Nov. 15, 1938. E. S. HUMPHREYS 2,137,122

X-RAY APPARATUS

Filed March 14, 1935

Fig. 1.

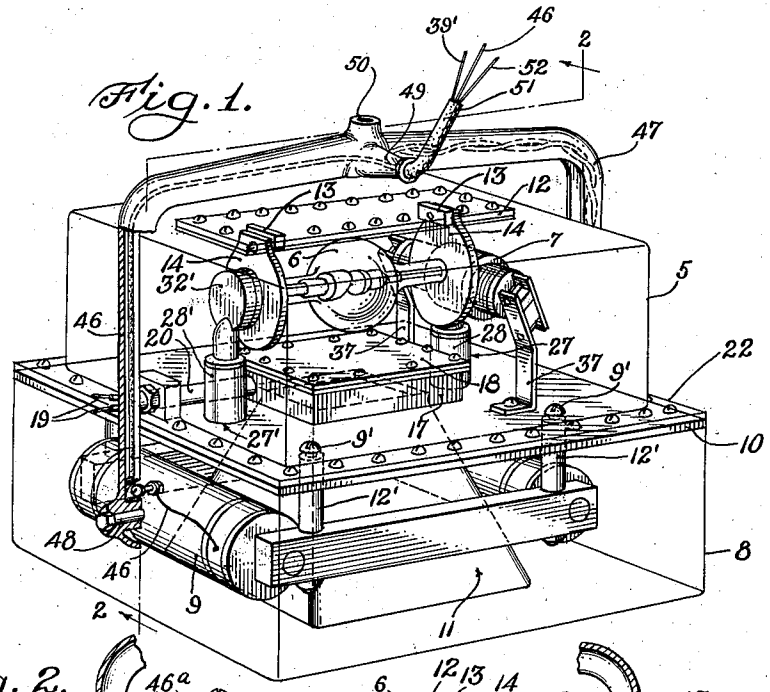


Fig. 2.

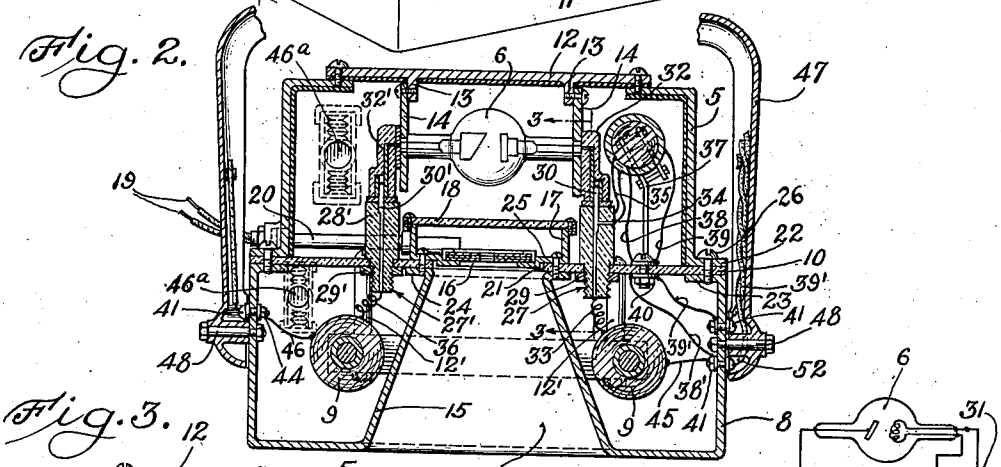


Fig. 3.

