

Dec. 4, 1934.

S. H. STUPAKOFF

1,982,885

INSULATOR AND CATHODE EMBODYING THE SAME

Filed April 2, 1932

2 Sheets-Sheet 1

Fig. 1.

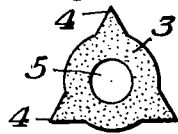


Fig. 1a.

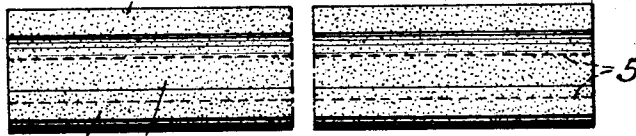


Fig. 2.

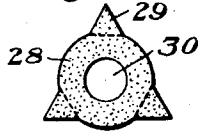


Fig. 2a.

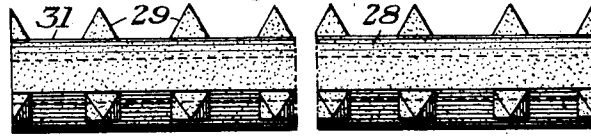


Fig. 3.

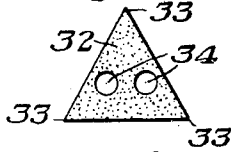


Fig. 3a.

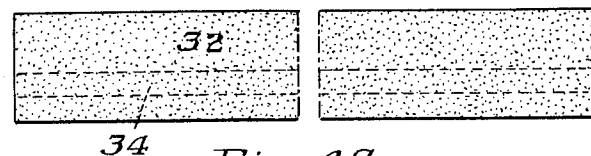


Fig. 4.

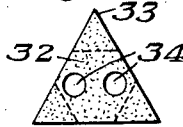


Fig. 4a.

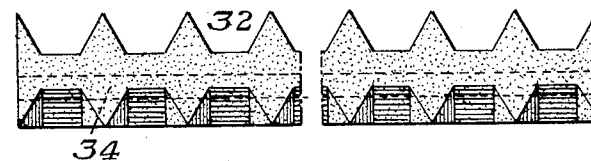


Fig. 5.

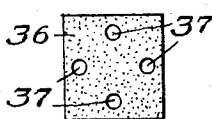


Fig. 5a.

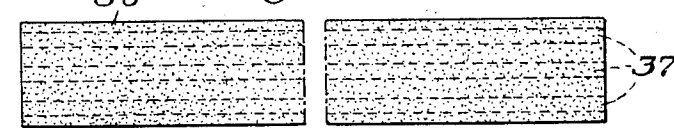


Fig. 6.

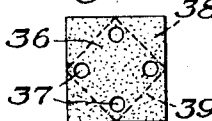


Fig. 6a.



Fig. 7.

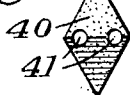


Fig. 7a.



Fig. 8.

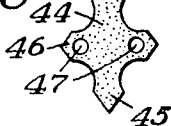
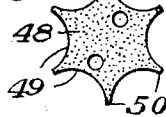


Fig. 9.



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Fig. 10.

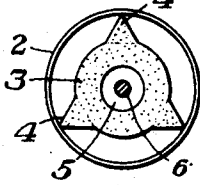


Fig. 11.

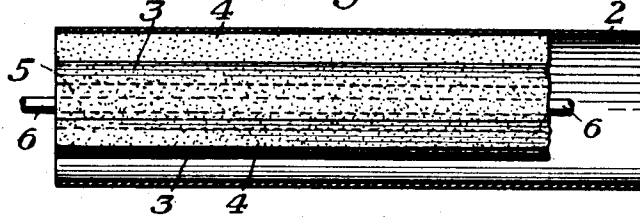


Fig. 12.

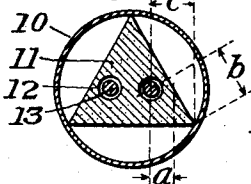


Fig. 13.

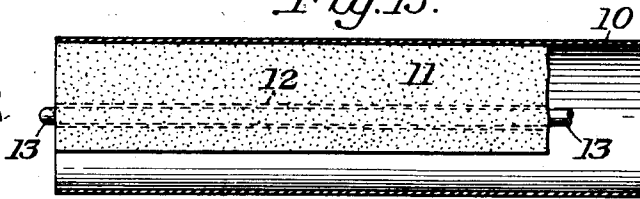


Fig. 14.

