March 9, 1943. J. J. HEGER 2,313,145

X-RAY APPARATUS

Filed July 31, 1940 2 Sheets-Sheet 1

Fig. 1

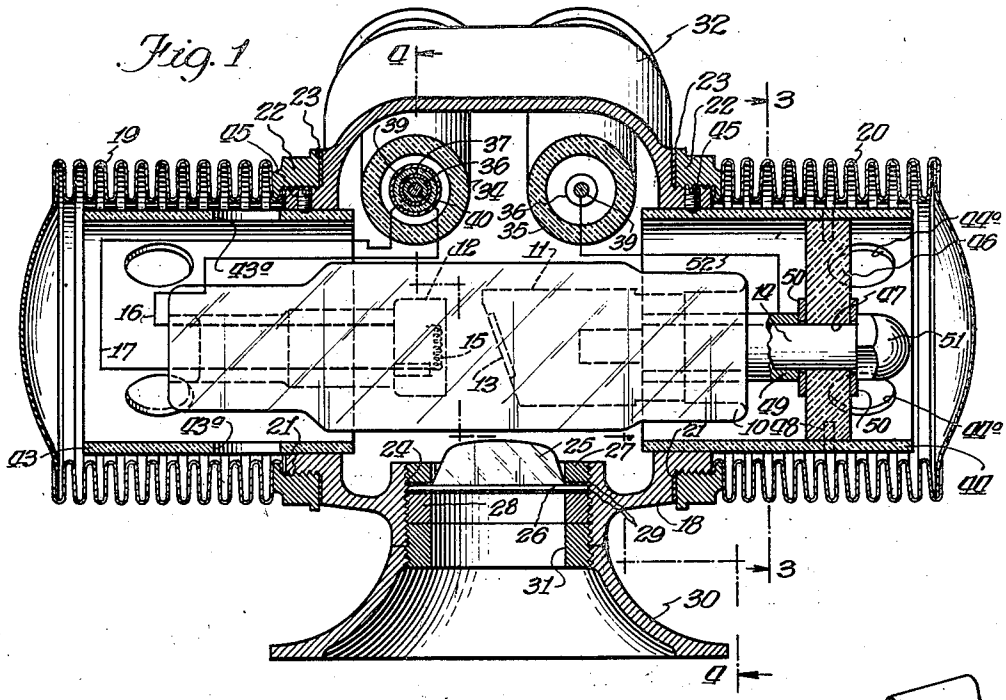


Fig. 2

