Oct. 31, 1950 C. N. SMYTH 2,527,587

ELECTRON DISCHARGE DEVICE

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FIG. 1.

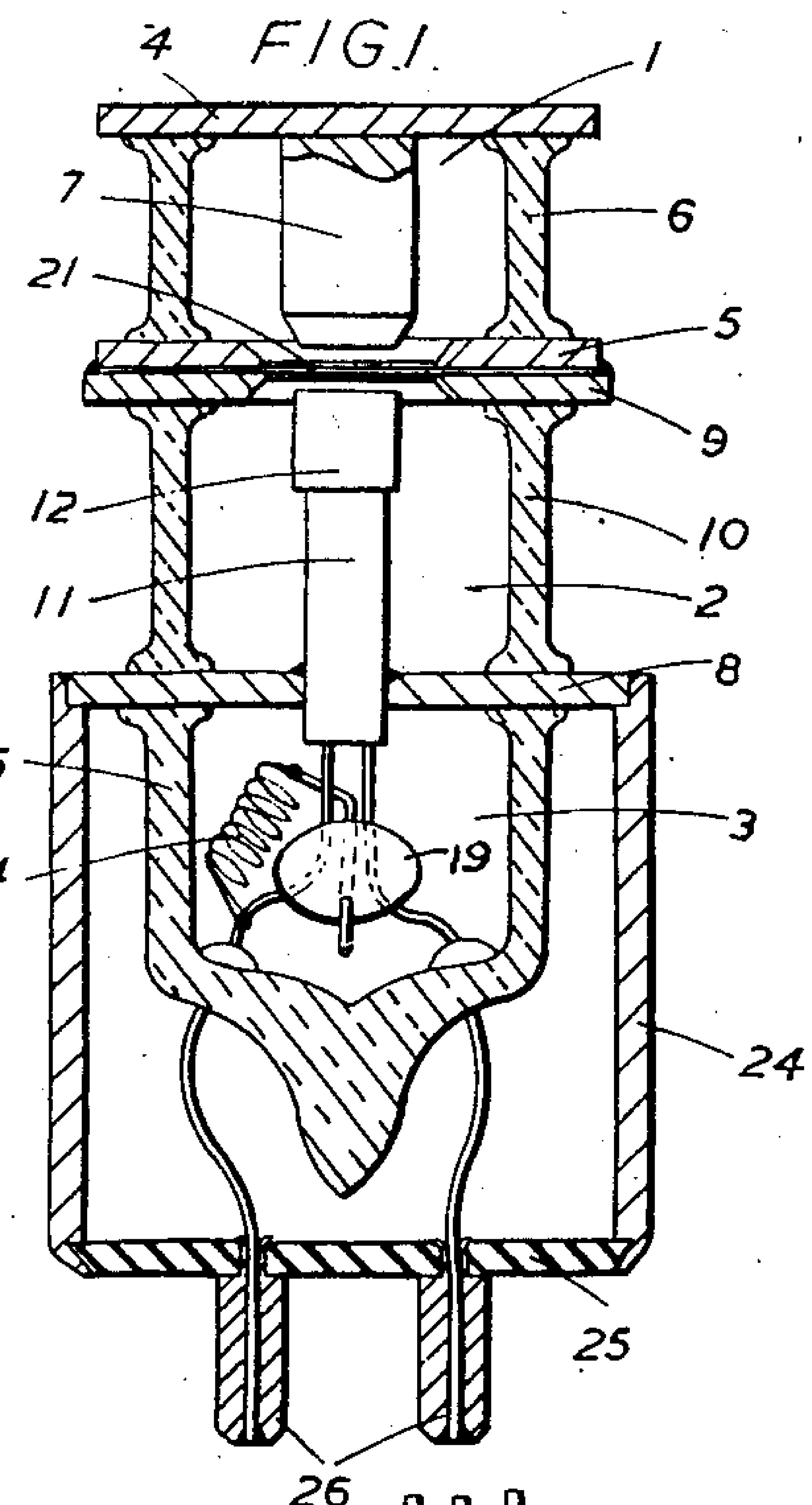

FIG. 5.

