July 5, 1932. J. B. WANTZ 1,866,141

X-RAY APPARATUS

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FIG. 1

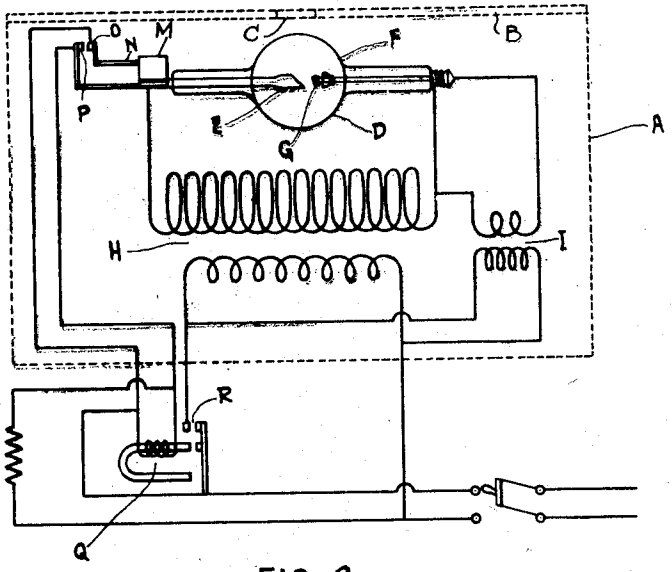


FIG. 2

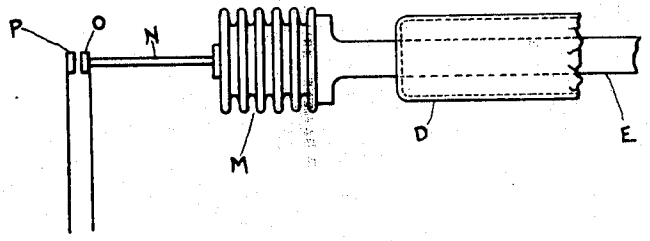
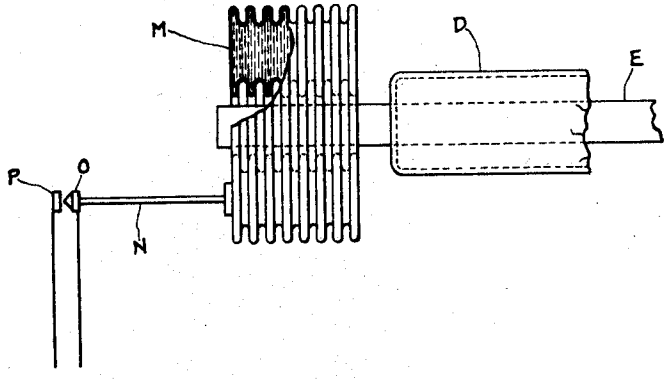


