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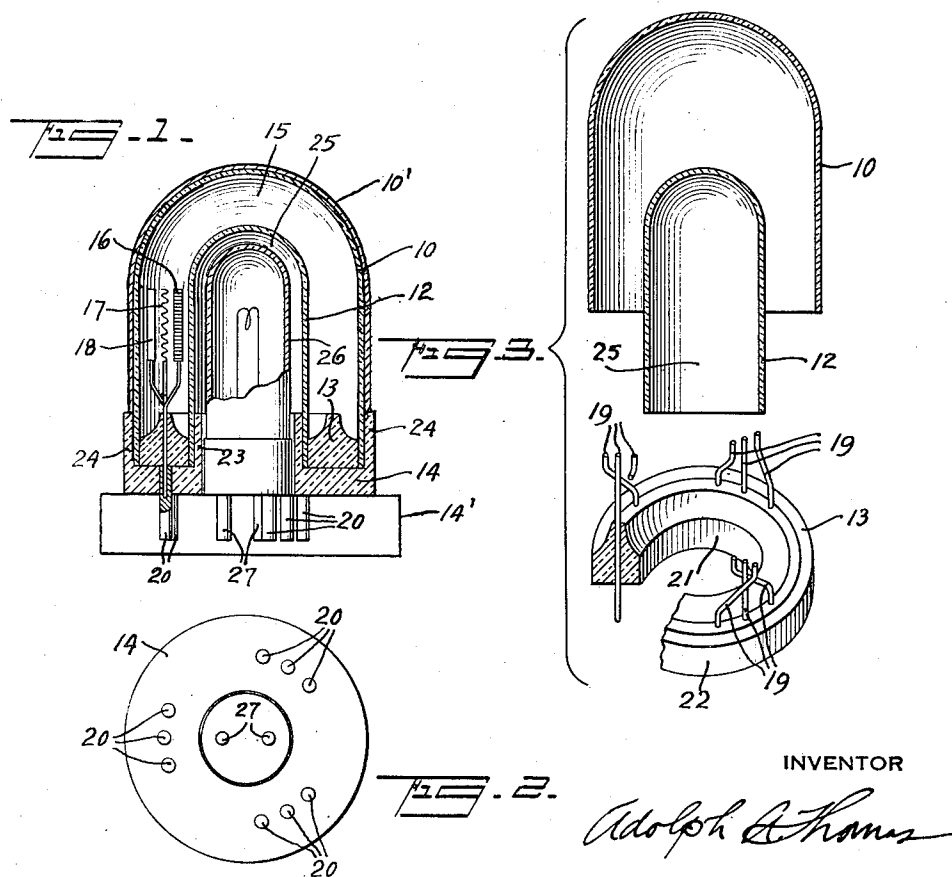
A. A. THOMAS