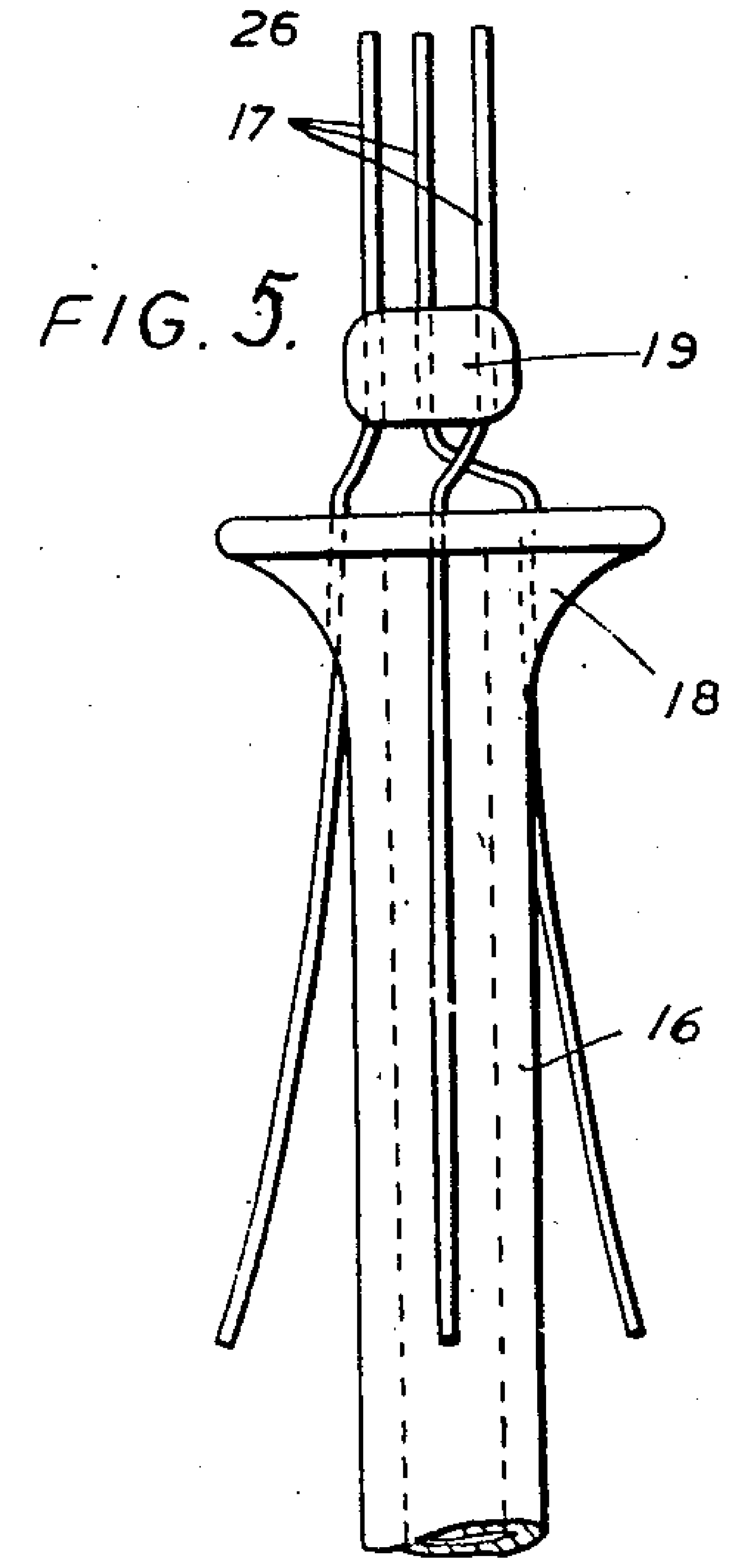

FIG. 2.