FIG. 3



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FIG. 4

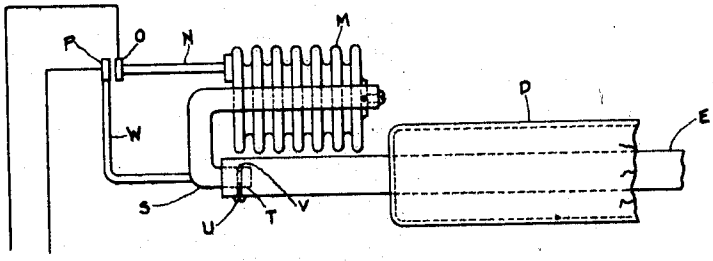


FIG. 5

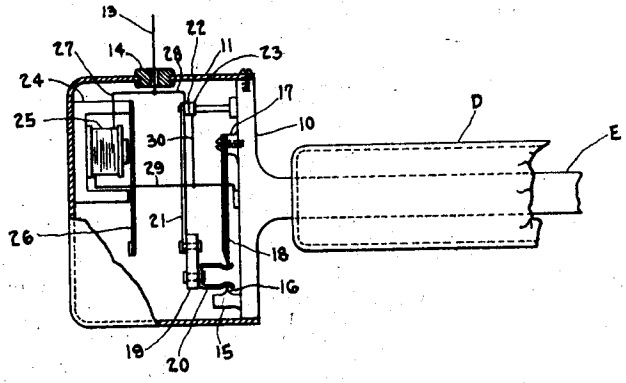
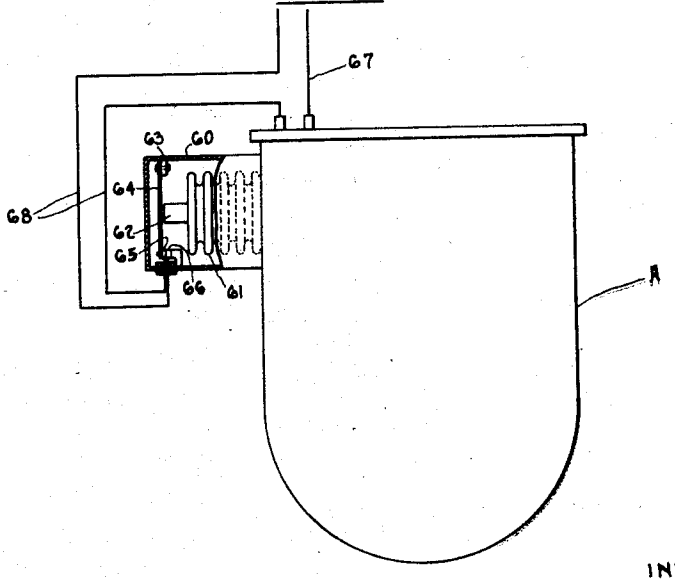


FIG. 6



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X-RAY APPARATUS

Application filed September 6, 1927. Serial No. 217,664.

The present invention relates to X-ray tubes and the like. It has primarily to do with means for giving notice to an operator of a tube that such tube has become overheated. It may provide means for causing the electromotive force actuating the tube in use to be shut off as an incident to such overheating, or further overheating, and also, it may comprise a signal means and a means for de-energizing the X-ray tube in operation, or a combination of both.

Very high efficiency is being obtained by the employment of X-ray tubes and correlated apparatus. New results have been made possible by immersing an X-ray tube and sometimes the transformer or transformers and other apparatus in association with such X-ray tube, in an oil bath or in a vessel containing transformer oil. The invention as disclosed in the illustrations is, therefore, adapted for use in connection with oil immersed as well as conventionally mounted tubes.

In oil immersed apparatus, a suitable window or windows, either transparent, translucent, or opaque to actinic light, but transparent to X-light are provided in the containers or vessels for the tubes so that the efficiency of the X-ray is not affected by its oil immersion. One difficulty with such apparatus has been the inability of an operator to know by external manifestion the precise performance of the tube in use. This difficulty includes an inability of an operator of a tube to learn instantly whether there is an excessive flow of electromotive force thereacross.

Overheating of tubes has been frequent, with the result that punctured tubes and other disastrous results have frequently occurred.

In none of the oil immersed devices now upon the market is a visible or audible means supplied for association with an oil-immersed apparatus whereby an alarm to the operator is given as an incident to excessive heating of a tube.

There have been a number of devices introduced for the purpose of adding safety to combinations of X-ray apparatus. These divers apparatuses include means for controlling the electromotive force impressed upon the electrodes of an X-ray tube. None of these devices goes to the extreme hereinafter referred to, namely, the provision of a means for giving notice to an operator that the tube is overheated, and for de-energizing an X-ray tube or a transformer in association therewith as an incident to such overheating of a tube or as an incident to the continued excessive heat in the tube after actuation of a visible or audible signal.

The present invention, therefore, has to do with the combination with an X-ray outfit, conventional or oil immersed, firstly, of means for indicating an excessive heating of a tube, such means being a visible or audible signal; secondly, a safety means for the tube thermostatically or otherwise actuated to shut off the electromotive force impressed upon the apparatus; and thirdly, a combination of the two previously mentioned functions.

The signal and safety means may operate concurrently but preferably the latter should function subsequently to the former. The device, while remaining within the scope of the invention, may contain one or the other of the functions referred to, or a combination of two. In its simpler and more specific application, the invention comprises a means for signaling to an operator an excessive temperature in an X-ray tube in process of operation. When such excessive flow continues, the apparatus may be adapted to de-energize the tube. The two functions may be independent, correlated, or concurrent in their operation.