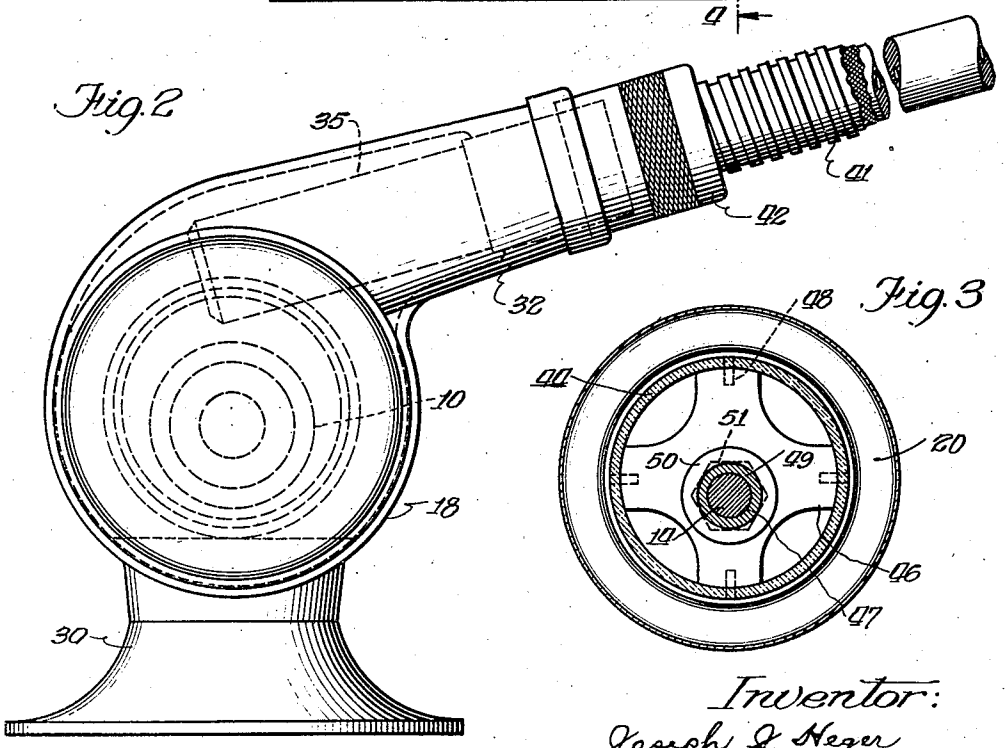


Fig. 3

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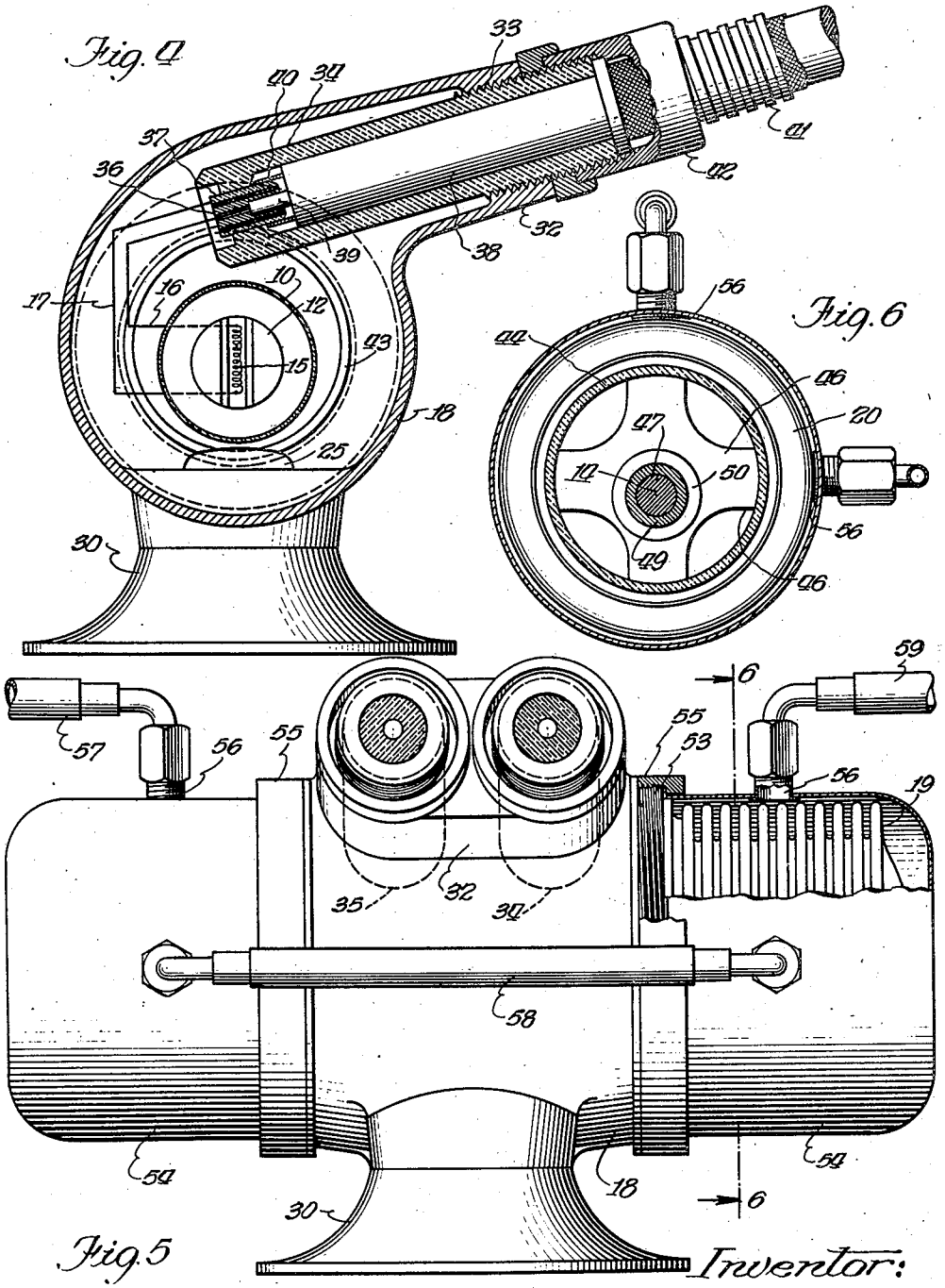