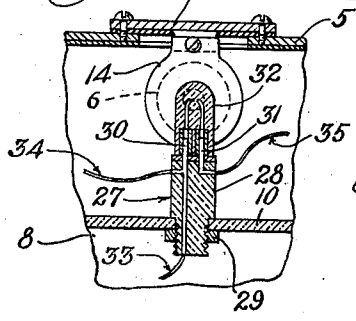
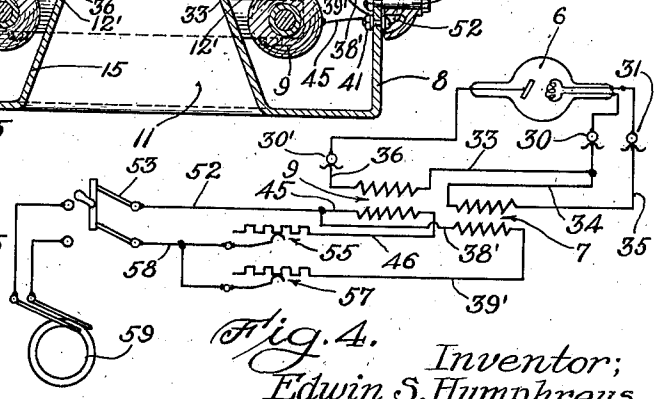


Fig. 4.



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UNITED STATES PATENT OFFICE

2,137,122

X-RAY APPARATUS

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9 Claims. (Cl. 250—87)

This invention relates to X-ray apparatus and more particularly to apparatus of this character in which the X-ray tube and tube energizing instrumentalities are all assembled in a shock-proof unit.

In the operation of X-ray apparatus in either fluoroscopic or radiographic work, inherent tube characteristics require substantial spacing of the X-ray tube from the patient or object under examination. With X-ray units as heretofore constructed, the proper spacing of the tube from the patient necessitates the provision of a relatively large operating space, that is, a substantial overall clearance between the patient and the unit, for the proper manipulation of the same. Reduction of the space required for this purpose is highly desirable both from the standpoint of increased efficiency in the operation of the unit itself and in the construction and operation of the auxiliary equipment. Accordingly, it is the primary object of the invention to provide an improved X-ray unit which requires a minimum amount of operating space. To this end the unit is enclosed in a casing structure so constructed and arranged that the tube energizing instrumentalities are interposed in the space between the patient and the tube, thus materially reducing the overall clearance of the unit with respect to the patient.

Another object of the invention is to provide an X-ray unit of more compact construction than has heretofore been practicable and to this end, the "cone" ordinarily employed for confining the X-rays to a desired area is incorporated in the casing structure which encloses the electrical elements of the unit.

Another object of the invention is to provide a unitary casing structure for an X-ray unit in which the X-ray tube and the tube-energizing transformer may be separately disposed in the insulating or cooling fluid media best suited to their individual requirements.

Another object of the invention is to provide improved means for connecting an X-ray tube with the energizing apparatus.

A further object of the invention is to provide in an X-ray unit an improved arrangement for mounting the shutter or diaphragm mechanism by which the emanation of X-rays is controlled.

Still another object of the invention is to provide an improved arrangement for connecting an X-ray unit with a source of electrical energy.

Other objects and advantages of the invention will become apparent from the following detailed description of a preferred embodiment thereof taken in connection with the accompanying drawing in which:

Figure 1 is a phantom perspective view of an X-ray unit embodying the features of the invention and showing the general form and relationship of the various parts comprising the unit.

Fig. 2 is a vertical sectional view through the unit taken on the line 2—2 of Fig. 2.

Fig. 3 is a fragmentary sectional view taken on the line 3—3 of Fig. 2 and showing details of one of the separable plug members provided for connecting the tube with the tube energizing instrumentalities.

Fig. 4 is a schematic representation of the circuit of the unit comprising the invention.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawing and will herein describe in detail a preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

In the embodiment of the invention herein illustrated, I employ a unitary casing structure providing separate compartments for enclosing the various electrical elements of the apparatus. Accordingly, the casing structure is composed of a top section 5 defining an upper compartment for an X-ray tube 6 and a low tension filament energizing transformer 7 and a bottom or base section 8 defining a lower compartment for a high tension tube-energizing transformer 9. As herein shown, the compartments do not communicate with each other but are separated by a common partitioning wall 10, preferably of Bakelite, while the sections themselves may be constructed of any suitable material. The upper section 5 is preferably lined with material such as lead which is impermeable to X-rays and the two sections may desirably be removably secured together with the partitioning member 10 interposed between them in a manner such as to provide a liquid tight seal between the upper and lower compartments.

