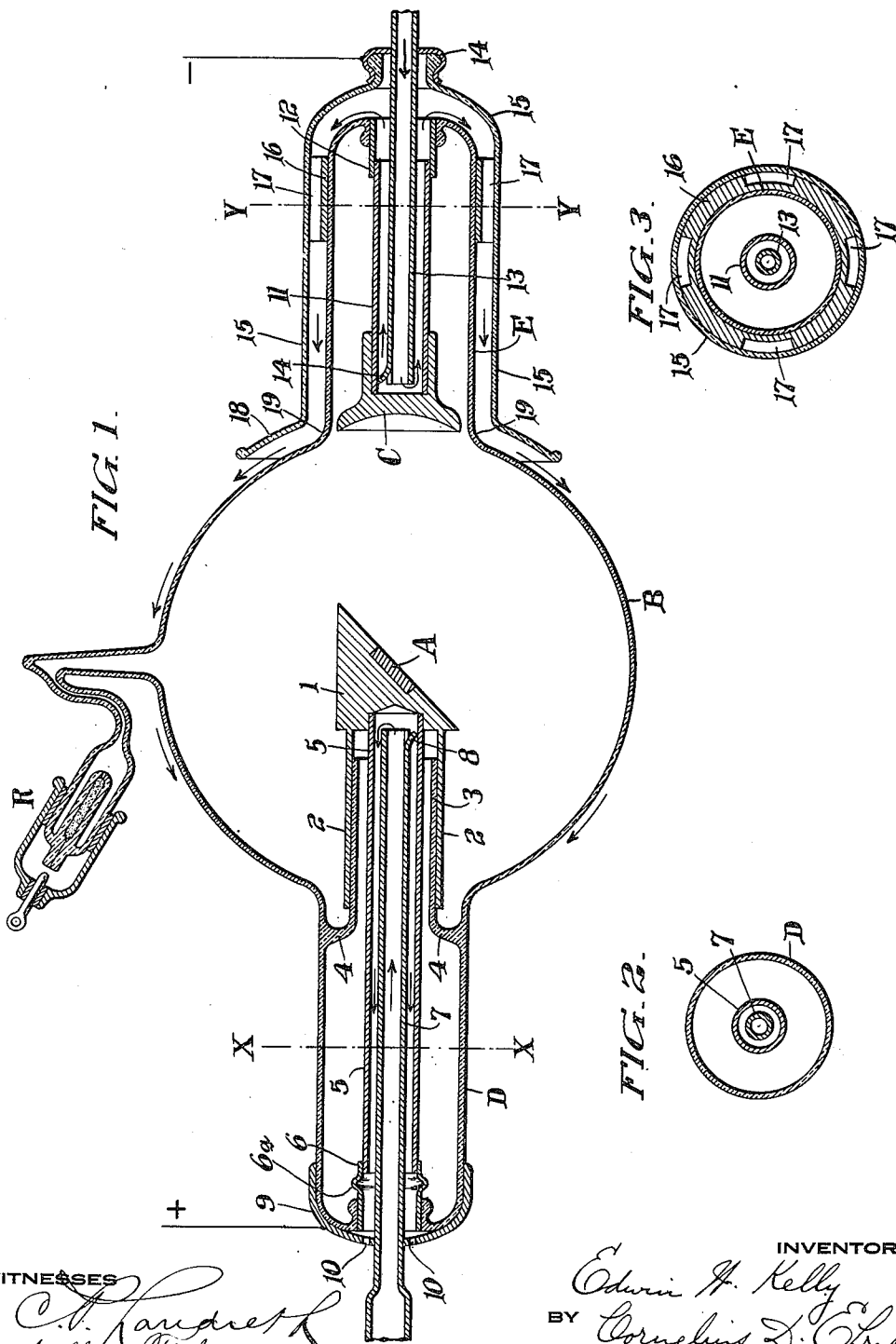


1,160,177.

Patented Nov. 16, 1915.



WITNESSES

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X-RAY TUBE.

1,160,177.

Specification of Letters Patent.

Patented Nov. 16, 1915.

Application filed June 27, 1914. Serial No. 847,618.

To all whom it may concern:

Be it known that I, EDWIN W. KELLY, a citizen of the United States, residing in the city of Philadelphia, county of Philadelphia, and State of Pennsylvania, have invented certain new and useful Improvements in X-Ray Tubes, of which the following is a specification.