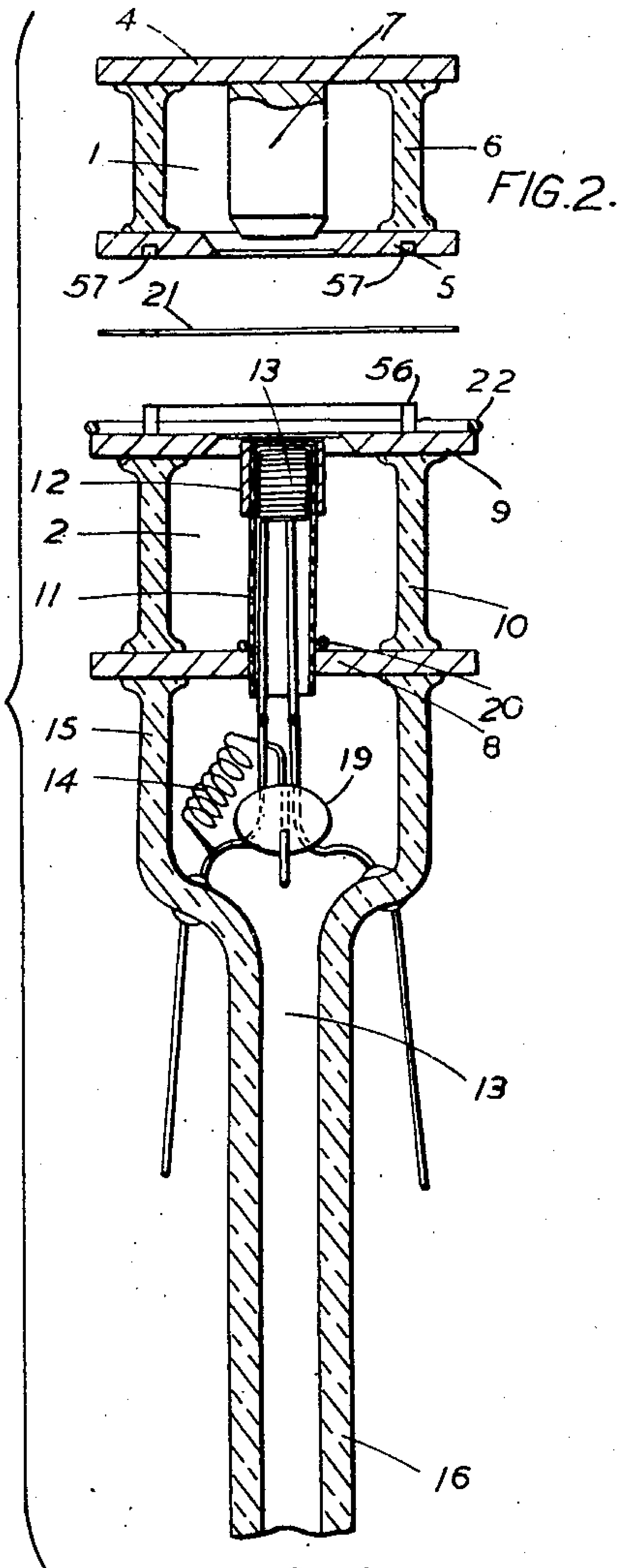

FIG. 4.

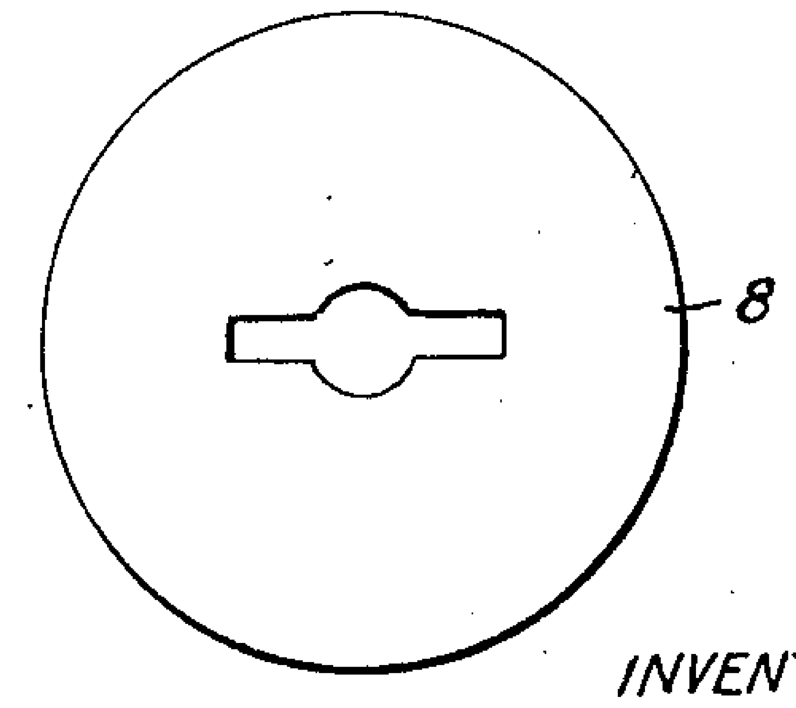

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FIG. 6.

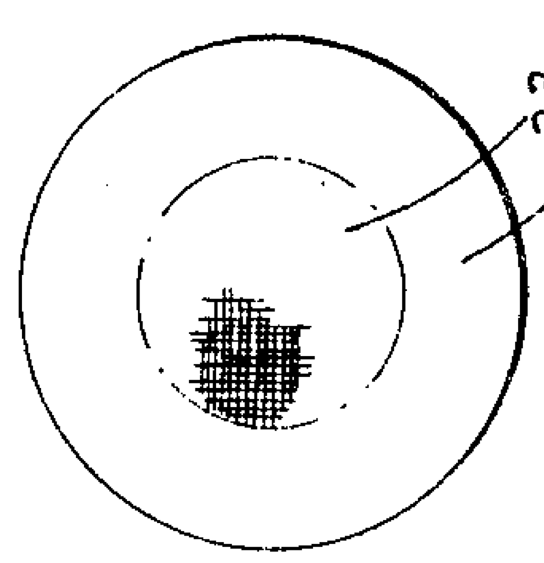


FIG. 8.