To reduce the operating space required by the unit, I utilize the space occupied by the base section and enclosing the high-tension transformer for the passage of X-rays. Thus, the base section 8 is preferably constructed with a tubular passage 11 for the passage of X-rays, and the walls of said passage define, with the

outer walls of the section, a continuous channel providing space for the mounting of the high-tension transformer which is appropriately shaped for this purpose.

The X-ray tube 6 is conveniently suspended from a top cover plate 12 which is removably secured to and covers an aperture in the top wall of section 5. For this purpose the cover plate is formed on its under side with lugs 13 to which are attached depending arms 14 between which the tube is supported. The tube is thus positioned so that the rays emanating therefrom are directed toward the partitioning member and through the passage 11 in the lower compartment of the unit.

The passage 11 which provides an unimpeded channel through the lower compartment for the X-rays emanating from the tube 6 is formed in the present instance with a substantially rectangular cross-section and with walls 15 diverging downwardly and outwardly to define a "cone" for confining the X-rays to a desired area. As herein shown, the passage is disposed substantially centrally of the base section 8. The transformer 9, which is of generally rectangular form, is disposed within the channel defined by the outer walls of the section and walls 15 of the passage, the plane in which the transformer lies being substantially perpendicular to the axis of the passage.

To prevent the shifting of the high tension transformer 9 when the unit is tilted for use in different positions and to facilitate its removal from the transformer compartment, means may be provided for supporting it on the partitioning member 10. In the present instance the supporting means comprises the bolts 9' which project through holes in the partitioning plate 10 and in the magnetic elements of the transformer. Proper positioning of the transformer is secured by means of sleeves 12' on the bolts 9' which are interposed between the transformer elements and the plate 10. The transformer thus positioned around the "cone" assists in screening out unwanted X-rays so that radiation is substantially confined to the area defined by the "cone", and moreover, in the operation of the unit, it occupies space that would otherwise be unused, thereby materially reducing the operating space required by the unit.

Passage of X-rays through the cone is controlled by a shutter or diaphragm 16 which may be of conventional construction and which, in the illustrative embodiment, is disposed in the tube compartment between the tube and the inner end of the passage 11. The diaphragm thus becomes an integral part of the unit, and by reason of its concealed location within the casing structure, may be provided with a less expensive finish than is desirable for diaphragms mounted in the usual manner outside of the casing. Diaphragm 16 is preferably enclosed in a housing 17 supported on the partitioning member 10 and closed by a cover plate 18 of material permeable or transparent to X-rays. Control of the diaphragm from outside the unit is effected by means of flexible control members 19 which are led into the diaphragm chamber through a conduit 20 having its opposite ends sealed into ports in the housing 17 and in the wall of the casing section 5. The diaphragm compartment may communicate with the passage 11 through an aperture or window 21 formed in the partitioning member 10, which window can be dispensed with if desired when the partitioning member is constructed of X-ray permeable or transparent material.

An effective seal is provided between the various compartments of the unit and the assembly of the parts thereof is facilitated by providing complemental flanges for securing the parts together. To this end, the section 5 is provided with an outwardly projecting flange 22 complemental with an inwardly projecting flange 23 of the section 8, the said flanges being disposed on opposite sides of the partitioning member 10 when the casing is assembled. Passage walls 15 are provided with flanges 24 projecting toward and disposed in the same plane as the flanges 23, the flanges 24 being complemental with inwardly projecting flanges 25 formed on the diaphragm housing 17. These various complemental flanges may be rigidly secured together by screws 26 threading into tapped holes in one of the flanges.