Fig. 5

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Patented Mar. 9, 1943

2,313,145

UNITED STATES PATENT OFFICE

2,313,145

X-RAY APPARATUS

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Application July 31, 1940, Serial No. 348,673

10 Claims. (Cl. 250—90)

My invention relates to an X-ray device comprising an X-ray tube, a housing for the tube, a body of heat conducting fluid in the housing and about the tube, and a housing portion constituting a part of the tube housing and being expansible and contractible with changes in volume of the fluid on corresponding changes in the temperature of the fluid.

One object of my invention is to provide an improved device of the aforesaid type which is so arranged that the heat-conducting fluid in the housing and thereby the X-ray tube is effectively cooled. To this end, it is an object of my invention to provide a device of this type in which the expansible and contractible housing portion is of corrugated sheet material and is so disposed that a cooling fluid, for example water or the air, may circulate freely about the corrugated housing portion.

It is another object of my invention to provide an improved device of this type which is compact, and to this end it is an object of my invention to provide a device in which the expansible and contractible housing portion surrounds the X-ray tube. In its preferred form the device comprises two tube-like, corrugated sheet metal housing portions each of which is expansible and contractible and is disposed over one of the ends of the X-ray tube.

It is a further object of my invention to provide an improved device of this type which is so arranged that there is little or no likelihood of the operator receiving a shock in the operation of the device.

It is another object of my invention to provide an improved device of this type which is simple in construction and may be economically manufactured.

The invention consists in the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will appear from the following description of certain preferred embodiments illustrated in the accompanying drawings, wherein—

Fig. 1 is a sectional view of an X-ray device embodying the principles of my invention;

Fig. 2 is an end elevational view of the device;

Fig. 3 is a cross sectional view taken on line 3—3 of Fig. 1;

Fig. 4 is a cross sectional view taken on line 4—4 of Fig. 1;

Fig. 5 is a rear elevational view of a modification of my invention, certain parts being broken away; and

Fig. 6 is a cross sectional view taken on line 6—6 of Fig. 5.

Like characters of reference designate like parts in the several views.

The embodiment illustrated in Figs. 1 to 4 comprises an X-ray tube 10 having an anode 11 and a cathode 12. The anode is preferably of copper and has a tungsten target 13 imbedded in its inner end. The anode extends from one end of the tube in the form of a stem 14. The cathode is provided with a filament 15 in its inner end opposite the target 13. Electric conductors 16 and 17 which extend through the end of the X-ray tube opposite the anode 11 connect with the filament 15, and one of the conductors connects directly with the main body of the cathode 12.

The X-ray tube 10 is surrounded by a housing comprising a central housing portion 18 and end housing portions 19 and 20. The central housing portion 18 is rigid and is of metal cast into suitable form with two opposite open ends. Each of the open ends of the central housing portion is threaded, as at 21. The end housing portions 19 and 20 are in the form of tube-like bellows and are of sheet metal. The sides of the end housing portions are corrugated and the outer ends of these portions are bulged outwardly in dish-like form as shown. Threaded rigid metal rings 22 are provided on the inner ends of the portions 19 and 20 and are screwed on to the threaded portions 21 of the housing portion 18, and the housing portions 18, 19 and 20 are thus connected together to form the housing for the tube 10. Annular gaskets 23 are provided at the threaded connections between the housing portions 18, 19 and 20 to make the connections fluid tight.