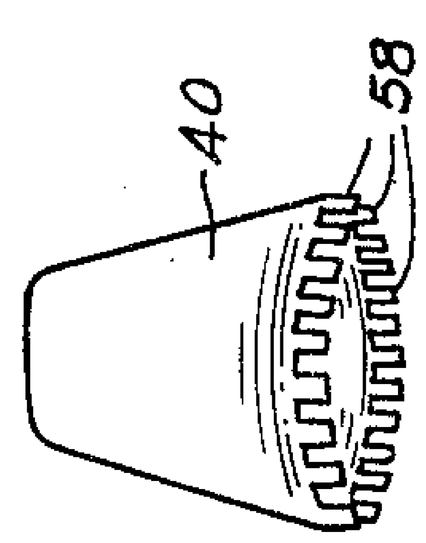


FIG. 7.

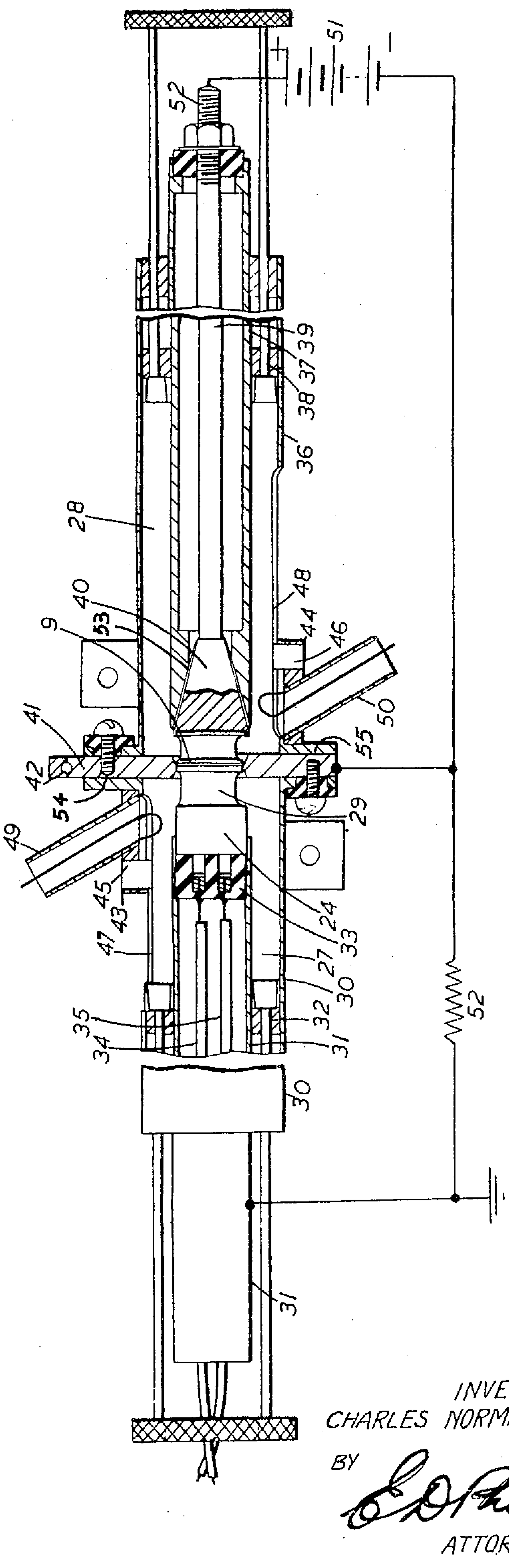
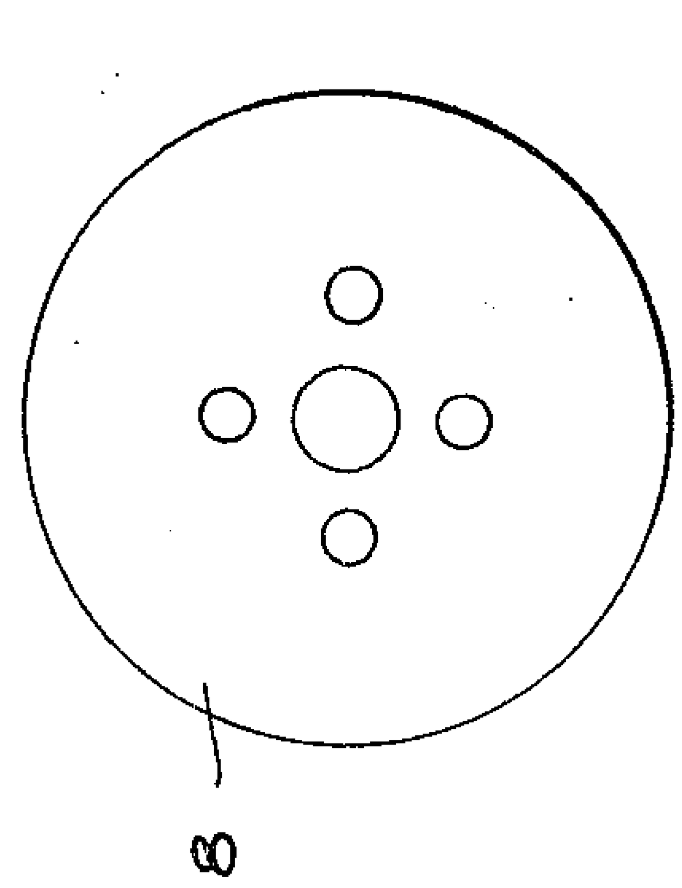