To facilitate the replacement of a tube, a readily detachable connection between the tube and the tube energizing instrumentalities is provided. This connection may desirably be in the form of separable plug members 27 and 27', one of which is shown in detail in Fig. 3 of the drawing. Plug 27 which, in the present instance provides an operative connection between the cathode of the tube 6 and one terminal of the high tension transformer preferably comprises a base member 28 of porcelain or other suitable insulating material having a lower portion of reduced diameter adapted to project through an aperture in the partitioning plate 10. The reduced portion of the member is threaded to receive a nut 29 which holds the member rigid with respect to the plate and effectively seals the aperture. The upper end of the member 28 is provided with two prongs 30 and 31 adapted to be received in complemental sockets carried by an upper plug member 32.

Prong 30 preferably extends longitudinally through the member 28 projecting into the transformer compartment to provide a terminal for the connection of conductor 33 leading from one terminal of the secondary winding of high tension transformer 9. The prong 30 also has a branch conductor projecting into the tube compartment which provides a terminal for the connection of conductor 34 leading from one terminal of the secondary winding of low tension transformer 7. Prong 31 has a branch conductor projecting into the tube compartment and providing a terminal for the connection of conductor 35 leading from the other terminal of the secondary winding of transformer 7.

The upper plug member 32 may be secured to the tube supporting member 14 and the sockets for engaging the prongs 30 and 31 are electrically connected to contacts engaging the respective cathode terminals of the tube 6. Low tension transformer 7 is thus connected across the filament of the tube for supplying energizing current thereto and one terminal of the high tension transformer is likewise connected thereto.

The plug 27' which provides a connection between the anode of the tube and the other terminal of the high tension transformer may be of substantially the same construction as the plug 27. In this case, however, the prong corresponding to prong 31 of base member 28 is not required and can be omitted if desired or, if provided, is simply left unconnected. Prong 30', corresponding to prong 30, extends longitudinally through the member 28' and projects into the transformer compartment to provide a terminal

for a conductor 36 leading from the other terminal of the secondary winding of high tension transformer 9. Upper plug member 32' is secured to the tube supporting member 14 and the socket cooperating with the prong 30' is electrically connected with a contact engaging the anode terminal of the tube which may be of the ordinary commercial type.

With the detachable connection provided by the separable plug members, the tube 6 may be removed from the container by simply taking out the cover plate retaining screws and lifting up the cover plate 12. As the plate is lifted, the upper plug members 32 and 32' are raised until the prongs 30, 31, and 30' are disengaged from their respective sockets. The entire cover plate assembly including the supporting members 14, plug members 32 and tube 6, may then be withdrawn from the unit. Moreover, the tube may be readily detached from the supporting member 14 by loosening the screw which secures either member to its associated cover plate lug and thereafter swinging the member out of engagement with the tube. Replacement of burnt out tubes or the interchange of tubes of different character can therefore be effected by a simple and easily performed operation.

As a means of conserving space and simplifying construction, the filament transformer 7 has been placed in the tube compartment in the illustrative embodiment of the invention. The transformer may be conveniently supported between a pair of brackets 37 bolted or otherwise secured to the partitioning plate 10. Electrical connection between the primary winding of the transformer and the conductors leading into the unit is provided by conductors 38 and 39 which connect to respective terminal posts 40 set into the partitioning plate 10. The terminal posts extend through the plate and project into the transformer compartment and the projecting ends thereof are connected respectively with conductors 38' and 39' which, in turn, are terminated on the binding posts 41 set into the side wall of the casing section 8.

The connection between the primary winding of the high tension transformer and the external electrical apparatus required for the operation of the unit may be provided by one of the binding posts 41, above mentioned and a binding post 44 set into the side wall of section 8 opposite the post 41. A conductor 45 connects one terminal of the transformer winding with the binding post 41 on which conductor 38' is terminated. A conductor 46 connects the other terminal of the transformer winding with the binding post 44. These conductors are preferably of sufficient length to permit the transformer to be lifted bodily from its compartment when desired, without disturbing the connections.