The housing portion 18 is provided with a threaded opening 24 opposite the target 13 of the X-ray tube. A transparent window forming member 25, dish-shaped and having an outer peripheral flange 26, is provided in the opening 24. The member 25 is preferably formed of a suitable material pervious to X-rays as is well known to the art, and is held in position by two sleeves 27 and 28 and a pair of gaskets 29 as shown. A cone 30 having a central opening on the same axis as the window forming member 25 is held fastened to the housing portion 18 by a threaded sleeve 31.

The rigid housing portion 18 is formed with a rearwardly extending portion 32 provided with a pair of openings 33 and is threaded about such openings, one thereof being shown in Fig. 4. In-

sulating sleeves 34 and 35 are placed within the respective openings 33, each of said sleeves having threaded connection with the rigid housing portion as shown. Each of the sleeves 34 and 35 at its inner end is provided with a sleeve-like metallic connector 36, and the sleeve 34 is also provided with a second sleeve-like metallic connector 37 which is concentrically disposed with respect to and is insulated from the sleeve portion 36. A cylindrical member 38 of insulating material fits in each of the sleeves 34 and 35, and each member 38 is provided on its inner end with a pin 39 which fits into the associated connector 36. The member 38 fitting in the sleeve 34 is also provided with a metallic connector 40 on its inner end which fits over the sleeve-like connector 37. The members 38 are slidable in and out of the sleeves 34 and 35, and when inserted in the sleeves, connection between the pins 39 and the connectors 36 and between the connector 40 and connector 37 is automatically made. Electric cables 41 are connected to the respective members 38. Threaded collars 42 fit about the cables 41 and cylindrical members 38 and are screwed to the sleeves 34 and 35 and hold the members 38 in position in the sleeves 34 and 35 respectively. The cable 41 and the member 38 associated with the sleeve 34 carry two supply wires (not shown), one of which is connected to the connector 40 and the other to the pin 39 on that particular member 38. The cable 41 and member 38 associated with the sleeve 35 carry a single supply wire (not shown) which is connected to the pin 39 on that particular member 38. The supply wires in the cables are connected to such sources of electro-motive force that there is a small voltage between the connector 40 and pin 39 in the sleeve 34 and there is a large voltage between the connector 40 or pin 39 in the sleeve 34 and the pin 39 in the sleeve 35.

Rigid cylindrical members 43 and 44 of any suitable material are fastened in the opposite open ends of the central housing portion 18 by means of screws 45 and the members 43 and 44 extend into the end housing portions 19 and 20 respectively. An insulator 46, preferably of a ceramic material and having an opening 47 therein is fastened in the member 44 by pins 48. The anode 11 of the X-ray tube, which extends from the tube in the form of a stem 14, passes through the opening 47. A sleeve 49 and washers 50 are positioned on the stem 14, and a nut 51 screwed to the end of the stem 14 holds the tube 10 rigidly to the insulator 46 and in proper horizontal position in the tube housing. The insulator 46 and the member 44 thus act as means for supporting the tube 10 in its proper position. Electric connection is made between the anode stem 14 and the connector 36 in the sleeve 35 by a wire 52; and electric conductors 16 and 17, extending from the other end of the tube, are connected to the connectors 36 and 37 in the sleeve 34. A small voltage between the connector 40 and pin 39 in the sleeve 34 is thus applied between the conductors 16 and 17 which lead to the filament 15, and the large voltage between the connector 40 or pin 39 in the sleeve 34 and the pin 39 in the sleeve 35 is applied between the anode 11 and cathode 12 of the tube.