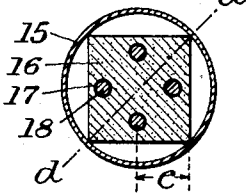


Fig. 14a.

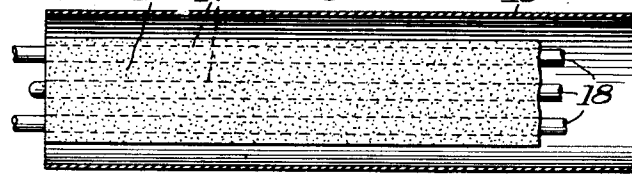


Fig. 16.

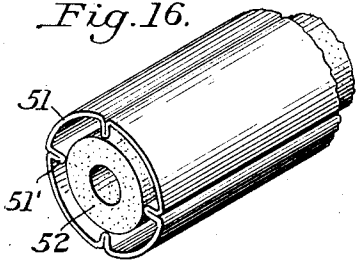


Fig. 15.

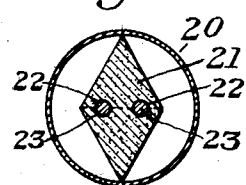


Fig. 18.

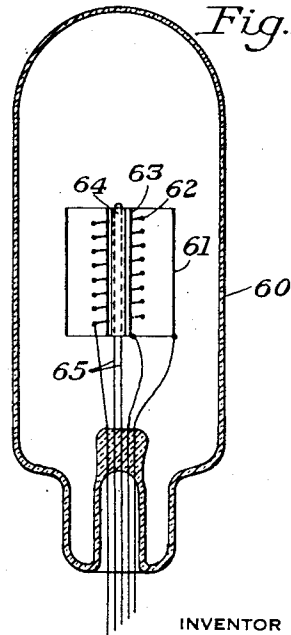
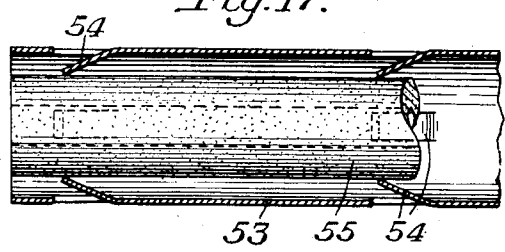


Fig. 17.



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## UNITED STATES PATENT OFFICE

1,982,885

INSULATOR AND CATHODE EMBODYING  
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Application April 2, 1932, Serial No. 602,819

17 Claims. (Cl. 250—27.5)

This invention relates to thermionic devices of the type employing an indirectly heated cathode, and more particularly to the cathode construction and the insulator employed therein.

5 Thermionic devices, such as the ordinary radio vacuum tube, are commonly constructed with a cathode in the form of a metal sleeve of very small diameter. Into this sleeve is inserted a refractory rod or tube through which passes a filament or heater wire. Sometimes the heater wire is in the form of a small helix; other times it is in the form of a hairpin loop, or it may be arranged in a number of otherways, depending on the design, style, construction and purpose of the tube. At the temperature at which the cathode operates the refractory inside the metal sleeve becomes electrically conductive, such materials generally having a negative coefficient of electrical resistance, being fairly good insulators when they are cold, but offering a decreased resistance as they become hotter.

By reason of this fact there is a slight leakage of current from the heater wire to the cathode, this leakage of current, while of very small magnitude, may nevertheless slightly affect the output of the tube, particularly where alternating current is used on the heater wire. While the effect on the output of a single tube may be relatively slight, the output current of a tube in a radio set is frequently amplified many times so that the effect of leakage may produce a distinctly audible sound in the loud speaker. It has been noticed, moreover, that in tubes made of the same lot of material a considerable variation will exist in the magnitude of the current which leaks through. Consequently it is very difficult for a tube manufacturer to assure a set builder that a shipment of tubes will all have equal characteristics insofar as this matter of leakage is concerned.

According to the present invention provision is made for maintaining the leakage current to a very much smaller and practically negligible amount and enable tube manufacturers to maintain more nearly constant uniformity in their product. This is effected by maintaining the greater portion of the area of the body of the insulator out of direct contact with the interior of the metal sleeve, but keeping it centered in the sleeve, and by further providing an arrangement in which the heater wire is at all times separated from the interior of the sleeve by a greater thickness of insulation than the distance from the wire to the nearest surface of the insulator.

