

Jan. 7, 1947.

J. E. CLARK ET AL

2,413,689

ELECTRON DISCHARGE DEVICE

Filed Feb. 12, 1942

2 Sheets-Sheet 1

FIG. 1

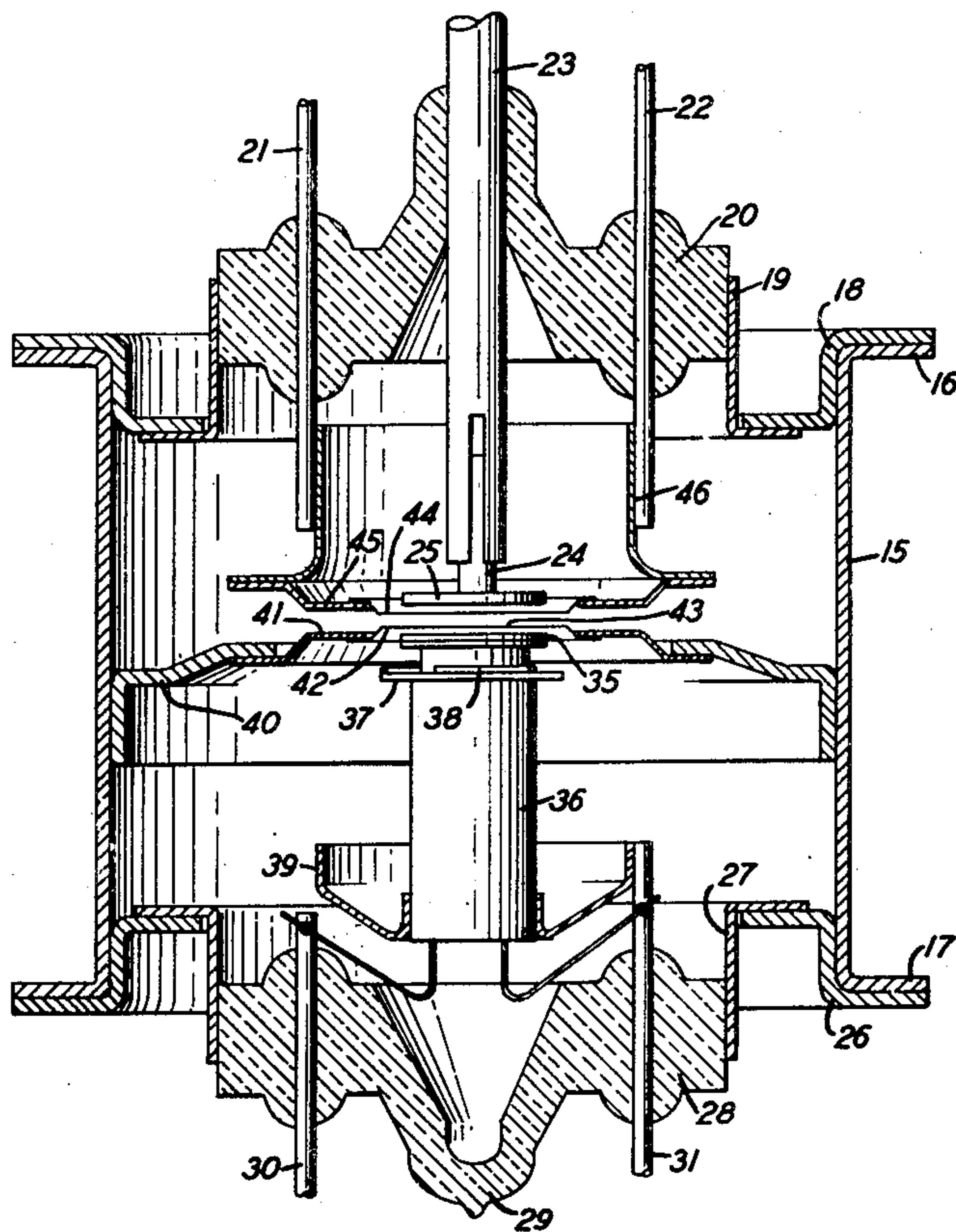


FIG. 2