2,052,542

ELECTRONIC DEVICE

Filed Feb. 5, 1931

2 Sheets-Sheet 1



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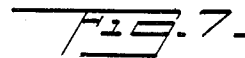
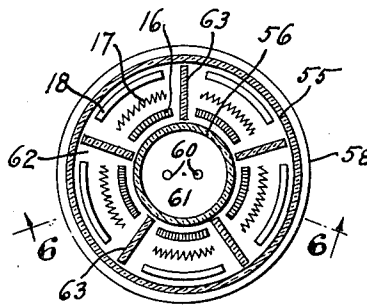
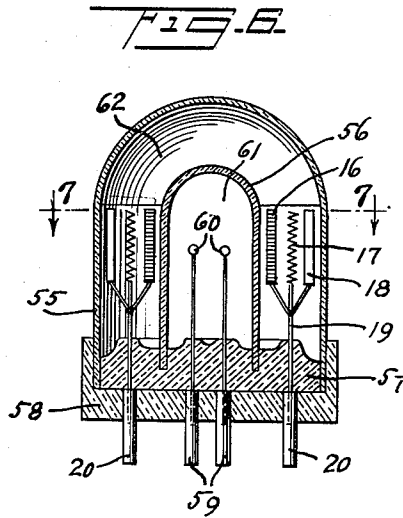
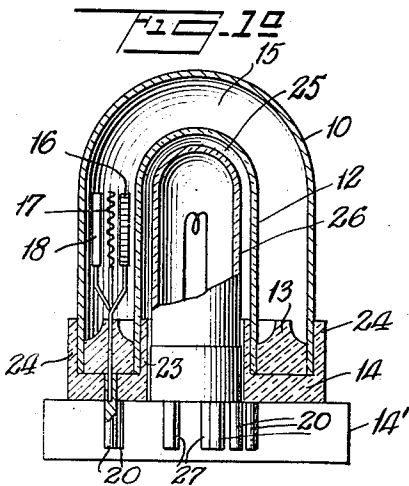
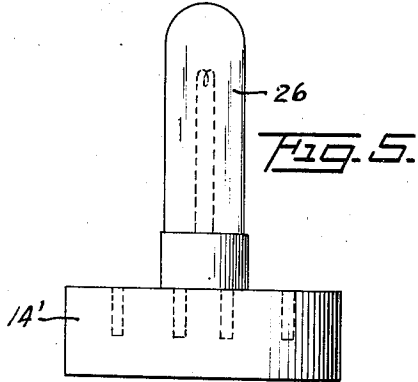
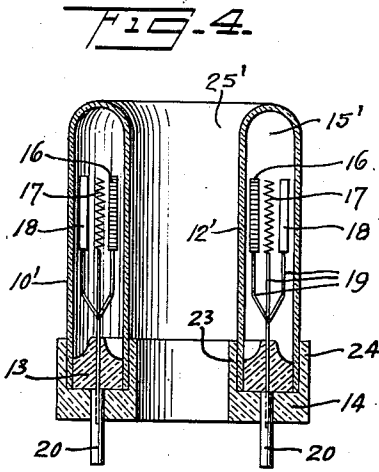
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2 Sheets-Sheet 2



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2,052,542

ELECTRONIC DEVICE

Adolph A. Thomas, New York, N. Y.

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18 Claims. (Cl. 250—27.5)

In one of its aspects, this invention relates to electric tubes and one of its objects is to provide a photo-electric tube capable of giving several stages of amplification in a multi-stage transmitting or receiving system. My new phototube has a plurality of sets or groups of electrodes, each set representing one stage of amplification. The cathode of each group of electrodes is a photo-electric element, and a single source of light arranged centrally of the tube illuminates all cathodes simultaneously with the same degree of intensity.

In one form of my invention, the phototube is annular in cross-section to provide a central recess for receiving an electric lamp. That is to say, the phototube is shaped like a cap or hood for the electric lamp, which is thereby brought close to the cathodes and equi-distantly therefrom. This lamp may be a glow tube adapted to emit a steady light of sufficient intensity and of a color to which the cathodes are most sensitive. The electric lamp may be separate from the phototube, or the two devices can be built into a unitary structure. I may also arrange the source of illumination in the phototube itself, so that a single chamber (vacuum or gas-filled, as required) encloses the central light filament or glow terminals and the surrounding sets of amplifying electrodes.

In another aspect of my invention I provide an electronic tube in which the evacuated chamber is formed by an envelope of sheet metal, the electrodes being supported in glass which is sealed to the metal in an airtight joint. The metal envelope, preferably of steel, not only strengthens the tube mechanically but also acts as an electric shield.

Considered in still another aspect, my invention comprises a double-walled tube in which the outer and inner walls are formed of materials having different coefficients of expansion, that of the outer wall being higher than that of the inner wall. In a preferred form of this feature of my invention, the outer wall is of sheet metal, such as steel, while the inner wall is of vitreous material, such as glass or quartz. The adjacent ends of the two spaced walls are sealed together in an airtight joint which completely closes off the space between the walls from the outer air.