In other words, insulators as heretofore constructed have a substantial area of the heater in contact with the metal cylinder of the cathode, whereas the present invention provides for a very small area of contact, and insulators as heretofore generally used have been so constructed in many instances that the thickness of insulation between the heater wire and the metal sleeve has only been very slight.

The invention may be readily understood by reference to the accompanying drawings, in which Figures 1 and 1a are end and side views, respectively, of one form of insulator embodying my invention;

Figures 2 and 2a are views similar to Fig. 1 and Fig. 1a of a similar type of insulator which is serrated;

Figures 3 and 3a are views similar to Figs. 1 and 1a of a modified shape;

Figures 4 and 4a show modifications of the insulator of Figs. 3 and 3a, in which the insulator is serrated;

Figures 5 and 5a show further modifications and are views similar to Figs. 1 and 1a;

Figures 6 and 6a are modifications of the insulator shown in Figs. 5 and 5a in which the insulator is serrated;

Figures 7 and 7a are views similar to Figs. 1 and 1a showing further modifications;

Fig. 8 is a view similar to Fig. 7 of still another shape of insulator;

Figure 9 is an end view of another fluted type of insulator;

Figure 10 is an end view of a cathode assembly embodying my invention;

Figure 11 is a longitudinal section through the cathode assembly of Fig. 10, the insulator shown being the insulator of Fig. 2;

Figure 12 is a transverse sectional view showing a cathode assembly embodying a triangular form of insulator;

Figure 13 is a longitudinal section through the assembly of Fig. 12;

Fig. 14 is a view similar to Fig. 12 showing the assembly in which the squared insulator is employed;

Figure 14a is a longitudinal sectional view through the assembly of Fig. 14;

Figure 15 is an end view of the insulator assembly using the cathode assembly of Fig. 7;

Figure 16 is a perspective view of a metal sleeve and insulator without the heater wire, wherein the projections are on the metal sleeve instead of on the insulator;

Figure 17 is a longitudinal section through the

sleeve and insulator assembly, the heater wire not being shown, showing another arrangement for supporting the insulator by projections on the interior of the metal sleeve; and

5 Figure 18 is a diagrammatic view representing a conventional radio tube embodying my invention.

Referring to the drawings, it will be understood that they represent very greatly enlarged views of the elements as actually used in the standard radio tube, the inside diameter of the cathode sleeve usually being of the order of magnitude of about .050 of an inch. Referring first to Figs. 10 and 11, 2 designates the cylindrical metal sleeve comprising the body of the cathode. Within the sleeve and extending longitudinally thereof is an insulator 3. This insulator is made of a refractory material, such as magnesium oxide, and, as shown in the drawings, has an outside diameter somewhat less than the inside diameter of the sleeve 2.

Formed on the outside of the insulator are a plurality of radially projecting points or ribs 4. There are preferably three of these ribs, as three serve to effectively center the insulation inside the sleeve, and a greater number merely tends to increase the area of contact between the insulator and the sleeve. The height of the points or ribs above the outside diameter of the body of the insulator is such that the insulator may be pushed into the sleeve and will be centered in the sleeve, the parts preferably being as accurately dimensioned as possible in order that the insulator cannot rattle or shift to position laterally inside the cylinder.

This type of insulator is particularly designed for use with that type of a heater comprising a helical wire or comprising a single length of straight filament wire. For this purpose it has a single hole 5 extending coaxially thereof and the heater wire extends through this hole. The heater wire is designated 6.

In this assembly it will be seen that there is a very small area of contact between the insulator and the surrounding metal sleeve so that the leakage path for current is almost negligible. This leakage path can be further reduced by notching or serrating one or more of the ribs 4 so that the insulator contacts with the sleeve only through the sharp points projecting from its surface.

It will be noted, moreover, that by reducing the diameter of the body of the insulator and providing the ribs on its surface instead of having the diameter of the insulator such as to entirely fill the cylinder, the mass of refractory to be heated up is very materially reduced, so that the cathode heats up much more quickly.

In Figs. 12 and 13 I have shown another type of three-cornered insulator in a cathode assembly, the insulator in this case, however, having two holes therein to receive a hairpin type of heater wire rather than a straight filament or helix, as contemplated in Figs. 10 and 11.