FIG. 3.



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UNITED STATES PATENT OFFICE

2,527,587

ELECTRON DISCHARGE DEVICE

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Application September 17, 1945, Serial No. 616,910
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12 Claims. (Cl. 250—27.5)

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The present invention relates to improvements in electron discharge devices, and is concerned particularly with the design and method of construction of a diode or triode valve adapted for use at ultra high frequencies.

The dimensions of such valves must be exceedingly small, and it becomes a matter of considerable difficulty to obtain the interelectrode spacings with the necessary accuracy. It is the principal object of the present invention to provide a design which is adaptable for accurate setting of these spacings.

Valves are now well known in which some or all of the electrodes are mounted on metal discs which are sealed through the walls of the envelope, which may be of glass or ceramic material. Such discs are used as the terminals for the corresponding electrodes. A metal disc terminal consisting of a tubular portion with an outwardly extending flange and sealed at both ends to glass portions of the valve envelope has been described in two patents of C. V. Litton, U. S. Pat. No. 2,336,488, issued December 14, 1943, and U. S. Pat. No. 2,379,584, issued July 3, 1945, and modifications of this form are described in C. V. Litton's U. S. Pat. No. 2,309,967, issued February 2, 1943, and his U. S. Pat. No. 2,423,066, issued June 24, 1947, in which the metal terminal is effectively divided into two portions by a transverse cut through the flange, the envelope being made up by sealing each tubular portion of the terminal to the corresponding glass envelope portion and finally uniting the two metal portions round the flange by soldering or the like.

None of these arrangements are suitable or convenient when it is necessary to maintain accurate spacing between the electrodes, and it is the object of the present invention to provide a construction adapted for this purpose. The arrangement according to the invention resembles the arrangements covered by the two last mentioned specifications in that the valve envelope constructed in two or more separate parts each of which consists of a portion of glass or other insulating material sealed to a metal portion, two of the metal portions being finally sealed together; but the characteristic feature by which it differs from all preceding types is that the two metal portions are both plain discs, not comprising any tubular portions which effectively form part of the envelope.

In the preferred form of the invention the sections of the envelope are constructed separately, each section being closed at the ends by metal discs, one of which carries an electrode and the

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other has a corresponding central aperture. The spacing between the electrode in each section and the outer face of the corresponding apertured disc may be easily and precisely set in a suitable jig, so that when the envelope is completed by sealing the apertured discs together face to face, the desired electrode spacing is automatically obtained with precision. Where a grid is interposed between the anode and the cathode, this may be sandwiched between the two discs which are sealed together, thereby securing accurate spacing for all the electrodes.

While this type of construction is particularly suitable for miniature valves, it is evident that valves of any size may be constructed in this way.

The invention will be described with reference to the accompanying drawings in which—

Fig. 1 shows a longitudinal section of a triode valve according to the invention;

Fig. 2 shows an exploded view of some of the parts of Fig. 1 to show the method of construction and to show a slightly modified form of grid discs;

Figs. 3 and 4 show plan views of two forms of the cathode disc;

Fig. 5 shows the glass stem before sealing on to the remainder of the valve;

Fig. 6 shows a plan view of the grid of the valve; and

Fig. 7 shows a partly sectional view of an ultra high frequency amplifier in which a valve according to the invention is used.

Fig. 8 is a perspective view of an element of Fig. 7.

