United States Patent

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[33] **Germany**
[31] **M73983**

[54] **CATHODE FOR AN X-RAY TUBE COOLED BY HEAT-CONDUCTIVE COAXIAL CYLINDERS**
5 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** 313/37; 313/46
[51] **Int. Cl.** H01j 61/52; H01j 7/24
[50] **Field of Search** 313/37, 46, 55, 346

[56] **References Cited**

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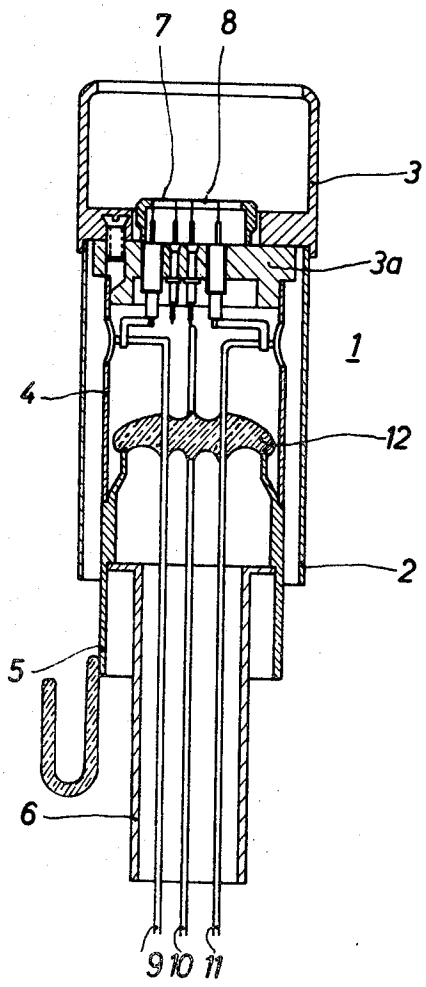
ABSTRACT: A cathode for an X-ray tube which is mechanically rugged and cooled through coaxially arranged hollow cylinders at least one of which is joined to the cathode with good thermal conductivity and the other projects from the glass envelope of the X-ray tube, both cylinders being joined to one another.