The objects of the invention, in part, include the following:

The combination with an X-ray tube of signal means whereby an excessive flow of current is communicated to an operator by visual, audible, or other manifestation;

The combination with an X-ray tube of safety means whereby the electromotive force energizing said tube is shut off from such tube when a dangerous flow of energy therethrough occurs;

The combination with an oil-immersed

X-ray tube of an alarm mechanism adapted to be actuated coincidently with the presence of an excessive heat in the tube or excessive flow of current through such X-ray tube;

The combination with the anode of an X-ray tube of means adapted to be actuated as an incident to an impression of excessive electromotive force upon the electrodes of such tube, whereby such electromotive force is modified, actuates a visual or audible signal, is reduced or is otherwise altered;

The combination with an X-ray tube of means adapted to be oil-immersed and in association with such tube whereby the flow of excessive energy through said tube is communicated to an operator of the tube;

The combination with an X-ray tube of oil-immersed means in association with such tube whereby a flow of excessive energy through said tube is arrested upon becoming dangerous to the operation of said tube;

The combination with an X-ray tube of means whereby knowledge of overheating of the tube is communicated to an operator and the further heating of said tube is arrested when dangerous to the operation of said tube; and

The combination with an X-ray tube of an alarm adapted to communicate to an operator a notice that the tube in use is becoming over-heated. These, and such other objects as may hereinafter appear, are obtained by the novel combination of the elements comprising the invention, the construction of the divers parts, and the arrangement thereof with respect one to another.

Several embodiments of the invention are disclosed in the accompanying drawings, in which

Figure 1 is a schematic representation of an oil-immersed apparatus adapted to carry out that part of the invention which suggests the shutting off of electromotive force from a tube which has been over-heated;

Figure 2 is a schematic fragmentary detail illustrating a second form of such invention;

Figure 3 is another schematic fragmentary view disclosing an additional form which such invention may take;

Figure 4 is an additional fragmentary schematic detail of another form which the invention may take;

Figure 5 is a fragmentary schematic view of a second form of the invention and in which an audible signal is operated;

Figure 6 is an end elevation, partly in section, of another form of the invention in which the tube is de-energized.

Like reference characters are used to designate similar parts in the specification which follows and in the drawings.

For a ready understanding of the first illustrated form of the invention and those forms of the invention in which a tube is de-energized, a schematic representation of an apparatus embodying the invention and of the X-ray circuits and apparatus in association therewith and found in Figure 1 should be examined.

Within a tank or other suitable container A, and having a cover B, the latter being provided with a window C, an X-ray tube D and its associated apparatus are disposed. This is the general arrangement generally followed in the other forms of the invention shown in Figures 1 to 4, inclusive, and in Figure 6.

An X-ray tube D is suitably mounted in the container A so that the X-rays generated in said tube D will be projected through the window C in cover B.

Said X-ray tube D includes an anode E. The tube D disclosed is of the hot cathode type and is provided with a cathode F having the conventional filament G. Within the container or box A, there is also disposed a main transformer H which is adapted to generate the electromotive force impressed across the anode E and cathode F; and also, a filament transformer I which is adapted to provide the electromotive force used to heat the filament G in forming a part of cathode F. The wiring system within the container A so far described and in so far as it relates to the main transformer H, the filament transformer I, the anode E and the cathode F, is conventional.

Also disposed within the container or box A, is a thermostat, or an equivalent heat-affected apparatus, designated M. Associated with the thermostat M is an insulated rod N at the end of which is a contact O. Said contact O, when moved to the left is adapted to engage a stationary contact P. Said contacts are parts of an electric circuit which when closed, is adapted to short circuit the holding coil of a relay Q, which when energized is adapted to close a circuit to the main transformer H, whereby electromotive force is impressed upon the primary of the main transformer H. The short circuiting of said holding coil de-energizes the tube D. In the event of over-heating the tube D, the thermostat M moves the rod N to the left to bring together the contacts O and P whereby a switch R controlled by relay Q and opening the circuit to the primary of transformer H, is opened. In place of switch and relay, as described, the closing of contacts O and P may be used to close a light circuit providing a visual signal, or to close a bell circuit, providing an audible signal, as previously indicated.