An example of a valve in accordance with the invention is shown in Fig. 1. It comprises an anode chamber **1**, a cathode-chamber **2** and a stem **3** attached to the back of the cathode chamber. The anode chamber, also seen separately in Fig. 2, comprises a plain flat nickel-iron anode disc **4** and an apertured sealing disc **5** of nickel-iron having an inwardly bevelled central aperture, both of which discs are sealed by butt seals to a short length of glass tube **6**. The anode **7** is secured (by copper soldering, for example) to the disc **4**, and may consist of a short length of mild steel rod slightly chamfered at one end as indicated. The outer surface of the disc **5** is ground optically flat and is copper plated.

In order to obtain the necessary accurate spacing between the electrodes of the completed valve, the glass sealing of the anode chamber is carried out in a jig which ensures that the distance between the outer surface of the disc **5** and the end surface of the anode **7** has a specified value. The adjustment of this distance can evidently be easily made while the glass is soft, and the adjustment will be maintained so long as the parts are held in the jig until the glass has set. The outer surface of the disc **5** is then cleaned and polished and given a very thin plated coating of gold, for a reason which will be explained later on.

The cathode chamber consists of a flat nickel-iron cathode disc **8**, a nickel-iron sealing disc **9** of slightly larger diameter than the disc **5**, and having a similar inwardly bevelled central aperture. The sealing discs **5** and **9** may have corresponding projecting and recessed portions for insured registry of the sealing discs. Apertures may be correspondingly provided in grid **21** to accommodate the projection on one of the sealing discs. The discs **8** and **9** are sealed by butt seals to a short length of glass tube **10**. The disc **8** has apertures which may be arranged as shown in Fig. 3 or Fig. 4. The central circular hole is provided for the cathode support tube **11**, and the other holes are provided in order to allow passages for exhausting the completed envelope. The cathode is the upper surface of a cap **12** which slips over the end of the support tube **11**. The cathode surface is coated in the usual way with electron emitting material. To the back of the disc **8** is sealed the glass stem **3** on which are mounted the leads for the cathode heater **13** (seen in Fig. 2 only) and for the getter coil **14**. The elements **11** and **12** may be of nickel, or preferably of nickel-iron.

The cathode chamber and stem assembly is constructed in the following way:

The disc **9**, glass tube **10**, disc **8**, and a short piece of glass tube forming the part **15** of the stem **3**, are placed in a jig and heated to make the metal-to-glass seals. The jig ensures the proper spacing of the parts. The outer surface of the disc **9** is then polished and gold flashed, and the upper surface of the cathode disc **8** is also gold flashed.

The next step is to take a glass flared stem tube **16** similar to that shown in Fig. 5, provided with three lead-out wires **17** sealed through the flare **18** and anchored by a button of glass **19**. The cathode heater coil **13** and getter coil **14** are first welded on to the three leads as indicated in Fig. 2. The cathode heater coil **13** is passed through the central hole in the disc **8** and the flare **18** of the stem tube **16** is sealed on to the end of the glass portion **15** which as already explained has been previously sealed to the disc **8**.

The cathode cap **12** is next spot welded to the end of the support tube **11**, and is then sprayed with electron emitting material. A ring of tin wire **20** is placed around the tube **11** and the latter is pushed into the central hole of the disc **8**, in which it is a tight fit, until the coated surface of the cathode cap **12** lies below the upper surface of the disc **9** by a specified amount as determined by a suitable gauge, an allowance of perhaps a few thousandths of an inch being made for expansion.

The next operation is to seal the end of the tube **16** carrying the cathode chamber assembly on to the exhaust pump header. The grid **21** shown in Fig. 6 is laid centrally upon the surface of the disc **9** surrounded by a ring of tin wire **22**, and the anode chamber **1** is laid on top of the grid with the disc **5** inside the ring of tin wire **22**. The disc **9** is made slightly larger than the disc **5** so that the tin ring **22** can be temporarily supported. A suitable clamp is used to hold the chambers **1** and **2** together in the proper position, and the assembly is now placed inside the baking oven which has an inert atmosphere. The temperature is raised to about 330° C. with the vacuum pump working, and the tin rings then melt and flow, sealing the cathode support tube to the disc **8** and the two discs **5** and **9** together, confining the grid **21** between them. It is found that when the tin flows, a vacuum-tight seal is formed while the tin is still liquid. The temperature can be then raised to 400° C. for baking, and the valve is pumped in the usual way and allowed to cool. The tube is then processed, the getter outgassed and the cathode activated, and sealed off. The getter is then fired and the getter lead is cut off short.

The grid **21** (Fig. 6) consists of a very thin metal foil having a central section **23** perforated with a very fine mesh of holes, say 200 or 300 to the inch. This grid is preferably produced by a known process in which a former photographically prepared from a drawing is copper plated, forming a copper grid which can be stripped off, the former being used again.