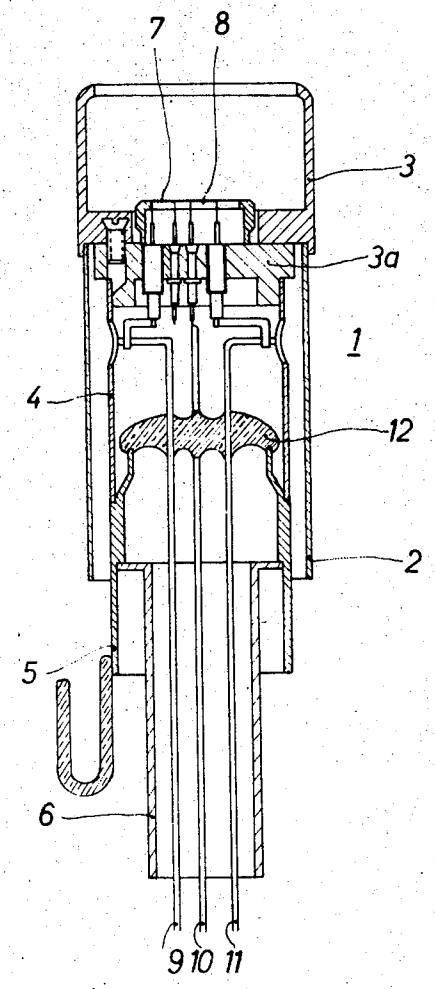


Fig.1

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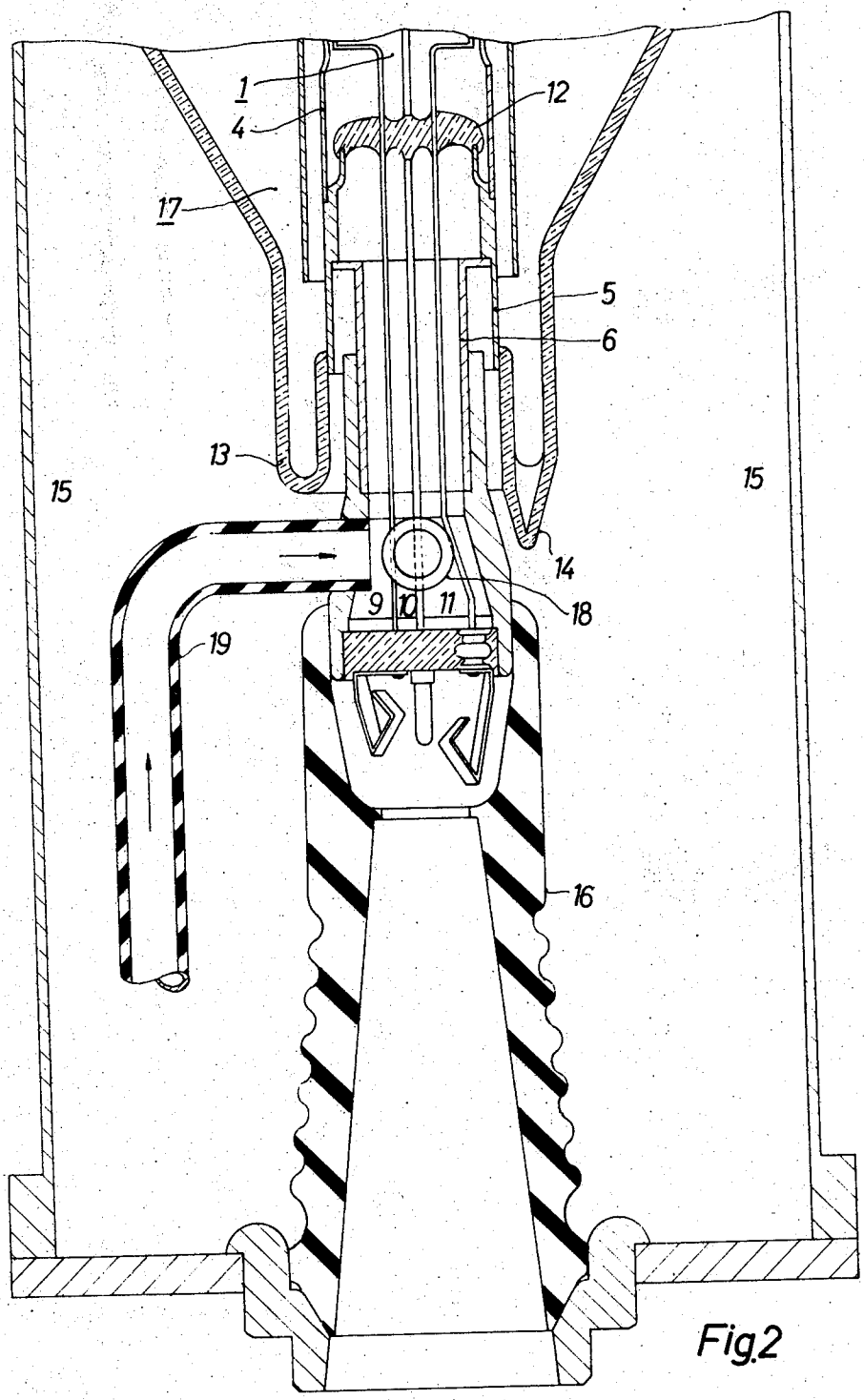