The novel features and practical advantages of my invention will be clear from a description of the accompanying drawings, in which—

Fig. 1 shows an axial section of the phototube and electric lamp in assembled relation;

Fig. 1a is like Fig. 1 except that the outer envelope of the double-walled tube is of metal;

Fig. 2 is a bottom view of Fig. 1;

Fig. 3 is a so-called exploded view of the phototube to show the two cylinders and the base separated from each other;

Fig. 4 illustrates in vertical section a modified form of phototube in which the annular vacuum chamber is formed by a double-walled cylinder made in one piece;

Fig. 5 shows an electric light bulb adapted to fit into the central open recess of the phototube in Fig. 4;

Fig. 6 shows a combined phototube and electric lamp constructed as a unit, this view being a longitudinal section on line 6—6 of Fig. 7; and Fig. 7 is a transverse section on line 7—7 of Fig. 6.

Referring to Figs. 1-4, the phototube comprises a pair of concentrically spaced envelopes or cylinders 10 and 12 sealed to a glass ring 13, and these parts are secured to an insulating base member 14 in any practical way. The spaced cylinders 10 and 12 form an annular vacuum chamber 15 in which two or more sets of electrodes are supported. By way of example, I have shown three sets of electrodes, each set consisting of an anode 16, a grid 17 and a photo-electric cathode 18. The electrodes 16, 17 and 18 are rigidly supported on rods or stiff wires 19, which are embedded in the base ring 13 and so curved or shaped as to hold the electrodes properly spaced. In the exploded view of Fig. 3, the supporting rods 19 are broken off and the electrodes are omitted to prevent the obscuring of other parts. The rods 19 also act as conductors and are connected to contact pins 20 projecting from the insulating base 14, which is supposed to fit into a socket provided with terminals arranged to be engaged by the contact pins. This will be understood without the need of detailed illustration, it being sufficient that the outline 14' represents any suitable support for holding the phototube in operative position.

In assembling the component parts of phototube, the electrodes will usually be mounted on rods 19 before either one of the cylinders 10 and 12 is attached to ring 13. Next, the inner cylinder 12 is sealed at its lower edge to the inner side 21 of ring 13, and then the outer cylinder 10 is sealed to the outer side 22 of the ring. The insulating base 14 is channelled to provide annular flanges 23 and 24 adapted to embrace the lower end of the assembled unit 10—12—13, to which the base is cemented or otherwise per-

manently attached. The chamber 15 is exhausted in the usual way, either through a tube in base members 13 and 14 (known as the tipless method), or through an opening in the top of the outer cylinder 10. The base ring 13, instead of being a separate piece as shown in Figs. 1 and 3, may also be blown integral with the lower edge of cylinder 12 and projecting outwardly therefrom. This construction saves the step of uniting those two parts in the assembly operation. The outer cylinder 10 is either of glass or of sheet metal, as more fully explained later on.

The inner cylinder 12 provides a central recess or chamber 25 adapted to receive an electric lamp 26 for simultaneously illuminating all the photo cathodes 18 with substantially equal intensity. The contact pins 27 of lamp 26 are arranged to engage a pair of terminals in the supporting socket 14', which is common to the lamp and the surrounding phototube. The latter may be removed and inserted without disturbing the lamp, which may be the usual filament type, or a glow tube adapted to emit light of certain color to which the cathodes 18 are most sensitive. The illumination of lamp 26 should be of constant intensity, and the anodes 16 and grids 17 are constructed to permit the maximum amount of light to reach the cathodes 18. For this purpose the electrodes 16 and 17 may be in the form of perforated plates, grill work, wire mesh, and similar designs. It is hardly necessary to explain that in Fig. 1 the reticulated or net-like character of electrodes 16 and 17 is indicated merely in a diagrammatic way, and this also applies to the anodes and grids in Figs. 4, 6 and 7. The photo-electric cathodes 18 are preferably solid metal plates coated in the inner side (facing the lamp 26) with suitable light-sensitive material. Since the cathodes 18 are at substantially equal distances from the central source of light 26, they are simultaneously illuminated with equal and constant intensity. As shown in Fig. 7, the electrodes are preferably curved on arcs having their common center coincident with the axis of the lamp, whereby the entire sensitive area of each cathode is at the same distance from the source of light.