My invention relates to means for cooling a vacuum tube, more particularly an X-ray tube, by any suitable cooling medium, such as air or gas, to the end that unusually large amounts of energy may with safety and for long periods be passed through the tube without endangering its life or structure and to the further end of procuring better behavior of a vacuum or X-ray tube, either with normal or excessive amounts of energy, by preventing the vacuum from varying materially or widely from a predetermined or desirable degree.

To these ends I provide means for conducting the cooling medium to the electrodes within the vacuum or X-ray tube by structure of the character hereinafter described. And it is a further feature of my invention that I provide a stream or blast of cooling medium over the exterior walls of the vacuum or X-ray tube, and particularly over the region of union between the bulb proper and the cathode stem, or over the region approximate the cathode where, under normal conditions, local heating of the glass occurs which is likely to cause devitrification of the glass with resultant lowering of the vacuum or rendering the vacuum erratic and changeable, or cracking of the glass wall.

For an illustration of one of the forms my invention may take reference is to be had to the accompanying drawing, in which:

Figure 1 is a longitudinal sectional view taken through an X-ray tube embodying my invention. Fig. 2 is a cross sectional view taken on the line X—X of Fig. 1. Fig. 3 is a cross sectional view on the line Y—Y of Fig. 1.

Referring to the drawing, B is the usual glass bulb of an X-ray tube having the usual glass anode stem D and the usual cathode stem E and a vacuum regulator R. Within the tube are the usual anode or target A and cathode C.

In the example illustrated the head 1, of copper or other suitable material is secured to a metallic tube 2, as of steel, which fits over the tubular glass stem 3 joined to the stem D at 4. A tube 5, of copper or other suitable material, is set into the head 1 and preferably welded thereto forming a vacuum tight joint. The tube 5 extends through the stem D and at its end is welded or soldered at a vacuum tight joint to the platinum or other tube 6 which is sealed into the end of the glass stem D forming a vacuum tight joint. A corrugation 6^a in the tube 6 yields, under expansion and contraction of the tube 5 due to temperature changes, and thereby prevents breakage of seal between tube 6 and glass stem D. Within the tube 5 is disposed a metallic tube 7 which at its inner end has any suitable metallic projection 8 forming electrical contact with the tube 5 or head 1. Near its outer end the tube 7 is connected, as by soldering or brazing, to the metallic ferrule 9 embracing the end of the glass stem D. Electrical connection is made from the positive terminal of a suitable high tension source of current with the ferrule 9 or the tube 7. The extreme end of the tube 7 is connected by rubber hose or otherwise with a supply of any suitable cooling medium, for example, a supply of air under pressure.

Accordingly the air will pass into and through the tube 7, strike the head 1, from which the tube 7 is suitably spaced, extracting heat from the head 1 which conducts the heat away from the target proper, the air then passing outwardly as indicated by the arrow through the annular space between the tubes 5 and 7 to the outer air through perforations 10 in the cap or ferrule 9.

The cathode C is counterbored to receive the tube 11 of copper or other suitable material, there being a vacuum tight joint between the cathode C and the tube 11 as by welding, brazing, soldering, etc. At its other end the tube 11 is welded, soldered or brazed to the platinum tube 12 sealed in the outer end of the glass cathode stem E making vacuum tight joints. Within the tube 11 is a metallic tube 13, spaced at its inner end from the cathode C and having the projection 14 making electrical connection with the cathode C or the tube 11.

The other end of the tube 13 is soldered or otherwise connected to the metallic ferrule 14, making an air tight joint therewith, the ferrule 14 being secured upon the end of the outer tube or sleeve 15 of glass or any other suitable material. Electrical connection is made from the negative terminal of the aforementioned source of current with the ferrule 14 or the tube 13 which communicates electrically with the cathode C. The sleeve or tube 15 is supported upon the glass cathode stem E by the member 16, of cork or other suitable material, which has a plurality of longitudinally extending grooves 17 forming air passages.

The tube or sleeve 15 preferably terminates in the bell 18 which extends around the bulb B to any suitable distance.

Air or other cooling medium is introduced into the tube 13, passes therethrough and strikes the cathode C, cooling the same, and then passes outwardly in the annular space between tubes 11 and 13 into the sleeve or tube 15 thence through the passages 17 over the outside of the cathode stem E into the bell 18 from which it issues over the outer surface of the bulb B, all as indicated by the arrows. And I have found that the air or other medium issuing from the bell 18 clings or remains close to the bulb B even beyond its middle or equator.