Fig.2

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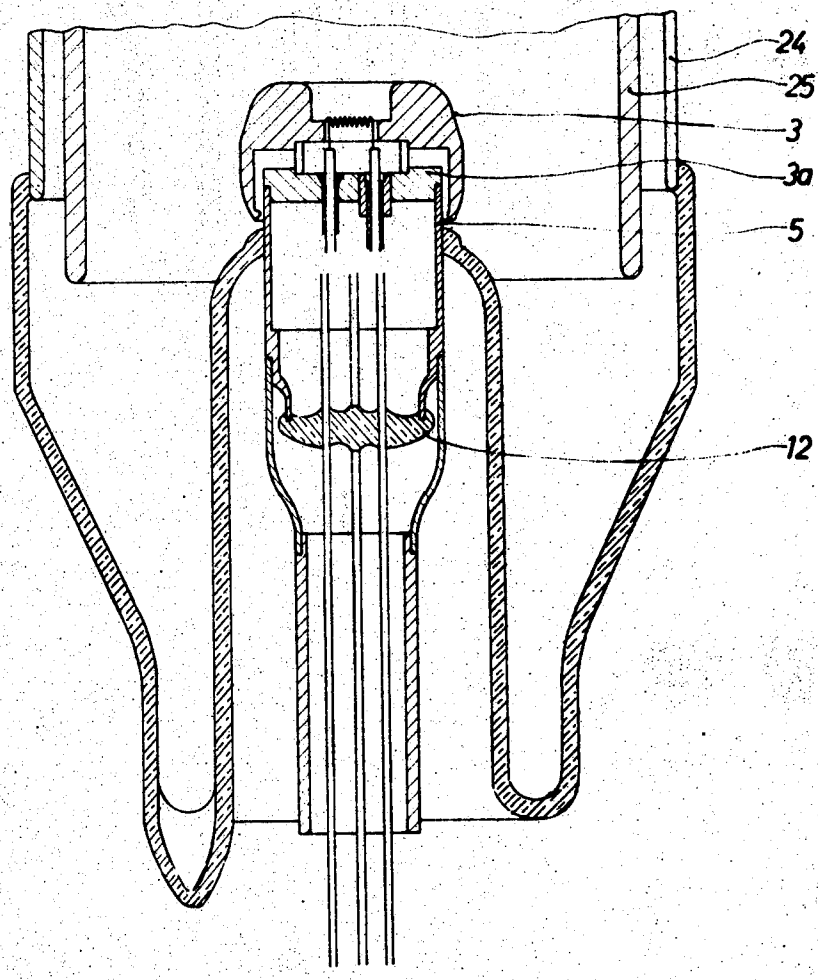

Fig.3

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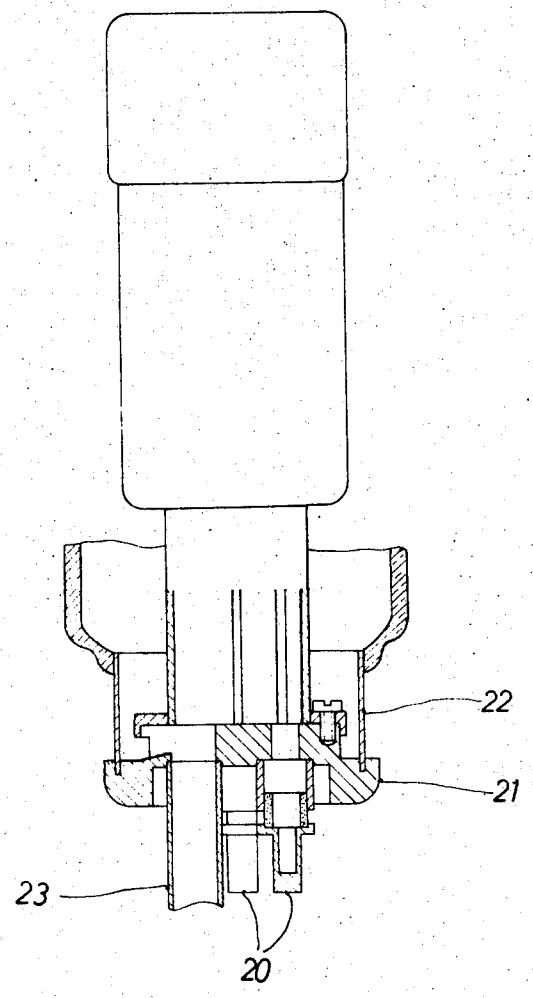

Fig 4

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CATHODE FOR AN X-RAY TUBE COOLED BY HEAT-CONDUCTIVE COAXIAL CYLINDERS

The invention relates to a mechanically strong construction of a cathode for an X-ray tube which during the process of sealing in can be satisfactorily centered and cooled and from which the heat generated in operation can be readily conducted away. With proper use of the cathode construction in accordance with the invention, the occurrence of spark discharges to the glass envelope, which are likely to damage the tube, can be prevented with certainty.