At the present time, the substances most used in photo-electric cathodes are alkali metals or compounds, particularly sodium, potassium, rubidium and caesium. These do not all respond most efficiently to the same kind of light. For example, a caesium oxide tube is most highly sensitive to red, while a cathode comprising potassium is most active when subjected to the blue portion of the spectrum. For the first type of tube, the lamp 26 may be a neon tube or is otherwise made to give out red light. When a potassium tube is used, the illuminating lamp may be an argon glow tube which emits chiefly blue and green rays. Cathodes of lithium and cadmium give maximum electron emission in ultra-violet light, but in that case the bulb of lamp 26 and the inner wall 12 of the phototube should be of quartz or other material transparent to that part of the spectrum. If the cathodes 18 are sensitive to white light, the outer cylinder 10 is preferably provided with a light-proof coating or shield 10', which may be an electrolytic deposit of metal, a removable cap of suitable material or the like. In certain embodiments of my invention, the outer cylinder 10 is preferably of sheet metal like aluminum, duralumin, brass, steel or nickel as shown in Fig. 1a, so that the

outer wall of the tube is unbreakable and at the same time acts as a shield against electric, magnetic and optical disturbances from the outside. In the broad aspect of my invention I do not limit myself to any particular cathode material, nor to any specific structure or arrangement of the electrodes 16, 17 and 18. These details can be determined by experiment to obtain the best results in a given case.

When the inner wall 12 is of glass and the outer wall 10 of steel or nickel, as stated, the two walls of the double-walled tube thus formed have different coefficients of expansion, that of steel or nickel being inherently higher than that of any glass usable for this purpose, as is a matter of common knowledge among those skilled in the art.

Each set of electrodes 16—17—18 represents a stage of amplification, so that a single phototube may be so connected as to provide multiple amplification in an electric transmission or receiving system, particularly in radio receivers.

The multi-stage phototube shown in Fig. 4 differs from that of Fig. 1 in that the spaced cylinders 10' and 12' are formed as a unit, instead of being separate members as in Fig. 1. As a result of this construction, the annular vacuum chamber 15' does not have the dome-shaped top of chamber 15 in Fig. 1, and the central recess 25' is open at both ends, so that the lamp 26 is exposed to the outer air for ventilation, if that should be necessary. Otherwise, what has been said about the construction and operation of the phototube in Fig. 1 applies fully to Figs. 4 and 5 without the need of repetition.

Another embodiment of my invention is shown in Figs. 6 and 7, where the phototube and its activated lamp are built into a unitary device, which can be handled like a single tube. The outer cylinder 55 and inner cylinder 56 are mounted in concentrically spaced relation on a glass base 57, to which they are fused or otherwise connected by a sealed joint. The base 57 also carries several sets of electrodes 16—17—18, which are constructed and arranged as previously explained in the detailed description of Fig. 1, except that the phototube of Fig. 7 has five sets of electrodes. An outer cup-shaped base 58, preferably of molded composition material, is secured to the bottom end of the tube and carries the contact pins 20 to which the electrodes 16—17—18 are connected. The two central contact pins 59 are connected to electrodes 60 in chamber 61, which in this instance is filled with a suitable gas to constitute a glow lamp. The lamp chamber 61 may also contain a filament to produce white light or light containing a large percentage of ultra-violet rays, and for that purpose the chamber 61 is either a high vacuum or filled with a suitable inert gas, as required. It will be understood that the nature of the light rays emanating from lamp 61 depends upon the character of the sensitive surface of cathodes 18, as already explained.