In the several apparatuses hereinafter referred to and illustrated in Figures 2 to 4, inclusive, the same general circuit arrangement exists. It is contemplated that there shall be associated with the anode E, or an-

other part of the apparatus, a thermostat or other heat affected element M adapted to be actuated by excessive heat, which heat-actuated element is adapted to set in motion the necessary parts to automatically actuate a switch R to the transformer whereby the circuit to such transformer H, which is closed while the tube D is in operation, is opened.

The theory of operation in the present invention is that in an oil-immersed X-ray outfit the place where the flow of excessive energy through the tube D will be first noticed is either upon the anode E of the X-ray tube D, or in juxtaposition thereto, and that such excess of energy will demonstrate itself by the generation of heat in such anode E, and that such heat is dissipated in the insulating oil surrounding such anode E.

The anode E is invariably of a material rapidly dissipating heat, that is, one of high heat conductivity. The portion of such anode E external to the tube D, shortly after the impression of excessive electromotive force across said anode E and cathode F, will become highly heated. The thermostat M is in association or in juxtaposition to said anode E, and it is therefore adapted to be operated as an incident to the increased heat in the exposed portion of the said anode E when the temperature thereof exceeds a certain degree. Of course, it is recognized that the apparatus is not sensitive enough to prevent a sudden excessive flow of energy through the tube D. To be actuated, it is necessary that there be an accumulation of excess energy, which accumulated excessive energy takes the form of heat energy.

For convenience, the temperature at which the apparatus is operated will be called the critical temperature. This critical temperature must be derived from the accumulation of excess energy.

It is to be noted that the transformer oil which surrounds the exposed end of the anode E will become hot quickly and that the heat of the anode E will be communicated to such oil in the tank promptly and with such rapidity that any device actuated as the result of overheating of the transformer oil will be highly efficient.

Thus, when there is a flow of energy across the tube D in excess of the amount prescribed for the particular apparatus, the anode E will be overheated, and the heat in said anode E will heat the thermostat M or the transformer oil whereby the thermostat M will be affected by such excessive heat. Such thermostat M will energize, either within the container A or external thereto, through operating mechanisms, a relay Q which affects a switch R in the line to the main transformer H. Such switch R will open the circuits between the transformer H and the source of electromotive force by which said transformer H is energized. In present day practice, such source of electromotive force generally is a local power station.

It is quite manifest that the device may assume other forms than those herein shown, but that the principle upon which the invention operates is the same in each case. That principle, restated, is that the anode of an X-ray tube becomes hot earlier than any other part of the tube and is a criterion for determining the accumulation of excess energy. A second and quite convenient means of actuating a device of the character here disclosed is to cause its actuation when the transformer oil which is used for insulation in the X-ray apparatus becomes excessively hot.

By associating a thermostat with the anode of a tube or with another preferred part of a tube, or with the transformer oil, it is thus possible to establish or break electrical contacts mechanically or electrically within or outside of the container A, whereby to operate directly or through an independent circuit, a switch adapted to open the closed circuit to the transformer H. Such theory includes the employment of a means for opening such transformer circuit by direct movement brought about by the effect of heat upon a thermostat or other element.

In Figure 2, there is shown a type of anode E to which a sylphon or similar thermostat M is directly secured. Excessive heat in the anode E causes the thermostat M to mechanically operate an insulation rod N secured at its center. Said rod N has at its end a movable contact O, such movable contact when actuated by the rod N being adapted to provide contact with a stationary contact P and thus close the previously described circuit to the relay Q.

Rod N necessarily is of insulation material and of such length that there is no possibility of high tension from the anode E reaching the low tension circuit energizing transformer H or relay Q.

In Figure 3, a different type of thermostat M is shown. In this form the thermostat M is of the liquid type and doughnut shaped and is adapted to actuate a rod N secured at one side thereof. Through rod N, it actuates movable contact O to cause contact with fixed contact P to actuate relay Q to break the low tension line to transformer H just as in the previously described embodiment of the invention.

It is to be noted that in this particular form of the apparatus, the thermostat M is of a doughnut type, and it is thus enabled to enclose the exposed end of the anode E. Irrespective, then, of the position of the container A, the thermostat M will be instantly affected by excessive heat in anode E and caused to actuate the rod N.