The cathode constructions commonly used include a so-called pinch, a hollow cylindrical glass tube being pinched at one end about a number of lead-through wires which serve to supply current to the filament or filaments. In order to prevent the occurrence of high field stresses due to the small diameter of the wires, a metal sleeve provided with a so-called cathode cap is slipped onto the pinch. The glass tubing can readily be joined to the glass envelop of the tube by sealing. For this purpose, the cathode part and the glass envelope of the tube are each gripped in one of two chucks of a sealing in machine which run in synchronism, the chuck for the cathode part being wound with asbestos wool to avoid injury to the glass tubing. Naturally, in this manner it is substantially impossible for the cathode to be accurately centered, and this is a great disadvantage especially in tubes having long electron paths.

The ends of the glass envelope and of the cathode parts are heated along their entire peripheries, bent into engagement with each other and sealed together. In this process, part of the heat required for the sealing is transferred to the cathode sleeve arranged in close proximity to the sealing zone, so that in spite of the use of a protective gas the sleeve is often oxidized. During subsequent operation, the heat generated may liberate the oxygen thus bound to the surface of the metal with consequent disturbances.

A further disadvantage of the known construction is the insufficient transfer of heat from the interior of the tube to its surroundings with the result that during operation the cathode part is heated to temperatures at which the residual gases always present in the interior of the cathode sleeve and of the cathode cap are liberated, which may also give rise to disturbances in the completed tube.

It is an object of the invention to avoid these disadvantaged by improving the heat conduction, and the invention relates to a cathode provided with a metal cathode sleeve joined to a metal cathode cap. According to the invention, the heat generated is conducted away from the cathode cap through coaxially arranged hollow metal cylinders, of which one is joined with good thermal conductivity to the cathode cap and the other projects beyond the glass envelope of the X-ray tube, both hollow cylinders being joined to one another and, as the case may be, to one end of a further coaxially arranged hollow metal cylinder.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a sectional view of a cathode in accordance with the invention;

FIG. 2 is a sectional view of a cathode in accordance with the invention in which heat is abstracted from the cathode by additional cooling;

FIG. 3 shows a cathode in accordance with the invention, which is joined to the glass tube envelope immediately below the cathode cap; and

FIG. 4 shows a cathode in accordance with the invention having a metal exhaust tube.

In FIG. 1 the outer surface of a cathode 1 is constituted by a cathode sleeve 2 and a cathode cap 3 joined thereto. To the cathode cap 3 is rigidly secured a cathode plate 3*a* and to this plate one end of a nickel sleeve 4 is rigidly secured. At its other end the sleeve 4 is welded to a cylindrical member 5 which is made of a metal alloy the coefficient of thermal expansion of which is substantially equal to that of glass. Such metal alloys are known, for example, under the trade name "Vacon". To this cylinder a copper sleeve 6 is joined by soldering. The lower rim of the cylinder 5 is sealed in a vacuum-tight manner to a glass envelope 13 and its upper rim is covered by a cap 12 of hard glass through which pass supply wires 9, 10, and 11 which serve to supply heating current to filaments 7 and 8. During the process of sealing the cathode 1 in the glass envelope 13, the cylinder 6 is gripped, without the interposition of any material, in the chuck of the sealing-in machine so that the cathode can be accurately aligned with respect to the axis of the envelope. A further advantage is that the heat generated during the sealing-in operation is conducted away to the chuck through the cylinder 6 and heating of the cathode sleeve 2 and/or cathode cap 3 is avoided. In the operation of the tube, the heat radiated by the filaments 7 and/or 8 to the cathode cap 3 is conducted away from the interior of the tube through the cylinders 4, 5 and 6. This ensures the cathode cap is heated to a temperature considerably lower than the usual temperature of 250° C and more, even if the X-ray tube is operated in a gas atmosphere, for example, SF_6.