By this construction not only is the cathode C cooled, but the glass of the stem E or bulb B near their junction, as at 19, that is, in the region near the outer margins or rim of the cathode C is kept cool, so that it cannot rise to that temperature at which decomposition or devitrification of the glass takes place, and consequently the vacuum within the tube is prevented from lowering or varying, with the result that the X-ray tube operates with substantial uniformity under either normal or above normal excitation or for long periods.

I have found that with an X-ray tube constructed as above described that when a current of 10 milliamperes was passed through the tube continuously for four hours, the vacuum at the end of the run was as high as at the start. I found that the tendency was for the vacuum to become higher, that is, rarer, and it was necessary to regulate the vacuum of the tube frequently, as by vacuum lowering regulator R, to keep the vacuum down to the same degree as at the start of the run.

To those skilled in the operation of X-ray tubes this will be understood to be a desirable advantage for, as is well understood, when an X-ray tube is energized continuously for some considerable time the tube becomes hot which causes the vacuum to lower.

But by my invention this tendency to lowering of the vacuum is overcome and

there is no tendency to lowering of the vacuum when the tube has been run for such length of time as would cause it, without my improvement, to be heated to such degree as to cause erratic or undesirable behavior.

What I claim is:

1. The combination with a vacuum tube having an electrode, of a hollow support for said electrode and a conduit for cooling medium communicating with the interior of said hollow support and surrounding a part of the vacuum tube at its exterior.

2. The combination with a vacuum tube having an electrode, of a hollow support for said electrode, a conduit for cooling medium communicating with the interior of said hollow support and surrounding a part of the vacuum tube at its exterior, and a second conduit for cooling medium extending into said hollow support.

3. The combination with a vacuum tube having an electrode, of a tubular member supporting said electrode, and an outer sleeve embracing and spaced from the exterior of the vacuum tube and communicating with the interior of said tubular member.

4. The combination with a vacuum tube having an electrode, of a tubular member supporting said electrode, an outer sleeve embracing and spaced from the exterior of the vacuum tube and communicating with the interior of said tubular member, and a tube for cooling medium extending into said tubular member.

5. The combination with a vacuum tube having an electrode, of a stem on said tube, a hollow support for said electrode, a sleeve surrounding and spaced from said stem and communicating with the interior of said hollow support.

6. The combination with a vacuum tube having an electrode, of a stem on said tube, a hollow support for said electrode, a sleeve surrounding and spaced from said stem and communicating with the interior of said hollow support, and a tube for cooling medium extending into said hollow support.

7. The combination with a vacuum tube having an electrode, of a stem on said tube, a hollow support for said electrode, a sleeve surrounding and spaced from said stem and communicating with the interior of said hollow support, and a bell on one end of said sleeve.

8. The combination with a vacuum tube having an electrode, of a stem on said tube, a hollow support for said electrode, a sleeve surrounding and spaced from said stem and communicating with the interior of said hollow support, a tube for cooling medium extending into said hollow support, and a bell on one end of said sleeve.