The annular chamber 62 of the phototube in Figs. 6-7 may contain insulating plates 63 arranged between the sets of electrodes and rigidly supported by the base member 57. These plates or partitions do not extend across the dome-shaped top of chamber 62, but terminate at about the height of the electrodes and are not connected to the glass walls 55 and 56, from which the plates may be slightly spaced. The purpose of plates 63 is to prevent possible interaction between the electronic fields of adjacent 75

cathodes, but I do not say that this precaution is necessary in all cases. The baffle plates 63 will usually be glass or mica, but they can also be formed as integral projections on the glass base 57. In fact, it is possible to embed the rods 19 in the radial plates 63, so that the latter would act as supports for the electrodes 16-17-18. The chambers 61 and 62 are most conveniently exhausted through separate tubes passing through base members 57 and 58, and these tubes can be connected to the same vacuum pump for simultaneous exhaustion of the chambers. In those cases, however, where the chambers 61 and 62 require different degrees of vacuum, or where one chamber is filled with gas and the other remains evacuated, they are subjected to separate treatments. In some designs of phototube, it is possible to omit the inner cylinder or partition 56, thereby providing a single chamber for the central lamp electrodes and the surrounding groups of amplifying electrodes. This can be done when the phototube and its activating lamp are capable of functioning properly in the same degree of vacuum or in the same gas-filled atmosphere. This also applies to the phototubes and lamps of Figs. 1 and 4. As a general rule, I may say that greater stability of electronic operation and control is obtainable in a high or "hard" vacuum.

By showing five sets of amplifying electrodes 16-17-18 in vacuum chamber 62, I do not intend to convey the idea that this particular form of phototube is restricted to that number of electrode sets. I have chosen to illustrate a tube capable of giving five stages of amplification in order to emphasize the possible use of a single tube for combined radio and audio amplification. For example, two sets of electrodes 16-17-18 in Fig. 7 may be connected for two stages of radio amplification, and the other three sets of electrodes may be connected for three stages of audio amplification in the same radio set. This will be understood without the addition of a separate circuit diagram. The normal plate voltages impressed on the various anodes in this combined radio-audio amplifying tube will, of course, be regulated for the most satisfactory results in any particular system. In a radio receiver operating on two or three radio frequency stages and two or three audio frequency stages, a single phototube built in accordance with my invention will be sufficient to obtain both kinds of amplification in the required degree. If the lamp 61 gives out chiefly ultra-violet rays for cathodes 18, the envelope 56 is made of quartz or a type of glass that allows the rays to pass through. The outer cylinder 55 may have a light-proof covering, if the cathode 18 is sensitive to white light.

Attention is called to the fact that the unitary device of Figs. 6-7, aside from its compactness and convenience of handling, provides a single source of light placed in the closest possible proximity to all cathodes. This arrangement increases the efficiency of the phototube, for the intensity of light varies inversely as the square of the distance that separates the cathodes from the lamp filament or glow terminals 60. The light rays have to pass through only one intervening wall 56, which is out of contact with the atmosphere and is therefore free from dust, dirt and other contamination. Even the inner wall 56 can be omitted, as previously explained, whereby the structure is made even more simple, compact and efficient. It is obvious that the electrode arrange-

ment in Fig. 7 for combined radio and audio frequency amplification may also be used in the phototubes of Figs. 1 and 4.

Certain types of phototubes are filled with gas at low pressure to improve their operation, and I include these within the scope of my invention. It is hardly necessary to add that the drawings do not show the various parts of the phototube in exact relative proportions, and this is particularly true of the electrodes, which are purposely shown in exaggerated dimensions for clearness.

I do not herein claim the mechanical construction of the double-walled member 10-12-13 per se.

Although I have shown and described certain specific constructions, I want it understood that my invention is not limited to the details set forth, and certain features thereof may be used in other devices than photo-electric tubes.

I claim as my invention:

1. A photo-electric tube comprising a pair of spaced concentric cylinders which form a sealed ring-shaped chamber containing electrodes, these electrodes including light-sensitive electronic means, the base ends of said cylinders being sealed to a separate glass member which closes off said ring-shaped chamber and supports said electrodes, the inner cylinder being transparent to light waves and forming a central chamber which contains a source of light for affecting said light-sensitive means.

2. A phototube comprising a pair of spaced concentric walls which form a sealed ring-shaped chamber containing electrodes, these electrodes including light-sensitive electron-emitting means, the base ends of said walls being closed by a glass ring which supports said electrodes, the inner wall being transparent to light and forming a central cylindrical recess open at the base end of the tube for receiving an electric lamp as a source of light for said light-sensitive means.