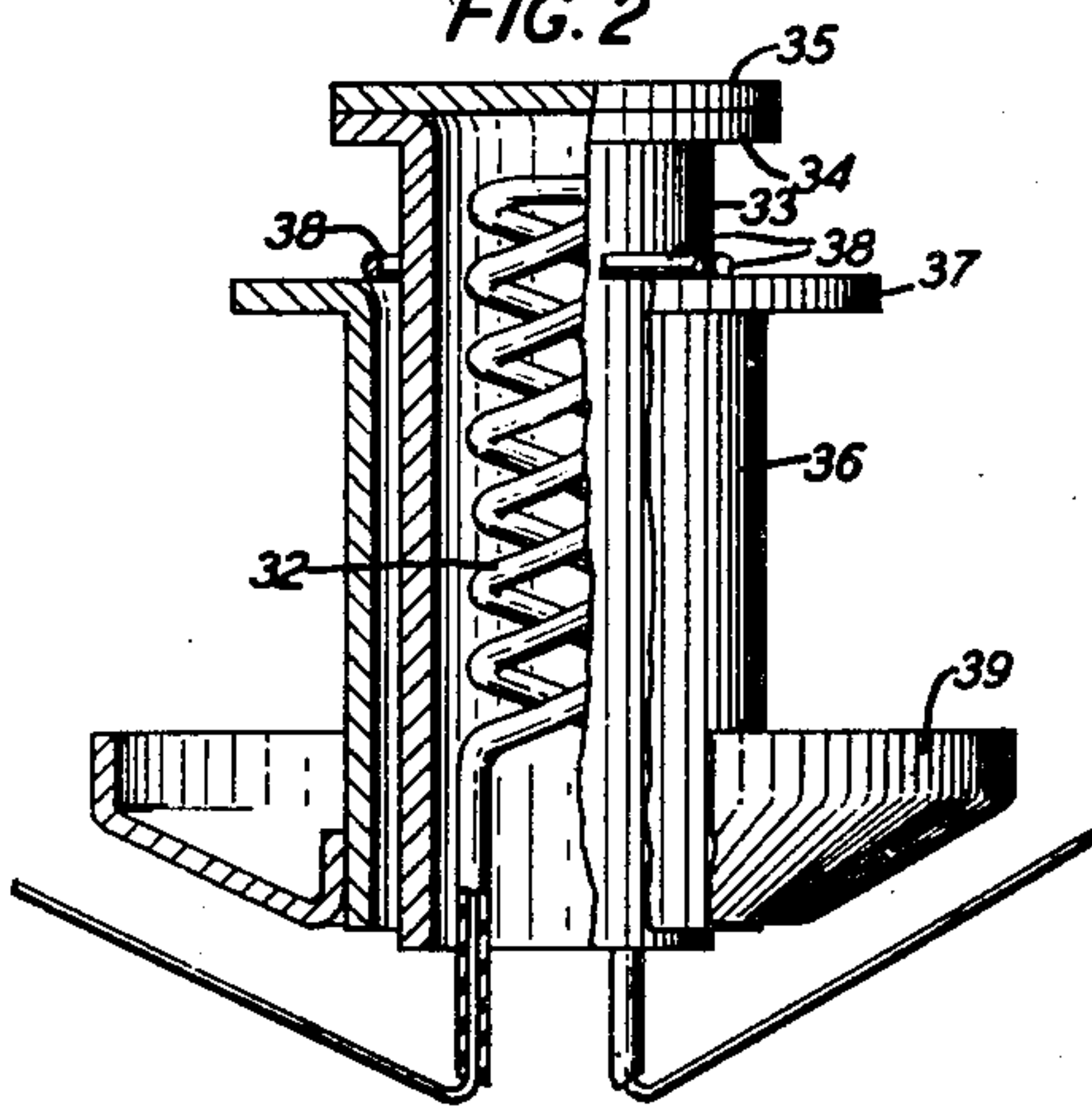
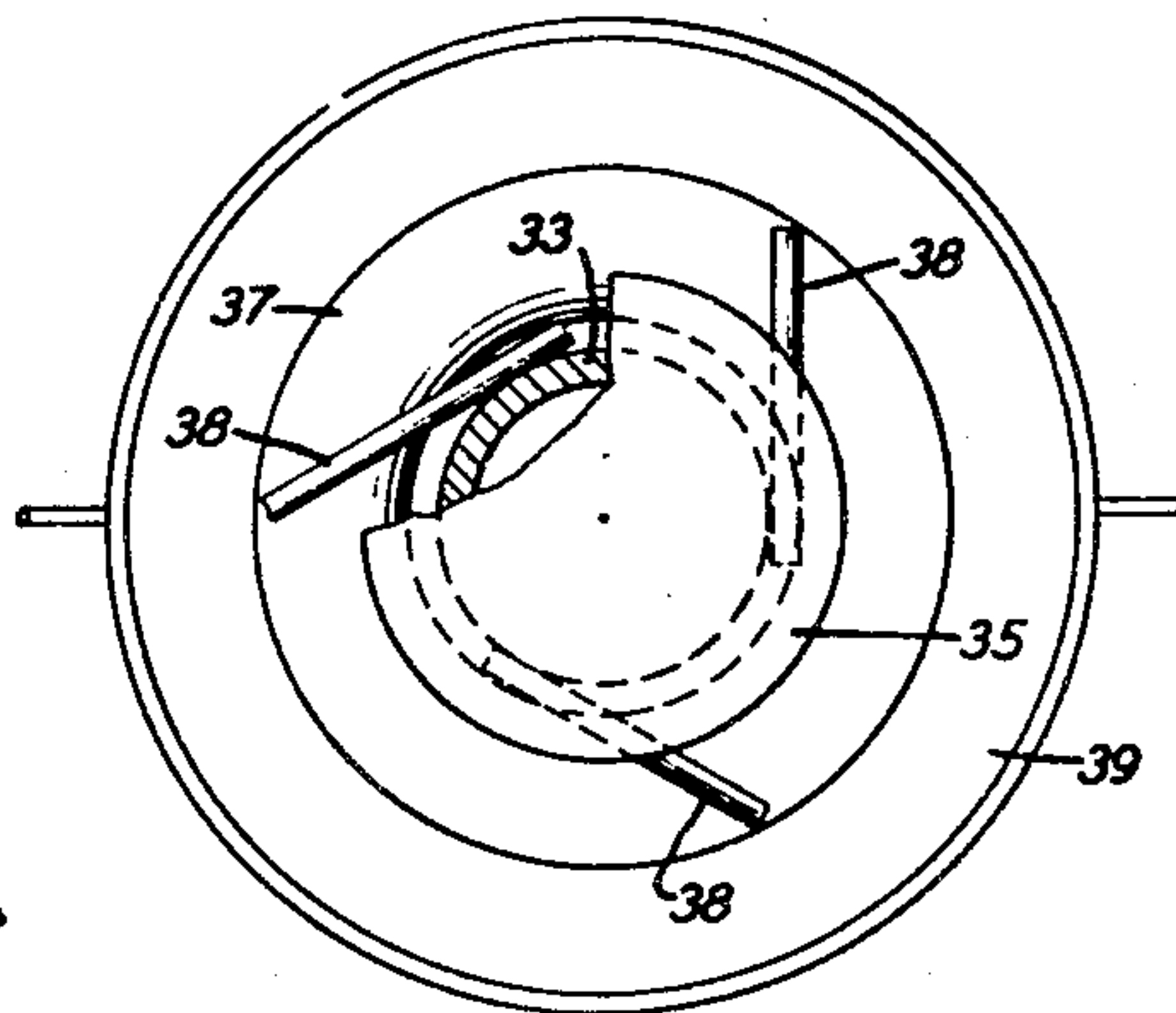