9. The combination with a vacuum tube having an electrode, of a stem on said tube,

- a hollow support for said electrode, a sleeve surrounding and spaced from said stem and communicating with the interior of said hollow support, and a perforated support for said sleeve upon said stem. 5
10. The combination with a vacuum tube having an electrode, of a stem on said tube, a hollow support for said electrode, a sleeve surrounding and spaced from said stem and communicating with the interior of said hollow support, and a tube for cooling medium extending into said hollow support, and a perforated support for said sleeve upon said stem. 10
11. The combination with an X-ray tube comprising a bulb and stem, of a cathode within said tube and disposed approximate the junction of said stem and bulb, a tubular support for said cathode, a sleeve spaced from and embracing said stem, the interior of said tubular support communicating with the space between said sleeve and stem. 15
12. The combination with an X-ray tube comprising a bulb and stem, of a cathode within said tube and disposed approximate the junction of said stem and bulb, a tubular support for said cathode, a sleeve spaced from and embracing said stem, the interior of said tubular support communicating with the space between said sleeve and stem, and a tube for cooling medium extending into said tubular support. 20
13. The combination with an X-ray tube comprising a bulb and stem, of a cathode within said tube and disposed approximate the junction of said stem and bulb, a tubular support for said cathode, a sleeve spaced from and embracing said stem, the interior of said tubular support communicating with the space between said sleeve and stem, and a bell on said sleeve approximate the junction of said bulb and stem. 25
14. The combination with an X-ray tube comprising a bulb and stem, of a cathode within said tube and disposed approximate the junction of said stem and bulb, a tubular support for said cathode, a sleeve spaced from and embracing said stem, the interior of said tubular support communicating with the space between said sleeve and stem, a tube for cooling medium extending into said tubular support, and a bell on said sleeve approximate the junction of said bulb and stem. 30
15. The combination with an X-ray tube comprising a bulb and stem, of an electrode within said tube, a tubular support for said electrode, a sleeve spaced from and embracing said stem, said sleeve being closed at its end approximate the outer end of said stem and communicating with the interior of said support, and a tube for cooling medium extending through said closed end of said sleeve into said support. 35
16. The combination with an X-ray tube comprising a bulb and stem, of an electrode within said tube, a tubular support for said electrode, a sleeve spaced from and embracing said stem, said sleeve being closed at its end approximate the outer end of said stem and communicating with the interior of said support, a tube for cooling medium extending through said closed end of said sleeve into said support, and a bell on said sleeve approximate the junction of said bulb and stem. 40
17. The combination with an X-ray tube, of a tubular support integral with the walls thereof, an anti-cathode having a tubular extension, said tubular support extending into said tubular extension, a second tube on said anti-cathode sealed in the wall of said X-ray tube and opening to the atmosphere, the gas pressure of said X-ray tube existing within said tubular support and extension, a third tube within said second tube, said second and third tubes being so disposed and spaced that cooling medium may be passed therethrough. 45
18. The combination with the bulb of an X-ray tube, of a stem integral with said bulb, a tube sealed at its one end in said stem, the free end of said tube disposed within said bulb, a yielding connection between said tube and said stem near the seal of said tube in said stem, an electrode attached to the free end of said tube within said bulb and forming a closure for said tube, a tubular support integral with said bulb, and a tubular extension on said electrode carried by said tubular support. 50
19. The combination with the wall of an X-ray tube, of a tube sealed therein, an anti-cathode attached to the end of said tube and forming a closure for said tube, a stem integral with the X-ray tube extending into said X-ray tube, and a tubular extension on said anti-cathode engaging said stem. 55
20. The combination with an X-ray tube, of a tubular support integral with the wall thereof, an electrode having a tubular extension carried by said tubular support, the gas pressure of the X-ray tube existing within and without said tubular support and extension, and a hollow member opening to the atmosphere attached to said electrode within said extension and sealed into a wall of said X-ray tube. 60
21. The combination with an X-ray tube, of a tubular support integral with the wall thereof, an electrode having a tubular extension carried by said tubular support, the gas pressure of the X-ray tube existing within and without said tubular support and extension, and a tube having a vacuum tight joint with said electrode and sealed in a wall of said X-ray tube. 65
22. The combination with a vacuum tube comprising a bulb, of a sleeve surrounding and spaced from said vacuum tube, said

sleeve terminating in a bell for directing cooling medium over said bulb beyond the end of said bell.

23. The combination with a vacuum tube 5 comprising a bulb, of a bell spaced from and surrounding a part of said bulb and open at its end nearest the center of said bulb, and means for delivering cooling medium to said bell, said bell guiding said medium 10 over said bulb.

24. The combination with a vacuum tube comprising a bulb and a stem, a sleeve surrounding and spaced from said stem, said sleeve terminating in a bell partly surrounding said bulb, and means delivering 15 cooling medium through said sleeve to said bell, said bell directing said medium over said bulb beyond the end of said bell.

25. The combination with a vacuum tube, 20 of a stem on said tube, a sleeve surrounding and spaced from said stem, said sleeve closed

at its one end and open at the other, said sleeve at its closed end inclosing the free end of said stem, and means delivering cooling 25 medium into said sleeve at its closed end.

26. The combination with a vacuum tube, of a stem on said tube, a sleeve surrounding and spaced from said stem, said sleeve closed at its one end and open at the other, said sleeve at its closed end inclosing the free end 30 of said stem, means delivering cooling medium into said sleeve at its closed end, and a perforated support for said sleeve upon said stem.

In testimony whereof I have hereunto 35 affixed my signature in the presence of the two subscribing witnesses.

EDWIN W. KELLY.

Witnesses:

ELEANOR T. McCALL,
NELLIE FIELD.