The tube housing is completely filled with a heat conducting and electric insulating fluid, preferably oil. The tube 10 and its connections are thus completely immersed in the fluid. Since the fluid is electrically insulating, there is no danger of an electric arc between the connector 36 and lead 52 on one side and connectors 36 and 37 and conductors 16 and 17 on the other side.

In operation the tube 10 and particularly the anode 11 and its stem 14 becomes heated and the fluid about the tube as a result also becomes heated. On such heating the fluid expands and the internal volume of the tube housing must also necessarily become greater. The end housing portions 19 and 20 are expansible and contractible along their longitudinal axes and expand to provide the additional internal volume for the tube housing necessary for the expanded fluid. When operation of the tube 10 is discontinued, the fluid in the tube housing on the decrease of temperature thereof returns to normal volume, and the end housing portions contract.

The fluid in the tube housing is heat conducting and acts to transfer heat from the X-ray tube to the tube housing. The sides of the end housing portions 19 and 20 being corrugated present a large surface to the fluid in the housing, and heat in the fluid, therefore, passes readily to the corrugated surfaces. The member 43 is provided with openings 43*a*, and the member 44 is provided with openings 44*a* to facilitate movement of the oil in, through and about said members 43 and 44. The end housing portions are uncovered and air about the X-ray device may freely circulate thereabout. The corrugated sides of the end housing portions present a large surface to the surrounding air, and heat in the end housing portions is readily transferred to the surrounding air. The end housing portions are constructed of relatively thin sheet metal and for this reason also heat in the fluid in the housing is readily transferred to the outside air. It will be noted that the end housing portions have a two-fold function; namely, first, they act as efficient heat radiators for cooling the fluid in the housing, and second, they act as housing means of variable volume.

The rigid cylindrical members 43 and 44 act to prevent the expansible and contractible end housing portions, due to a decline of temperature of the housing fluid, or an accidental loss of the housing fluid, or an accidental bumping of one of the end housing portions inwardly by the operator from collapsing on the electric conductors extending from the ends of the X-ray tube, including conductors 16 and 17 and the nut 51 on the end of the tube anode. There thus is no danger of an operator being shocked electrically from the X-ray tube housing.

With the tube in operation, the X-rays come from the target 13 and through the window member 25. The housing portions 18, 19 and 20 are of metal and prevent substantially any X-rays from being emitted from the unit except through the window member 25, and the operator of the device is thus protected from undesired dosages of X-rays.

The embodiment shown in Figs. 5 and 6 is the same as the embodiment shown in Figs. 1 to 4 except that provision is made for cooling the heat radiating end housing portions 19 and 20 by circulating a cooling medium or fluid such as air or water around them. The end housing portions 19 and 20 are supplied with rings 53 threaded not only on the inside to fit on the threaded portions 21 of the central housing portions 18, but also threaded on the outside. Jackets 54 are positioned over the respective end housing portions, each jacket being held in position by a threaded sleeve 55 which is screwed on the ring 53. Each jacket is provided with

two openings 56 for the entrance and exit of the cooling fluid. In the illustrated arrangement, the cooling fluid is fed through a hose 57 to the jacket on the left, and the fluid circulates about the end housing member 20 therein and cools it. The fluid then flows through the hose 58 on the rear of the X-ray unit to the jacket on the right which is positioned over the end housing portion 19 and cools the latter. The fluid leaves the right jacket through the hose 59.

Each of the embodiments described has an efficient cooling system which permits a large number of exposures over a given length of time to be made without overheating the X-ray tube. The corrugated housing portions are exposed directly to a cooling fluid which may circulate about them and they arct not only as efficient cooling means but also as expansible and contractible housing portions which vary in volume with the volume of the heat conducting fluid in the X-ray tube housing. The corrugated housing portions are disposed over the ends of the X-ray tube and form part of the housing actually surrounding the X-ray tube thus providing a compact arrangement. With my improved arrangement an operator cannot be shocked electrically even though he should accidentally bump against a contractible portion of the X-ray tube housing. My X-ray devices are simple in construction and may be economically manufactured.