When insulating materials of poor thermal conductivity, for example foamed material, is used the heat dissipation is extremely small but may readily be improved by means of additional oil cooling, as is shown in FIG. 2.

This Figure shows part of a hood 15 surrounding a tube 17 the cathode of which is insulated from the high voltage of the hood by means of a plug sleeve 16. The thermally conducting parts 5 and 6 of the cathode 1 are cooled by oil which is supplied through a pipe 19 and is conducted away by a pipe 18 at right angles thereto. Since in the cases in which the voltage set up at the X-ray tube is symmetrical with respect to ground potential cooling of the anode is always required, it is of advantage to extend the pipes 18 and 19, which obviously must be made of an insulating material, for example glass or plastic material, from the cathode to the anode so that the cathode and the anode, not shown, are cooled by means of one cooling circuit.

FIG. 3 relates to an X-ray tube having an grounded middle portion, the middle part of the glass envelope being replaced by a grounded cylindrical metal sleeve 24, 25. The anode, not shown, projects into the middle portion in the same manner as does the cathode cap 3 which, through the cathode plate 3*a*, is directly joined to the ring 5 of "Vacon". Immediately below the cathode cap, the glass envelope is joined to the ring 5 of "Vacon" which is closed at its lower end by a cap 12 of hard glass, which is pressed against the ring 5 by the pressure difference between the vacuum in the interior of the tube and atmospheric pressure. Since in this arrangement the glass envelope starts immediately below the cathode cap, metal surfaces face metal surfaces only, and this is conductive to preventing electrons emitted from impurities on the metal surface from striking the glass wall and consequently to preventing the tube from being damaged especially at very high voltages.

In tubes with grounded anodes, the same effect is obtainable by arranging the cathode to project into the anode cap as far as possible and by joining the glass envelope to the cathode immediately below the cathode cap.

A further possibility of carrying the heat generated by the cathode-filament away from the interior of the tube is shown in FIG. 4. A metal flange 21 is sealed to the glass tube envelope by means of a metal ring 22. Ceramic bushings for the current conductors are provided in the metal flange 21. The metal tubing 6 of the cathode system may be screwed to the flange 21, if required, after the sealing-in operation. In this arrangement, a particularly advantageous feature is a metal exhaust tube 23 which is soldered in the flange and after exhaustion may be closed by pinching with a pair of special pincers, so that the difficult operation of a closing glass exhaust tube by drawing is dispensed with.

We claim:

1. A cathode for an X-ray tube having a metal cathode cap, characterized in that the heat generated is conducted away from the cathode cap (3) through coaxially arranged hollow cylinders (4,5,6) of which one (4) is joined to the cathode cap (3) with good thermal conductivity and another (6) projects

from the glass envelop of the X-ray tube, both hollow cylinders being joined to one another, and as the case may be, to a further coaxially arranged hollow cylinder (5).

2. A cathode for an X-ray tube as claimed in claim 1 characterized in that the intermediate member (5) which the hollow cylinders (4,6) are joined to one another is made of metal the coefficient of thermal expansion of which corresponds to that of glass.

3. A cathode for an X-ray tube as claimed in claim 1 characterized in that the hollow cylinder joined to the cathode cap is

made of a metal the coefficient of thermal expansion of which corresponds to that of glass.

4. A cathode for an X-ray tube as claimed in claim 3, characterized in that the glass enveloped (13) is sealed to a hollow cylinder (4) immediately below the cathode cap (3).

5. A cathode for an X-ray tube as claimed in claim 1, characterized in that the space in the hollow cylinder is connected to the space outside the tube by a length of metal tubing (23) with serves as an exhaust tube.