In Figs. 12 and 13, 10 designates the cylinder of the cathode and 11 is an insulator in the cylinder extending longitudinally thereof. The insulator is triangular in cross-section, preferably being in the form of an equilateral triangle. Its dimensions are such that it will fit snugly in the cylinder, and when fitted in the cylinder has only three points of contact of very small area.

Formed within the insulator are two longitudinally extending holes 12 which receive the

heater wire 13. These holes are placed as close to the center of the insulator as possible so that there is a considerable amount of insulation between the heater wire and any point of contact with the metal cylinder. For instance, it will be noted that while the distance  $a$  from the center of the hole to the nearest surface of the insulator is relatively slight as compared with the distance  $b$  from the center of the hole to the nearest point of contact with the metal sleeve. At the points where the holes are relatively close to the surface of the insulator such surfaces of the insulator are spaced the distance  $c$  from the inside of the metal cylinder.

Fig. 14 illustrates an arrangement which may be employed in which the number of points of contact around the periphery of the insulator is greater than three. This form of insulator is especially adapted for a heater construction in which there are several lengths of heater wire. In this instance the insulator is shown as being square and as having four holes therein to receive four reaches of the heater wire. In this figure, 15 designates the metal cylinder; 16 is the insulator, which is square in cross-section, and having sides of such length that the insulator may be fitted into the cylinder 15. Thus it contacts with the interior of the cylinder only at the corners of the insulator. The insulator has four holes 17 extending longitudinally thereof to receive the heater wire 18. The four holes are set 90° apart and are spaced 45° from the diagonals of the square. By reason of this arrangement the heater wires can be kept equi-distant and a maximum amount of insulation is interposed between the center of each hole and the point where the insulator contacts with the cylinder. In Figure 14  $d-d$  indicates the diagonals of the square; and  $e$  represents the distance between the center of the hole and the nearest point of contact with the metal.

The arrangement shown in Figure 15, which is a transverse section through an insulator assembly, indicates an insulator having only two points of contact with the surrounding sleeve. In this view 20 designates the cylindrical metal cathode and 21 is an insulator which is of a cross-section approaching that of a rhomboid, being characterized by having a major transverse axis equal to that of the inside diameter of the cylinder and a minor transverse axis less than the inside diameter of the cylinder so that the insulator contacts with the cylinder along only two edges or corners.

I have shown the insulator as having two holes 22 to receive the heater wire 23. The center lines through the holes 22 coincide with the minor transverse axis of the insulator so that the distance from the center of a hole through the insulator to a point of contact with the cylinder is much greater than the distance from the center of a hole to the nearest surface of the insulator. This form of insulator has the advantage of reducing the area of contact to a minimum, but has the difficulty of being somewhat more difficult to center in the cylinder than those types having three or more points of contact.

Several different embodiments of the invention are illustrated in Figs. 1 and 1a to Figs. 7 and 7a, showing the insulator apart from the assembly. Figure 1 shows an insulator of the general type employed in Figs. 10 and 11, the insulator being shown apart from the cathode. Reference numerals corresponding to Figs. 10 and 11 designate corresponding parts. In Figures 2 and 2a I 150

have shown the same form of insulator, but having notches cut in the ribs or flutes to reduce further the area of contact between the insulator and the sleeve. In this view 28 designates the insulator; 29 are the ribs on the exterior thereof; and 30 is the central hole. Cut into the ribs of the insulator are notches 31, thus reducing the area of contact between the insulator and the metal to a number of relatively small points.

10 The insulator shown in Fig. 3 corresponds to that shown in Figs. 12 and 13. The insulator in this view is shown as being an equi-lateral triangle. The insulator is designated 32 and has three corners 33 providing the points of contact between the insulator and the metal sleeve which is adapted to surround it. Instead of being shown as having a single hole, as in Figs. 1 and 2, I have shown two holes 34 therethrough, one of which is located at each side of the longitudinal axis of the insulator. The insulator shown in Fig. 4 is similar to that shown in Fig. 3 and corresponding reference numerals have been used to designate the corresponding parts. It differs from the arrangement shown in Fig. 3 in that it is serrated along the corners to reduce the area of contact to a number of small longitudinally separated points.