The various apertures in the members comprising the container of the unit provided for the reception of the mounting screws and bolts, binding posts, plug members, etc., as well as the joints between the container sections and the partitioning plate are closed in a liquid tight seal when the unit is assembled as above described. The compartments of the unit are filled with suitable coolant or insulating substances, preferably in fluid form, which surround the electrical elements of the unit. Volume changes in the fluid resulting from variations of the temperature thereof are compensated for by the sylphon devices 46a which may be of any suitable construction.

With the construction contemplated by the invention, the transformer compartment may be filled with transformer oil such as is commonly used in connection with apparatus of this character. As the transformer and tube compartments are effectively sealed from each other, the fluid in the tube compartment does not necessarily have to be the same as that in the transformer compartment. Accordingly, the fluid having characteristics most suitable for the operating conditions of the particular type of tube being used can be employed. For example, when employing a tube having terminals separated by a distance less than the air gap equivalent of the working voltage of the tube, a fluid having good insulating properties is provided. On the other hand, when employing a tube capable of operating satisfactorily in air, the fluid will function mainly as a coolant and its insulating properties need only be the equivalent of that of air. This permits a material reduction in initial and operating costs of the unit as suitable fluids of the latter type may be obtained at substantially less cost than the insulating fluids heretofore employed in apparatus of this character.

Support for the unit in operating position is provided by a forked supporting member 47 between the depending arms of which the unit is pivotally carried. The pivotal support is provided in the present instance by studs 48 secured to opposite sides of the casing section 8 and journaled in suitable bearings formed in the ends of the supporting member arms. The member 47 is preferably constructed with an inwardly facing channel which extends to and surrounds the bearings in the arms, above referred to, and which communicates with a projecting outlet or duct 49 formed on the upper position of the member. A socket 50, also formed in the upper portion of the member 47 and centrally disposed with respect thereto, is adapted to receive the supporting arm or bracket of the supporting mast or equivalent which ordinarily comprises a part of the equipment with which units of this character are used.

As the unit will necessarily have to be swung into various positions for use under different conditions, it is highly desirable that the electrical conductor connecting the unit with the regulatory apparatus and power supply be arranged in a manner so that they will not become tangled up or interfere with the movement of the unit. To this end, the conductors are enclosed in a flexible cable 51 which is anchored in the outlet duct 49 of the bracket 47. In the present instance, three conductors are required as will be readily seen by reference to Fig. 4 of the drawing. Two of the conductors are led through the channel formed in one arm of the member 47 and are connected to the respective binding posts 41 carried by section 8. The other conductor is led through the channel formed in the other arm of member 47 and is connected to the binding post 44. Sufficient slack is provided to enable the unit to be turned on its pivot to any desired position without interference.

The electrical connections between the elements comprising the unit and between the unit and the associated apparatus is shown schematically in Fig. 4 of the drawing. The conductors 38' and 45, leading respectively from terminals of the primary windings of transformers 7 and 9 are connected to a common conductor 52 terminating at one contact of a circuit closing switch

53. The conductor 46, leading from the other primary winding terminal of the transformer 9 is connected with a current regulating device 55. Conductor 39', leading from the other primary winding terminal of transformer 7, is connected with a current regulating device 57. The current regulating devices which may be of any suitable type, such as induction regulators or auto-transformers, are multiply connected over a conductor 58 with a contact of the switch 53. Switch 53 functions to connect the above described circuits and apparatus with a suitable source of power, indicated diagrammatically by the alternating current generator 59. With the switch closed, current from the generator is supplied to the two transformers and thence to the tube 6 to energize the same.

From the foregoing, it will be apparent that the invention provides an improved, shock-proof X-ray unit of simple and compact construction which is particularly well adapted to perform the functions for which apparatus of this character is ordinarily provided.