FIG. 3



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FIG. 9

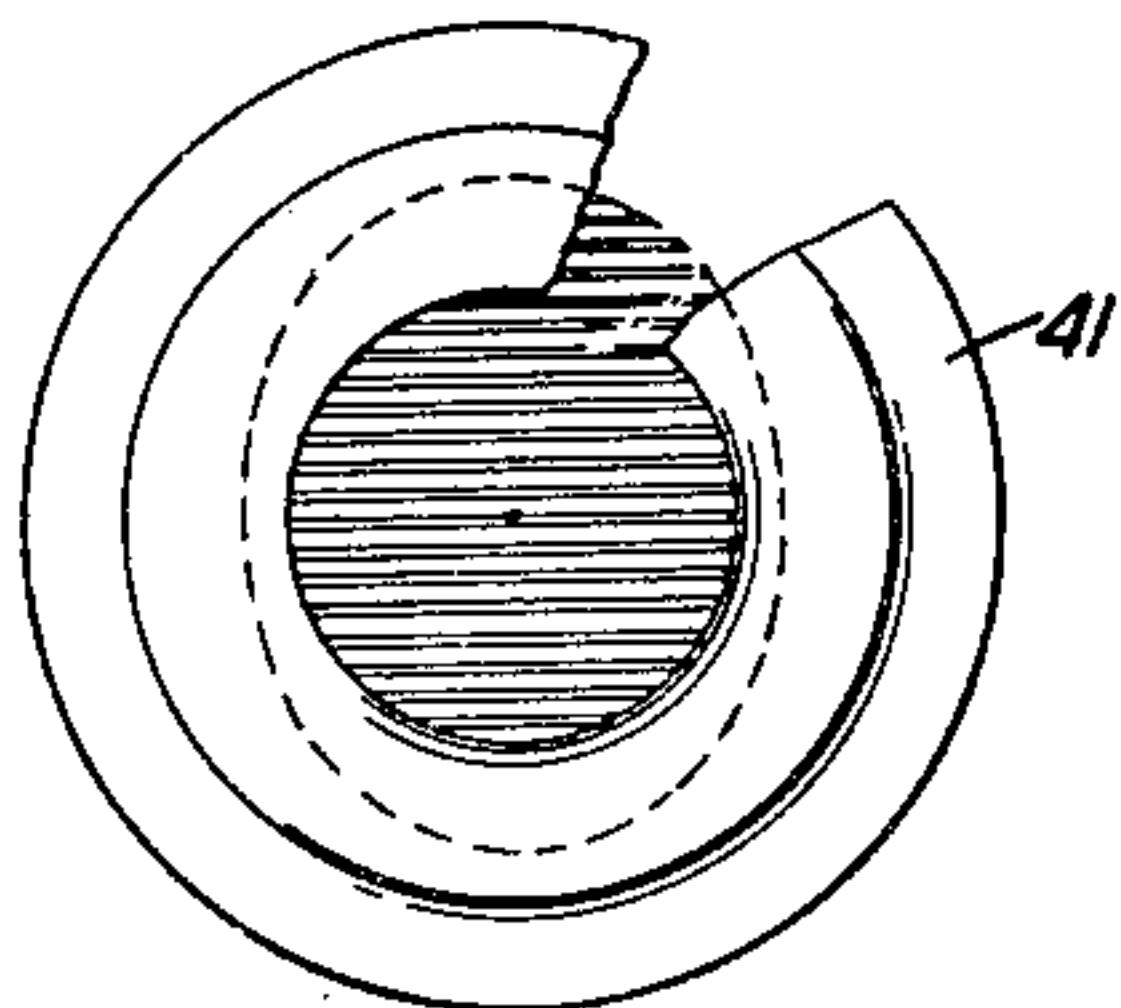