30 The insulator shown in Fig. 5 is similar to that described in connection with Fig. 14, it being square in cross-section. In this view the insulator is designated 36. I have shown it as having four holes 37 therethrough, these holes being positioned 90° apart and being spaced midway between the diagonals of the square. Such an insulator permits the use of a longer heater wire in that it may have four reaches instead of one or two and still provide only a small area of contact between the insulator and the surrounding metal shell.

40 The insulator shown in Fig. 6 is similar to that of Fig. 5, but I have shown it as being serrated by deep notches cut therein on opposite faces. Corresponding reference numerals have been used to designate the corresponding parts in Figs. 5 and 6. The notches may be cut either from opposite faces of the insulator or from opposite corners. In the drawings I have shown the notches as being cut in all four corners of the insulator.

50 Figure 7 shows an insulator similar to that shown in Fig. 15 but which is notched from the opposite sides. In this view the insulator is designated 40. It has a major transverse axis which is greater than its minor transverse axis and it has two holes extending longitudinally therethrough, the center lines through the holes coinciding with the minor transverse axis of the insulator. The holes are designated 41. The insulator may be straight or serrated. I have shown it as being serrated along opposite edges, deep notches 42 being cut along one edge thereof and a series of notches 43 being cut along the other edge thereof, the notches 43 being staggered with reference to the notches 42. These notches serve to reduce the area of contact between the insulator and the surrounding metal sleeve and at the same time they enable the heater wire to be at least partially exposed. Instead of deep serrations, shallow ones as described in Fig. 2 may be used.

70 In Figure 8 I have shown the end view of an insulator of still a different cross-sectional shape, it being essentially a modification of the shape shown in Fig. 7, in that the insulator 44 has a greater transverse dimension in one direction than the other. It is essentially in the form of

a cross, the arms of the cross having pointed tips. The two opposite arms 45 are longer than the two opposite arms 46 and the outer ends of the arms 45 contact with the interior of the cylinder, whereas the outer ends of the arms 46 are out of contact with the interior of the cylinder. Near the outer end of each arm 46 is a longitudinally extending hole 47 to receive the heater wire. The sides of the arms may be rounded, as shown. The particular advantage of this construction is that there is no straight path through the insulator from the holes 47 to the tips of the arms 45 so that leakage current must take a right angle path, thus giving a longer path of current flow with a correspondingly greater resistance. It has a further advantage because of the fact that these insulators are generally formed by extruding the refractory material through a die.

90 The refractory material being somewhat abrasive tends to wear away the die, the metal which is carried away adhering to the surface of the insulator. A very small amount of metal or metallic film may thus form on the surface of the insulator. The arrangement shown in Figure 8 gives a long path for any current which leaks from the heater wire to the outside of the insulator to the point where the insulator contacts with the surrounding sleeve. Any surface film of the nature described has a high resistance and is more or less discontinuous, so that by having a long path of surface travel for leakage current a higher resistance is obtained than in any of the other forms of insulators.

110 The arrangement shown in Figure 9 is for a simple fluted form of insulator. The insulator is designated 48 and has flutes 49 in the surface thereof, leaving points or ribs 50 for contact with the interior of the metal cylinder. It will be understood that the various cross-sectional shapes herein illustrated merely typify various shapes that can be used.

120 The adaptability of a particular shape for any tube depends somewhat on the size of the tube, or the size of the cathode. Some shapes can be extruded much more readily than others, particularly in the very small sizes.

125 It will be noted that in Figs. 1 and 2 I have shown the insulator as having but a single hole adapted to be a straight or helical cathode, and in the other insulators I have shown two or more holes. It will be understood that the single hole might be incorporated in the other forms of insulators or that multiple holes may be used with an insulator of the cross-section shown in Fig. 1, the various ramifications being obvious to one skilled in the art. It will also be understood that various serrations can be adapted to the different cross-sectional shapes.

