said cylinder, a pair of oil transformers carried by said end caps and housed within the ends of said cylinder, a pair of blocks of insulating material connected with said oil transformers and located opposite each other within said cylinder, and contact members carried by said blocks of insulating material and connected with said transformers, for energizing an X-ray tube.

8. An apparatus of the character described comprising an X-ray shield having the general form of a hollow cylinder and provided with a door, an X-ray tube adapted to be placed within said shield and removed therefrom through said door, oil tanks separately housed within said hollow cylinder and respectively located within the ends thereof, a pair of high tension transformers, one located within each oil tank, and contact mechanism located within said hollow cylinder and connected with said high tension transformers for the purpose of energizing said X-ray tube from said transformers.

9. An apparatus of the character described, comprising an X-ray shield having the general form of a hollow cylinder, a pair of high tension transformers separately housed within the ends of said cylinder, and an X-ray tube located within said cylinder and detachably connected with said transformers, said X-ray tube being spaced substantially coaxial with the wall of said cylinder and enveloped in a gaseous medium contained within said cylinder.

10. An apparatus of the character described, comprising a hollow shield made up of materials impervious to X-rays, a pair of high tension oil transformers separately housed within said hollow shield and spaced apart, and an X-ray tube located within said hollow shield and connected with said transformers, said X-ray tube being enveloped on all sides with a gaseous medium and thus insulated from said hollow shield.

11. An apparatus of the character described, comprising an X-ray shield made of metal and having the form of a hollow cylinder, a pair of oil transformers separately housed within the ends of said cylinder and separated by an air space, an X-ray tube, means for detachably supporting said X-ray tube within said air space, and electrical connections from said oil transformers to said X-ray tube.

12. An apparatus of the character described, comprising an X-ray shield made of metal and having the general form of a cylinder provided with a door, a pair of oil transformers housed within the ends of said cylinder and separated by an air space, an X-ray tube adapted to be moved into and out of said cylinder through said door thereof, and connections controllable by the removal and replacement of said X-ray tube for connecting said X-ray tube with said transformers and disconnecting the same therefrom.

13. An apparatus of the character described comprising a hollow shield made of material impervious to X-rays, a pair of oil transformers separately housed within said hollow shield and separated by an air space, an X-ray tube normally located within said air space, and contact mechanism located within said hollow shield and connected with said oil transformers, said contact mechanism being controllable by the removal and replacement of said X-ray tube for the purpose of disconnecting said X-ray tube from said transformers and of connecting the same therewith.

14. An apparatus of the character described comprising an X-ray shield, a pair of oil transformers carried thereby and separately housed therein, an X-ray tube extending between said oil transformers and energized thereby, and mechanism connected with said oil transformers and controllable by the removal and replacement of said X-ray tube, for making and breaking electrical connection from said X-ray tube to said transformers.

15. An apparatus of the character described comprising the hollow X-ray shield, a pair of oil transformers separately housed therein and spaced apart, an X-ray tube located between said transformers and so connected therewith that said transformers may cause a discharge to take place through the X-ray tube, said X-ray tube when in posi-

tion being substantially within the center of said hollow X-ray shield and insulated by an air space containing said X-ray tube.

16. An apparatus of the character described comprising a hollow X-ray shield, a pair of oil transformers separately housed therein and spaced apart, and an X-ray tube normally located within said hollow X-ray tube and detachably connected with said oil transformers, said X-ray tube being insulated from said X-ray shield by an air space completely encircling said X-ray tube.

17. An apparatus of the character described comprising an X-ray shield having the form of a hollow member, a pair of high tension transformers separately housed within said hollow member and spaced apart, a low tension transformer mounted within said hollow member, an X-ray tube removably housed within said hollow member, and mechanism connected with said transformers and controllable by the removal and replacement of said X-ray tube for making and breaking electrical connections from said X-ray tube to said transformers.

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