In Figure 4, is another thermostat M like

that shown in Figure 1 and which may be employed in the tank A whereby to actuate a rod N of insulating material to actuate a movable contact O which movable contact is adapted to be moved toward a fixed contact P, whereby a circuit to a relay Q may be closed to break the circuit in the low tension line to transformer H.

Upon the opening or closing of the circuit to the relay Q the switch R is opened, cutting off current flowing through the transformer H.

Whether there is or is not a difference in the transfer of heat from the anode E to thermostat M due to convection currents in the transformer oil used in the container A is immaterial in an apparatus such as is shown in Figure 4. In this form of the invention there is illustrated what may be termed a floating thermostat, for the thermostat M is disposed upon a bracket S which comprises an arm having a trunnion T adapted to be secured in anode E by lock screw U operating in groove V encircling trunnion T.

The weight of the thermostat M is such that it floats in the tank A, hence, as the tank A is moved, the thermostat M floats above the exposed end of anode E. It may be advantageous that the thermostat M be so disposed directly above the exposed portion of anode E. As the container A is moved from one position to another and turned, the thermostat M will continue to be situated above the anode E because of the freedom of movement of such thermostat M upon the loosely connected bracket S riding in anode E.

An insulating rod N is actuated by thermostat M and moves a contact O secured thereto into engagement with a fixed contact P which is mounted upon a second arm W of bracket S. Thus high efficiency may be obtained in an apparatus such as is illustrated in Figure 4, for the thermostat M is adapted to remain in a position for most effective use irrespective of the ordinary movements which may be made of the container A in which the principal parts of the apparatus are disposed. Most of such movements are about the axis of the tube D and therefore may be compensated for in the movement of bracket S.

Where contacts O and P, or their equivalents, are disposed within the insulating liquid in container A, such contacts may be very closely associated so that slight movement thereof by the thermostat M will establish electrical connection between said contacts. In view of the insulating qualities of the media called "transformer oil," it may be desirable to employ upon one or both contacts O and P a sharp point. Where only one of the contacts O or P is so provided, as is shown in Figure 3, movement thereof against the surface of the other contact establishes an electrical connection through such point or points and the impinged surface of the other contact. Where both contacts are provided with points, the points are ordinarily arranged to come into contact one with another, thus providing a sharp contact for the flow of electromotive force therebetween.

The establishment of contacts under these conditions is not seriously affected by reason of the contacts being immersed within the transformer oil or media used as an insulation with respect to the main and filament transformers of the apparatus and the remainder of the apparatus contained within the box or container A.

In another form of the invention such as is shown in Figure 5, a signal is made audible to an operator as soon as the tube becomes overheated. This type of the invention is adapted for use in connection with tubes not oil immersed as well as to oil immersed tubes. Ordinarily a few seconds of overheating of a tube will do no damage thereto, hence, where the operator is making fluoroscopic examination and has gone so far with such examination that the shutting off of the current instantly would deprive such operator of the benefit of effort so far made to complete the desired examination, the operator may be provided with a means whereby he is informed that the tube is over heating and that he must discontinue his examination shortly. The duty of terminating the energy flow is then transferred to the operator who may manually open a switch to the transformer H and discontinue the flow of energy. At the same time, there may be a combination in the apparatus of such signal means and an automatic safety means actuated at a definite time after the signal is given, or after the excessive heat is increased whereby, independently of any act on the part of the operator, the energy to the tube is terminated.

Integral with or secured to the anode E as shown in Figure 5, is a head or flange 10, circular in configuration or any other desired shape. Attached thereto peripherally is a cap or cover 11. Through an aperture in said cap, a conduit 13 passes. The walls of the cap 11 about the aperture are insulated by an insulating bushing or collar 14 whereby direct contact between the conduit 13 and the cap 11 is avoided.

Upon the flange 10 is a lug or boss 15 from which projects a pivot point 16. At the other side of said flange 10 is a boss 17 upon which is secured a composite strip of laminated heat affected materials having different coefficients of expansion. Normally such strip is parallel to the face of flange 10.

An insulating base 19 has attached thereto a bifurcated spring-like member 20 which is adapted to be seated upon the pivot 16 and the free end of the laminated strip 18.

Depending from the base 19 is an arm 21 terminating in a contact 22. This comprises the movable contact in this form of the ap-

paratus. The fixed contact thereof is indicated at 23 and it is mounted upon the flange member 10, as is shown in the drawings.