135 Referring to Fig. 16, I have shown an arrangement in which the centering of the insulator is obtained but in which the area of contact between the insulator and the metal is confined to a few points and wherein the arrangement is essentially the reverse of what has previously been described. In this case the metal cylinder 51 is provided with inwardly projecting ribs or projections 51'. The insulator 52 is round, but its outside diameter is less than the inside diameter of the sleeve. The only points of contact between the insulator and the sleeve are where the projections or ribs 51' engage the surface of the insulator. Figure 16 shows the projections as being in the form of ribs. In Figure 17, however, I have shown how the same result may be obtained by forming inturned projections on the metal sleeve. 150

In this view the sheet metal sleeve or cylinder 53 has inwardly struck lugs 54 which are integral therewith and which serve to hold the insulator 55 out of contact with the inside of the sleeve, but which maintain the insulator centrally positioned in the sleeve. The lugs may be sloped at a slight angle to the perpendicular in order to facilitate the insertion of the insulator.

Figure 18 illustrates more or less diagrammatically the embodiment of my invention in a conventional three-element radio tube. In this view 60 designates the envelope of the tube; 61 is the cylindrical anode; 62 is the grid; and 63 is the cathode. The insulator 64 inside the cathode supports the heater wire 65. The insulator 64 may embody any of the shapes herein specifically described, or other shapes adaptable to my invention, the desirable qualities of the insulator being that it shall support the heater wire throughout substantially its full length; it shall fit within the cathode sufficiently tight to prevent rattling or microphonic disturbances; and finally, that the area of contact between the insulator and the cathode shall be but a relatively small percentage of the total area of the cathode, with the contacting surfaces approaching a knife edge or point as closely as possible. The term "point" as used herein and in the claims shall be understood to include either an edge-like rib or a sharp point.

The advantages of my invention reside in the fact that the area of contact between the insulator and the metal sleeve is considerably reduced over the area of contact provided by the usual continuous insulator as now generally provided in structures of this kind, so as to reduce to a minimum the available leakage path through the insulator from the heater wire to the surrounding cathode when the insulator reaches a temperature at which it becomes partially conductive.

A further advantage resides in the fact that the heater wire is disposed closer to the center of the insulator than it is to any point where the insulator contacts with the metal sleeve. This is advantageous for the reason that it assures the heater wire being separated from the metal sleeve by an adequate thickness of insulation, which would not be the case if the heater wire were relatively closer to a point where the insulator contacted with the interior of the sleeve. Also by reason of the fact that the cross-sectional area of the insulator is smaller than the cross-sectional area of the interior of the sleeve, there is a relatively smaller mass of insulation which has to be heated up, with the result that the tube heats up more quickly.

I have illustrated several specific embodiments and adaptations of my invention, and it will be understood that various other embodiments and adaptations are within the scope of the appended claims.

I claim:

1. A cathode assembly comprising a metal sleeve member, an insulator member within the sleeve member extending longitudinally thereof, a heater wire passing through the insulator member, one of said members having point-like projections thereon for contacting with the other member to hold the insulator member in spaced relation to the inside of the sleeve member.

2. A cathode construction comprising a cylindrical metal sleeve, an insulator of non-circular cross-section within the sleeve and of a cross-sectional shape different from that of the sleeve,

and a looped heater wire passing through the insulator, the heater wire being closer to the center of the insulator than to the nearest point of contact between the insulator and the sleeve and being in a plane which intersects the plane of the longest transverse dimensions of the insulator, all parts of the sleeve being substantially equidistant from the center of the insulator.

3. A cathode assembly comprising a cylindrical metal sleeve, a non-circular insulator within the sleeve contacting therewith only at a plurality of points and of a cross-sectional shape different from that of the sleeve, said insulator having at least two wire receiving holes extending longitudinally thereof, said holes being closer to the center of the insulator than to the nearest points of contact between the insulator and sleeve, and a heater wire passing through the holes, the line of centers for said holes lying in a plane which intersects the plane of the longest transverse dimension of the insulator, the metal sleeve being substantially equidistant at all points from the center of the insulator.

4. A cathode construction comprising a metal sleeve of circular cross-section, a substantially triangular insulator extending longitudinally of the sleeve and having its corners contacting the interior of the sleeve, and a heater wire passing longitudinally through the insulator.

5. A cathode construction comprising a straight metal sleeve of cylindrical cross section which is substantially cylindrical, an insulator within the sleeve extending longitudinally thereof contacting with the interior of the sleeve at at least three equi-distantly spaced points around the interior, said insulator having a wire extending longitudinally therethrough.