3. An electric amplifying tube comprising a glass ring, a pair of concentrically spaced cylindrical walls united at their base ends to the opposite sides of said ring and forming a single sealed chamber axially elongated and ring-shaped in cross-section, electronic means in said chamber providing a plurality of stages of amplification, said electronic means comprising a plurality of spaced electron-emitting elements mounted in circular arrangement around the axis of said tube, the inner wall providing an axially elongated cylindrical recess for receiving electric means for simultaneously activating all of said elements in substantially the same degree.

4. A photo-electric tube having a pair of concentrically spaced cylindrical walls united at their base ends to the opposite sides of a glass ring to form a sealed chamber ring-shaped in cross-section, said chamber containing a plurality of sets of electrodes operatively supported in circular arrangement, each set of electrodes including a light-sensitive cathode, a source of light enclosed by said tube and located centrally of said circularly arranged electrodes for simultaneously illuminating said cathodes to produce electronic emission for all sets of electrodes, and leads whereby each set of electrodes provides a stage of amplification.

5. A photo-electric tube having a pair of cylindrical walls concentrically spaced and sealed together to form an evacuated annular chamber, the inner wall being pervious to light rays and the outer wall being sheet metal, said inner wall form-

ing a central recess or chamber for a source of light, and photo-electric means in said annular chamber to be influenced by said source of light.

6. A photo-electric tube having a sealed annular chamber containing operative electrodes, which includes a light-sensitive cathode, and an electric light bulb in the central cylindrical space surrounded by said annular chamber, the inner wall of said chamber being pervious to the light of said bulb and the outer wall of said chamber comprising an outer metal surface electrically disconnected from said electrodes to strengthen said outer wall and render said chamber optically opaque from the outside.

7. A photo-electric tube comprising a base, a pair of cylindrical walls concentrically spaced from each other and mounted on said base, a glass ring sealing the adjacent circular base ends of said walls and forming therewith a sealed annular chamber, electrodes supported by said ring and operatively mounted in said chamber, said electrodes including a light-sensitive cathode, terminal members projecting from said base, and an electric light bulb in the central cylindrical space enclosed by said annular chamber.

8. A photo-electric tube having a single annular chamber which contains a plurality of sets of electrodes, each set of electrodes including a light-sensitive cathode, an anode and an interposed grid, said cathodes being equidistantly spaced from the center of the tube and facing said center, an electric light bulb in the central cylindrical space surrounded by said annular chamber, whereby the light in said bulb is at maximum closeness to said cathodes for simultaneously illuminating all of them with substantially equal intensity, contact members projecting only from the base ends of said tube and bulb, the other ends of said tube and bulb being free of electric connections, and a supporting base having insulated terminals engaging said contact members for connecting the sets of electrodes in circuit.

9. An electronic tube having an envelope partly of metal and partly of glass, annular sealing means interposed between the metal and the glass rigidly uniting the metal and the glass in a permanent airtight joint, said metal portion of the envelope including a cylindrical base rim which extends down sufficiently to surround said glass portion and annular sealing means and completely enclose them circumferentially, an insulating base attached to said metal rim and carrying contact pins, and electrodes operatively mounted in said envelope and electrically connected to said contact pins, said insulating base forming the bottom of the tube for supporting the latter in operative position.

10. An electronic tube having an airtight chamber formed by a wall including a member of metal, a member of glass and an annular sealing element between said members rigidly and permanently uniting them in an airtight joint, said metal member including a cylindrical base rim which extends downward sufficiently to surround said glass member and sealing element and completely enclose them circumferentially, an insulating base having a circumferential edge fitting said metal rim and attached thereto, contact pins carried by said insulating base, and electrodes operatively mounted in said chamber and electrically connected to said contact pins, said insulating base having a flat portion from which said pins project and which forms the bottom of the tube for supporting the latter in upright position during operation.