Upon and attached to the opposite side of cover 11 is a yoke or base 24 in which is secured the coil 25 of a buzzer, the clapper member of such buzzer being designated 26.

The conduit 13 within the cover 11 is divided into two sections, one section 27 running to the coil 25, and the other section 28 going to the movable contact 22.

Another conduit 29 extends from the anode E to the opposite side of the coil 25, and has as a part thereof a branch 30 which is connected to the fixed contact 23.

When excessive heat is generated in the tube in operation, the anode E thereof is a result of accumulated excessive energy becomes hot. Such heat is transferred to the laminated strip 18 which is adapted to bend away from the face of the flange 10 whereby to move the frame 19 having as a part the bifurcated member 20, the movement thereof being in a direction whereby the contacts 22 and 23 are separated.

The current, previously flowing along the conduit 13, the conduit 28, the contact 22, the contact 23, the conduit 30, and anode E, which is of high potential, can no longer flow in the circuit described. Its flow must be through the conduit 13, the conduit 27, the coil 25, and conduit 29. In this manner the coil in the buzzer is energized as is customary in buzzer mechanism, whereby the clapper 26 is set into motion to provide an audible signal for the operator.

The operator may shut off the electromotive force to the tube as soon thereafter as he desires. Should he continue to impress electromotive force across the tube D after a signal is given, the disastrous results which may follow are wholly a matter of his own responsibility. The function of the apparatus disclosed is complete when the audible signal is created whereby the operator is afforded an opportunity to discontinue the impression of the electromotive force upon the apparatus.

When the device, after overheating, is allowed to cool, the heat affected element 18 will resume its normal position and concurrently with the movement of the frame 19 inwardly, the contacts 22 and 23 may again impinge and the current allowed to flow directly from the anode E to the conduit 13 in the manner hereinabove described.

It is quite manifest that an apparatus of this character may be added to the usual X-ray tubes by a slight modification of the anodes thereof, or that the flange member 10 may be made attachable to standard anodes. The whole device is compact and self-contained and is relatively simple to manufacture. Its efficacy is instantly apparent as an aid to the effective operation of tubes in that it affords an operator an instant signal when a danger point has been reached.

In Figure 6 a further modification of the apparatus is disclosed. Upon the side of the container A is mounted a cell or chamber 60. Within the cell 60 is a bellows 61, which is adapted to distend as an incident to the expansion due to heating of the transformer oil contained within the vessel A. A plunger 62 is arranged at a convenient point upon such bellows 61.

At one side of the chamber 60 is a boss 63 to which is secured a spring member 64 carrying a movable contact 65. The plunger 62 upon the bellows 61 is adapted to engage upon the spring member 64 and upon expansion of the oil in chamber A the member 64 is pushed in a left-hand direction (in Figure 6) whereby the contact 65 is moved in a similar direction.

Normally said member 65 is in impinging contact with a fixed contact 66, also within the chamber 60.

The electrical circuit to the transformer includes the conduit 67, which is directly connected to one side of said transformer.

Into the chamber 60, the two branches of a conduit 68 are introduced, one of said branches being connected to the movable contact 65 and the other to the fixed contact 66. One branch of conduit 68 is connected to the other side of said transformer, while the other branch of said conduit, like conduit 67, is connected to the source of electromotive force.

When a dangerous overheating of the tube within the tank A occurs, the bellows 61 functions to disconnect the contacts 65 and 66 whereby the circuit established by the two branches of conduit 68 is broken, thus cutting off the electromotive force which is used to energize the transformer within the chamber A.

I claim:

1. The combination with an X-ray tube having an anode and a transformer used in connection therewith of a thermostat secured to said anode, a relay, contacts controlled by said thermostat, and a circuit to said relay in which said contacts form a part, the overheating of said tube being adapted to cause said thermostat to close said contacts to said relay to open the circuit to said transformer.

2. In combination, an X-ray tube having an anode, a transformer, a thermostat upon the outer end of said tube and adapted to be actuated by said tube as an incident to the overheating thereof, a relay adapted to open the circuit to said transformer, and a circuit to said relay and controlled by said thermostat.

3. The combination described in claim 2, and in which said thermostat is adapted to float above the anode of said tube.

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