6. A cathode construction comprising a substantially cylindrical metal sleeve member, an insulator member within the sleeve member, said insulator having three equi-distantly spaced edge portions contacting with the interior of the sleeve, the remainder of the insulator being out of contact with the sleeve, and a heater wire extending through the insulator.

7. A cathode construction comprising a substantially cylindrical metal sleeve member, an insulator member within the sleeve member, said insulator having three equi-distantly spaced edge portions contacting with the interior of the sleeve, the remainder of the insulator being out of contact with the sleeve, and a heater wire extending through the insulator, at least one of said edge portions being serrated to further reduce the area of contact between the insulator and the interior of the sleeve.

8. A cathode assembly comprising a metal sleeve member having inwardly turned projections, an insulator of less diameter than the interior of the sleeve passing through the sleeve and maintained in spaced relation by engagement with said projections, and a heater wire passing through the insulator.

9. A cathode assembly comprising a straight metal sleeve member of circular cross section, an insulator within the sleeve member extending longitudinally thereof of a cross-sectional shape different from the cross-sectional shape of the sleeve member and contacting with the interior of the sleeve member at a plurality of separated points around the insulator, and a looped heater wire extending longitudinally through the insulator, the distance from the heater wire to the center of the insulator not exceeding the distance from the heater wire to the nearest place of con-

tact with the metal, the wires being in a plane which intersects the plane of the longest transverse dimension of the insulator whereby a maximum thickness of insulation is interposed between the wire and the point of contact with the metal.

10. An insulator for use in cathodes comprising a rod of refractory material the cross-section of which is in the form of a rhomboid having a major axis and a minor axis, said insulator having two holes therethrough positioned in the plane of the minor axis, one hole being at each side of the longitudinal axis of the insulator.

11. An insulator for use in cathodes comprising a rod of refractory material the cross-section of which is in the form of a rhomboid having a major axis and a minor axis, said insulator having a hole therethrough positioned in the plane of the minor axis, said insulator having a series of notches formed therein along two edges thereof, the notches of one series being staggered with relation to the other.

12. A cathode assembly comprising a metal sleeve, an insulator within the sleeve having a plurality of longitudinally extending flutes thereon, the tips of some of which contact with the interior of the sleeve the major portion of the surface of the insulator being out of contact with the sleeve, and a heater wire passing longitudinally through the insulator.

13. A cathode assembly comprising a metal sleeve, an insulator within the sleeve having a plurality of longitudinally extending flutes thereon, the tips of some of which contact with the interior of the sleeve, and a heater wire passing longitudinally through the insulator, the tips of the flutes forming a sharp edge or point.

14. A cathode assembly comprising a metal sleeve, an insulator within the sleeve having a

plurality of longitudinally extending flutes thereon, the tips of some of which contact with the interior of the sleeve, and a heater wire passing longitudinally through the insulator, the tips of the flutes forming a sharp edge or point, the tips of the flutes being notched to form longitudinally separated points of contact.

15. A cathode construction comprising a metal sleeve, an insulator within the sleeve of less diameter than the interior of the sleeve, a heater wire passing through the insulator, and ribs on the insulator extending longitudinally thereof, said ribs engaging the interior of the sleeve to hold the insulator in spaced relation to the sleeve and restrain it from relative motion or vibration in the sleeve.

16. A cathode construction comprising a metal sleeve, an insulator within the sleeve of less diameter than the interior of the sleeve, a heater wire passing through the insulator, and ribs on the insulator extending longitudinally thereof, said ribs engaging the interior of the sleeve to hold the insulator in spaced relation to the sleeve and restrain it from relative motion or vibration in the sleeve, the ribs terminating in sharp points.

17. A cathode construction comprising a metal sleeve, an insulator within the sleeve of less diameter than the interior of the sleeve, a heater wire passing through the insulator, and ribs on the insulator extending longitudinally thereof, said ribs engaging the interior of the sleeve to hold the insulator in spaced relation to the sleeve and restrain it from relative motion or vibration in the sleeve, the ribs terminating in sharp points, the ribs being notched at longitudinally spaced intervals to form longitudinally separated points of contact.

SEMON H. STUPAKOFF.

|    |     |
|----|-----|
| 40 | 115 |
| 45 | 120 |
| 50 | 125 |
| 55 | 130 |
| 60 | 135 |
| 65 | 140 |
| 70 | 145 |
| 75 | 150 |