11. An electronic tube comprising a shell of steel, a base member rigidly and permanently sealed to one end of said shell, and whereby said steel shell and base member are integrally connected into a rigid unitary structure which forms a vacuum-tight envelope, lead-in wires carried by said base member and electrically insulated from the steel shell, said steel shell completely enclosing said base member circumferentially, an insulating base attached to the tube and carrying contact pins, and electrodes in said tube connected to said contact pins, said base forming the bottom of the tube for supporting the latter in operative position.

12. An electronic tube having an airtight chamber formed by an envelope partly of metal and partly of glass, the glass being rigidly and permanently sealed to the metal and forming therewith a rigid unitary wall for said chamber, the metal of said envelope including a cylindrical rim which completely encloses the glass circumferentially, electrodes operatively mounted in said chamber and insulated by the glass, and an insulating base attached to a metallic portion of the tube and carrying contact pins electrically connected to said electrodes, said base forming the bottom of the tube for supporting the latter in operative position.

13. An electronic tube having an outer shell of sheet metal and a base sealed along its circular rim to said metal shell in a rigid permanent airtight joint, said base including glass and carrying lead-in wires which are electrically insulated from the metal shell by said glass, said metal shell completely enclosing the glass circumferentially, electrodes in the tube connected to said lead-in wires, and an insulating base attached to the tube and carrying contact pins which are connected to the lead-in wires, said base forming the bottom of the tube for supporting the latter in operative position.

14. An electronic tube having an airtight chamber formed by an enclosing wall partly of metal and partly of glass, the metal and glass contacting surfaces being rigidly and permanently united to keep said chamber airtight, lead-in wires supported by the glass and electrically insulated from the metal of the wall, the metal of said wall including a cylindrical rim which completely encloses the glass circumferentially, electrodes in the tube connected to said wires, an insulating base attached to the metal of the tube and forming the bottom thereof, and contact pins projecting from said base and connected to the lead-in wires.

15. An electron tube having an evacuated envelope comprising a metal shell and an insulating base which closes the open end of the shell, said base including a glass ring fused to the metal shell along a wide contact area to form a strong vacuum-tight seal, said metal shell completely enclosing the glass ring circumferentially and thereby fully protecting it, lead-in wires passing through and sealed to said insulating base, and electrodes operatively mounted in said envelope and connected to said lead-in wires.

16. An electron tube having an evacuated envelope comprising a metal cylinder and a glass closure sealing the open end of the cylinder, said closure including a concave glass member and a glass ring fused to the rim of said cylinder and glass member along a wide contact area to form a strong vacuum-tight joint, said glass ring having a peripheral portion extending axially of the metal cylinder and also having a flat portion extending radially thereof, said peripheral portion

of the glass ring being in sealing contact with the metal cylinder and said flat radial portion acting as a support for lead-in wires, and electrodes in the tube connected to said lead-in wires, said electrodes being supported by the glass ring independently of the glass member.

17. An electron tube having an outer cylindrical wall of metal, a closure rigidly sealed to the base end of said metal wall to form therewith a vacuum-tight envelope, the sealing contact between said closure and metal wall being over a circular area sufficiently wide to form a strong seal which integrally unites said parts, said closure including glass through which lead-in wires pass and to which they are sealed, the glass carrying the lead-in wires extending axially beyond the normal thickness of said closure to form a rigid support for said wires, said outer metal wall completely enclosing the glass circumferentially and thereby fully protecting the glass, electrodes

operatively mounted in said envelope and connected to said lead-in wires, an insulating base connected to said metal wall, and contact pins carried by said base and connected to said lead-in wires.

18. An electronic tube having an evacuated envelope composed of a wall of steel and cylindrical means of glass and rigid annular sealing means interposed between the steel and the glass, said annular sealing means being sealed to the steel wall and the cylindrical glass means in wide contact areas to weld the steel and glass into a strong unitary airtight structure, said steel wall surrounding said glass and sealing means and completely enclosing them circumferentially, an insulating base attached to said steel wall and carrying contact pins, and electrodes in said envelope connected to said pins.

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