I claim as my invention:

1. An X-ray apparatus comprising, in combination, a unitary casing structure having top and bottom sections respectively providing liquid tight tube and transformer compartments with a partitioning member common to said sections and forming the bottom wall of the tube compartment and the top wall of the transformer compartment, an X-ray tube supported in the tube compartment in a position to direct its rays through the partitioning member and the transformer compartment, a transformer supported in said transformer compartment with its core positioned to define a passage for the X-rays emanating from the tube, and means operatively connecting the transformer with the tube to energize the tube.

2. An X-ray apparatus comprising, in combination, a unitary casing structure having top and bottom sections respectively providing liquid tight tube and transformer compartments, an X-ray tube supported in the tube compartment in a position to direct its rays through the transformer compartment, a transformer supported in the transformer compartment and defining a channel for the passage of the X-rays emanating from the tube, and means operatively connecting the transformer with the tube to energize the tube.

3. In an X-ray unit, in combination, a casing structure, an X-ray tube and tube energizing transformer immersed in a fluid medium in the casing, a diaphragm chamber disposed within the casing and sealed against the fluid therein, a duct communicating with the chamber, an adjustable diaphragm disposed in the chamber in operative relation with the tube, and diaphragm adjusting means extending through said duct to permit the adjustment of the diaphragm from a point outside of the casing.

4. An X-ray apparatus comprising, in combination, a unitary casing setructure having top and bottom sections respectively providing liquid tight tube and transformer compartments with a partitioning member common to said sections and forming the bottom wall of the tube compartment and the top wall of the transformer compartment, said bottom section having inner and outer side walls coacting with said partitioning member and having a bottom wall connecting said side walls to form therewith a channel-like chamber, said inner side walls defining a tubular member of substantially rectangular cross-section providing a passage through the bottom section, an X-ray tube supported in the tube compartment in a position to direct its rays through the tubular member, a transformer supported within the channel-like chamber and surrounding said tubular member, and means for connecting said transformer to said tube to cause the tube to generate X-rays.

5. An X-ray unit comprising, in combination, an X-ray tube, a transformer mounted at one side of the tube and operatively connected with the tube for energizing the same, said tube being positioned to direct its rays toward the transformer, a unitary casing enclosing the tube and transformer, and means forming a passage extending into said casing and through the general plane of said transformer for a portion of the rays emanating from the tube, said transformer acting to screen out unwanted rays and thereby substantially confine the effective radiation of the unit to the area defined by said passage.

6. An X-ray unit comprising, in combination, an X-ray tube, a tube-energizing transformer of the core type, a casing structure enclosing said tube and said transformer, said casing structure having a reentrant portion extending through the core of the transformer to define a passage for X-rays generated by the tube, and means supporting said tube at one side of the general plane of said transformer in a position to direct its rays through said passage.

7. In an X-ray unit, in combination, an X-ray tube, a tube-energizing transformer, means for supporting said tube at one side of said transformer with its anode positioned to direct its rays through an area defined by the core of the transformer, and a diaphragm interposed between the tube and the transformer for restricting the flow of X-rays from the unit.

8. An X-ray unit comprising, in combination, a casing structure having tube and transformer compartments arranged in side-by-side relation, means defining a passage through the central portion of the transformer compartment to the tube compartment, an X-ray tube mounted in said tube compartment with its anode positioned to direct its rays through said passage, a core-type transformer disposed in said transformer compartment with its core surrounding said passage, and means extending between said compartments for operatively connecting said transformer and said tube to energize the tube.

9. An X-ray unit comprising, in combination, a casing structure comprising complementary sections defining tube and transformer compartments, respectively, one of said sections being formed to provide a passage extending from the tube compartment through the transformer compartment, means for supporting a tube energizing transformer in said transformer compartment, means in said tube compartment for supporting an X-ray tube in a position to direct its rays through said passage, and means for adjustably supporting the unit comprising a supporting member pivotally secured to the section of the casing forming the transformer compartment.

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