The final operation is to attach a cylindrical metal skirt or sleeve **24** by soft soldering to the disc **8**, carrying at the lower end an insulating terminal plate **25** with terminals **26** to which the cathode heater wires are soldered. The sleeve **24** protects the stem **3** and serves as the cathode terminal. This completes the assembly of the valve. The disc **4** forms the anode terminal, and the two discs **5** and **9** together form the grid terminal.

The gold plating mentioned above is for the purpose of causing the melted tin to run satisfactorily all over the surfaces to be sealed. It has been found that the molten tin does not always spread properly over the copper surfaces to be joined, but a trace of gold on the surface completely removes the trouble. It is therefore only necessary to provide a very thin coating or flashing of gold on the discs **5**, **8** and **9**. It has been found unnecessary to gold plate the nickel tube **11**.

It will be apparent that the method of constructing the valve will ensure that the desired electrode spacings are accurately obtained. It may be added that in case it is desirable to stretch the grid to ensure its flatness, an annular projecting ridge **56** as shown in Fig. 2 may be formed on the surface of one of the discs **5** or **9** fitting into a corresponding groove **57** of the other so that the grid will be stretched tight when the two discs are secured together.

It will be evident also that the grid **21** could be omitted so that the valve would then be a diode, without any other alteration to the method of assembly, which would ensure correct spacing between the cathode and the anode.

It will be noted that the diameters of the discs **4**, **5**, **9**, **8** are in ascending order of magnitude. This enables the valve to be inserted anode first into a system of parallel or coaxial screens having corresponding apertures in ascending order of magnitude.

A high frequency valve for use at a frequency of several thousand megacycles has been constructed in the manner described, of which the diameter over the skirt **25** did not exceed half an inch, the total length being about one and one eighth inches, excluding the terminal pins **26**, the other dimensions being as indicated in Figures 1 to 6, which are drawn approximately to scale.

Fig. 7 shows an example of a high frequency amplifying device employing an amplifying valve according to the invention. It consists of two coaxial resonators 27, 28 arranged end to end with a valve 29 similar to that described with reference to Fig. 1 arranged between them. The cathode resonator consists of an outer metal cylindrical tube 30 and an inner coaxial tube 31 with an annular sliding piston 32 between them. The tube 31 is adapted to make contact with the skirt 24 of the valve 29, and holds an insulating block 33 containing two sockets for the cathode heater terminals, the leads for which are 34 and 35, and are run through the inner tube 31.

The anode resonator 28 comprises an outer metal cylindrical tube 36 and an inner coaxial tube 37 with an annular sliding piston 38 between them. The tube 37 contains a coaxial inner conductor 39 terminating in a conical plug 40 resting in a conical socket at the end of the tube 37, but is electrically insulated therefrom by a thin layer 53 of mica or other suitable insulating material. The plug 40 (Fig. 8) has a shallow recess at the end having a number of slots cut round its periphery to form flexible fingers 58 for grasping the anode disc of the valve 29.

Sandwiched between the two tubes 30 and 36 is a split metal ring 41 having a circular central aperture into which the grid disc 9 of the valve 29 just fits. This ring is intended to be tightended up by means of a grub screw at 42 so that it grips the grid disc firmly. The split ring 41 is insulated from both the tubes 30 and 36 by thin mica sheets, or the like 54 and 55.

These tubes are provided with saddles 43 and 44 fixed by metal bands round the outsides of the tubes and having pegs 45 and 46 running in short longitudinal guide slots 47 and 48. The saddles carry metal tubes 49 and 50 into which coaxial transmission lines are fixed, these lines terminating in coupling loops which project through the slots into the corresponding resonators. These lines are for the purpose of introducing the input waves, and extracting the amplified waves, respectively. The saddles are adjustable longitudinally to enable the coupling to be made with suitable parts of the resonators.

When it is desired to extract the valve 29, the grid clamping ring 41 is loosened and the tube 31 is then withdrawn from the left hand end of the device bringing the valve with it.

For operating the device, the high tension supply source 51 is connected between the outer end 52 of the rod 39 and the clamping ring 41, as indicated, and a grid bias resistance 52 is connected between the clamping ring 41 and the cathode tube 31, which is preferably earthed. The necessary decoupling condensers are provided by the mica insulation between the clamping ring 41 and the two outer tubes 30 and 36, and between the plug 40 and the inner tube 37.

By providing suitable direct coupling (not shown) between the two resonators, the device may be used as an ultra high frequency generator.

What is claimed is:

1. An electron discharge device comprising an envelope divided into at least two chambers each consisting of a pair of parallel metal discs sealed to the ends of a glass tube, an anode fixed inside one of the chambers to one of the discs thereof, a cathode fixed inside the other chamber to one of the discs thereof, the other disc of each chamber having an aperture opposite the corresponding electrode, said apertured discs having corresponding projecting and recessed portions to insure registry of said apertured discs, and the said chambers being secured together by a metallic seal between the two apertured discs, one of which is slightly larger than the other.