I do not desire to limit my invention to the specific construction shown and described except only insofar as certain of the claims may be so limited as it will be apparent to those skilled in the art that changes in the construction and arrangement of the parts may be made without departing from the principles of my invention.

I claim:

1. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, an X-ray tube in said housing and in said fluid, said housing itself being in part formed of a corrugated tube-like portion of sheet material surrounding one of the ends of said X-ray tube, said corrugated housing portion being expansible and contractible with changes in volume of said fluid, an electric conductor extending from said tube at its said end, and stop means for limiting the contractive movement of said corrugated housing portion toward said electric conductor.

2. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing an X-ray tube in said housing and in said fluid, said housing itself being in part formed of a corrugated tube-like portion of sheet material surrounding one of the ends of said X-ray tube, said corrugated housing portion being expansible and contractible with changes in volume of said fluid, an electric conductor extending from said tube at its said end, and a rigid tube-like member in said corrugated housing portion and surrounding the X-ray tube at its said end for limiting the contractive movement of the corrugated housing portion toward said electric conductor.

3. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, an X-ray tube in said housing and in said fluid, said housing comprising a corrugated tube-like housing portion of sheet material surrounding the anode end of said X-ray tube and being expansible and contractible with changes in volume of said fluid, a rigid tube-like member in said corrugated housing portion, and an insulating member fastened in said rigid tube-like member and supporting the anode of said X-ray tube, said rigid tube-like member acting to limit the contractive movement of said corrugated housing portion toward said anode.

4. In a X-ray device, the combination of a housing, a heat conducting fluid in said housing, an X-ray tube in said housing and in said fluid, said X-ray tube having an electric conductor extending from each of its ends, said housing being formed of a central portion and a pair of corrugated tube-like end portions of sheet material each of which surrounds one of the ends of said X-ray tube, said corrugated end portions being expansible and contractible with changes in volume of said fluid, and a pair of rigid tube-like members one in each of said corrugated end portions for limiting the contractive movements of the corrugated end portions toward said electric conductors.

5. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, an X-ray tube in said housing and in said fluid, said X-ray tube having an electric conductor extending from each of its ends, one of said conductors constituting an anode of said X-ray tube, said housing comprising a central portion and a pair of corrugated tube-like end portions of sheet-like material each of which surrounds one of the ends of said X-ray tube, said corrugated end portions being expansible and contractible with changes in volume of said fluid, a pair of rigid tube-like members one in each of said corrugated end portions and carried by said central portion, and an insulating member fastened in one of said rigid tube-like members and supporting the anode of said X-ray tube, said rigid tube-like members acting to limit the contractive movements of said corrugated end portions toward said electric conductors.

6. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, an X-ray tube in said housing and in said fluid, said housing being formed of a central portion and a pair of corrugated tube-like end portions of sheet material each of which surrounds one of the ends of said X-ray tube, said corrugated housing portions being expansible and contractible with changes in volume of said fluid, and a pair of water jackets each having an inlet and outlet and each disposed about one of said corrugated end portions for the circulation of cooling water thereabout.

7. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, and an X-ray tube in said housing and fluid, said housing comprising a mid-section of rigid construction and two coaxial end sections of yieldable construction attached to the mid-section, said end sections consisting of corrugated sheet material expansible and contractible with volume changes of said fluid, the arrangement being such that a fluid for cooling said housing portion and thereby said fluid in the housing may circulate freely about the housing portion.

8. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, and an X-ray tube in said housing and in said fluid, said housing including end sections of corrugated sheet material expansible and contractbble with changes in volume of said fluid, said housing sections being so disposed that air about

the X-ray device may circulate freely about the housing portion for cooling the housing portion and thereby fluid in the housing.

9. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, and an X-ray tube in said housing and in said fluid, said housing having expansible and contractible end portions enclosing the ends of the tube.

10. In an X-ray device, the combination of a housing, a heat conducting fluid in said housing, and an X-ray tube in said housing and in said fluid, said housing having an end portion of corrugated metal surrounding and enclosing an end of said tube.

JOSEPH J. HEGER.