2. The method of manufacturing an electron discharge device which includes the steps of constructing separately two envelope sections, each section including a portion of insulating material, each section also enclosing and supporting an electrode having a flat operating surface; sealing an apertured metal disc to one end of each insulating portion and with a predetermined spacing between the operating surface of the electrode and the outer surface of the disc; the diameter of the two apertured discs being different, winding a piece of solder around the periphery of the larger apertured disc, placing the outer faces of the apertured discs of the two sections adjacent one another; and uniting the two envelope sections by melting the winding of solder and allowing it to solidify between the apertured discs.

3. The method of manufacturing an electron discharge device which includes the steps of constructing separately each of two envelope sections by securing an electrode having a flat end face to a flat metal disc, cutting an aperture in a pair of second flat metal discs of different diameters, sealing the said apertured discs respectively to the ends of a glass tube with the electrode opposite the aperture and with a specified spacing between the said end face and the outer surface of the apertured disc, and uniting the two envelope sections by winding a piece of solder around the periphery of the larger apertured disc, placing the outer faces of the two apertured discs adjacent one another, melting the winding of solder and allowing it to solidify between the apertured discs.

4. The method according to claim 3 which further comprises placing tin wire around each joint to be soldered, the tin being melted during the baking process, and gold flashing the surfaces of the discs to be sealed together by the tin.

5. The method according to claim 4 which includes the step of grinding flat and polishing the opposing surfaces of the two apertured discs.

6. The method according to claim 2 which further comprises sandwiching a grid electrode between the discs before sealing them together.

7. An ultra high frequency amplifying device comprising an envelope divided into at least two chambers each consisting of a pair of parallel flat metal discs sealed to the ends of a glass tube, an anode supported inside one of the chambers on one of the discs thereof, a cathode supported inside the other chamber on one of the discs thereof, the other disc of each chamber having an aperture opposite the corresponding electrode, a grid electrode placed between the apertured discs, the said chambers being aligned with the said apertured discs arranged adjacent each other and secured together by a metallic seal, a split metal ring adapted to engage said grid discs, a first hollow electric resonator connected coaxially between the cathode and the control grid of the said valve, a second hollow resonator connected coaxially between the control grid and the anode thereof, said hollow resonator comprising outer cylindrical members having end portions abutting against said split

ring on opposite sides thereof, means for introducing waves to be amplified to the first resonator, and means for extracting amplified waves from the second resonator.

8. A device according to claim 7 in which the said resonators are of the coaxial conductor type with means for adjusting the resonance frequency thereof.

9. An electron discharge device comprising an envelope divided into at least two chambers each consisting of a pair of parallel flat metal discs sealed to the ends of a glass tube, and an anode fixed inside one of the chambers to one of the discs thereof, a cathode fixed inside the other chamber to one of the discs thereof, the other disc of each chamber having an aperture opposite the corresponding electrode, a metallic seal between the two apertured discs securing said chambers together, one of said discs being slightly larger than the other, a sealed-off glass stem sealed to the cathode disc on the side remote from the cathode, said cathode disc being perforated to permit a connection between the interior of the stem and the cathode chamber for exhaust purposes, a hollow indirectly heated cathode having an internal heater coil whose leads are sealed through said stem, and a tubular metal sleeve surrounding said stem and attached to the cathode disc, said sleeve also supporting an insulating plate carrying the terminals for said heater coil.

10. An electron discharge device comprising an envelope divided into at least two chambers each consisting of a pair of parallel flat metal discs sealed to the ends of a glass tube, and an anode fixed inside one of the chambers to one of the discs thereof, a cathode fixed inside the other chamber to one of the discs thereof, the

other disc of each chamber having an aperture opposite the corresponding electrode, a metallic seal between the two apertured discs securing said chambers together, one of said discs being slightly larger than the other, a sealed-off glass stem sealed to the cathode disc on the side remote from the cathode and a tubular metal sleeve surrounding said stem and attached to the cathode disc, said sleeve also supporting an insulating plate carrying the terminals for said cathode.

11. An electron discharge device according to claim 1 wherein said projecting portion of one of said apertured discs constitutes an annular portion and said recessed portion of the other of said apertured discs constitutes an annular groove accommodating said annular projecting portion to stretch tightly said apertured discs in a plane transverse to the longitudinal axis of said device.

12. An electron discharge device according to claim 7 wherein said second hollow resonator comprises an inner conductor provided with a recessed metallic plug having flexible fingers engaging said anode disc.

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