FIG. 4

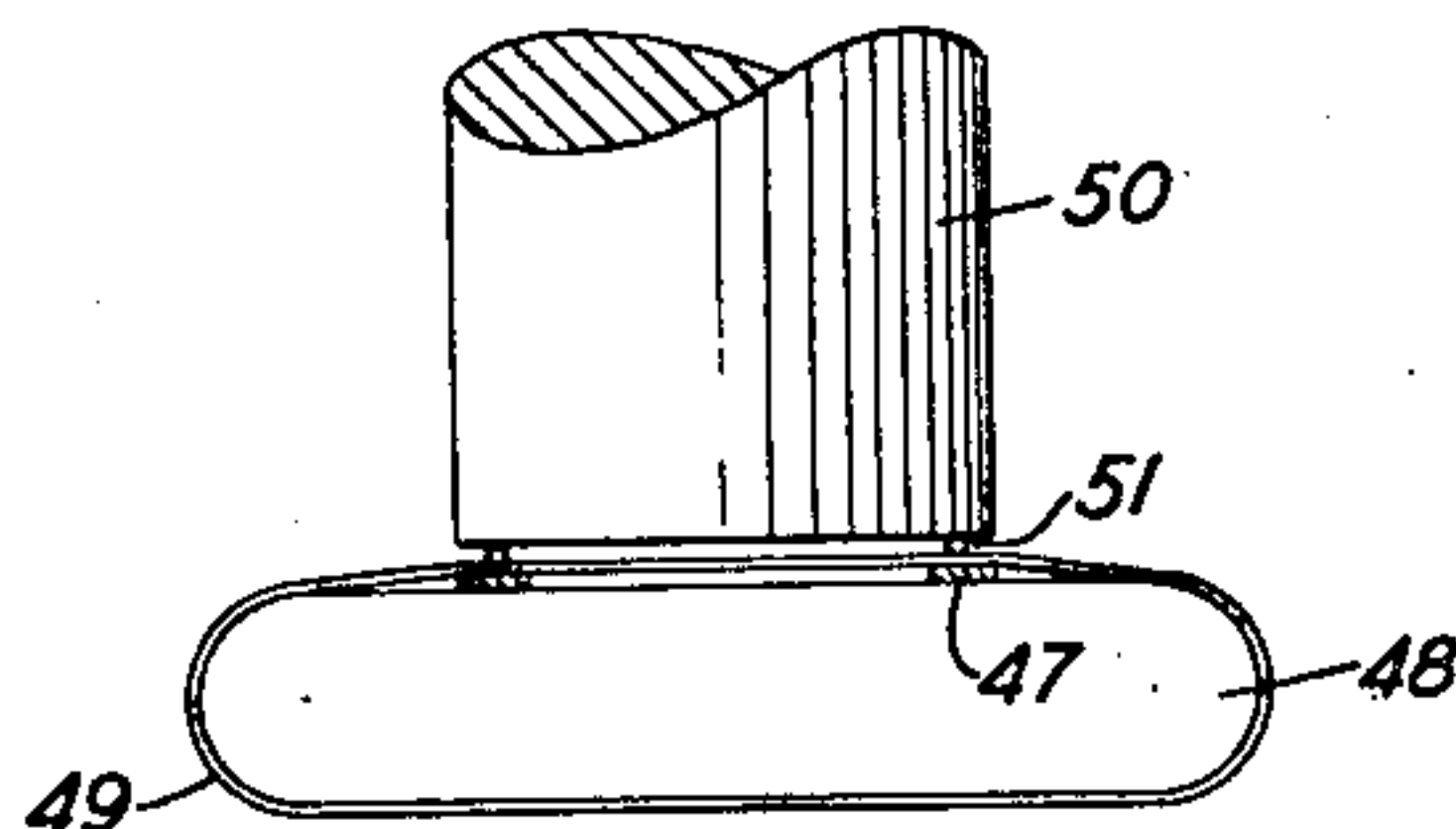


FIG. 5

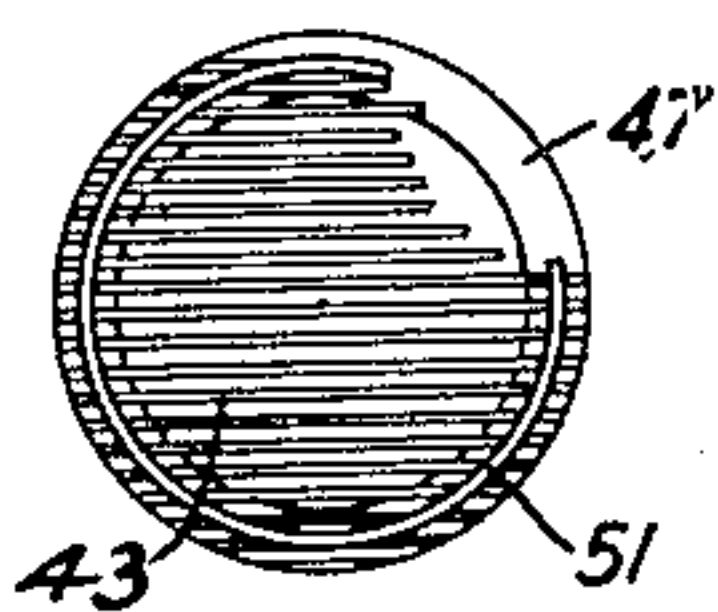


FIG. 6

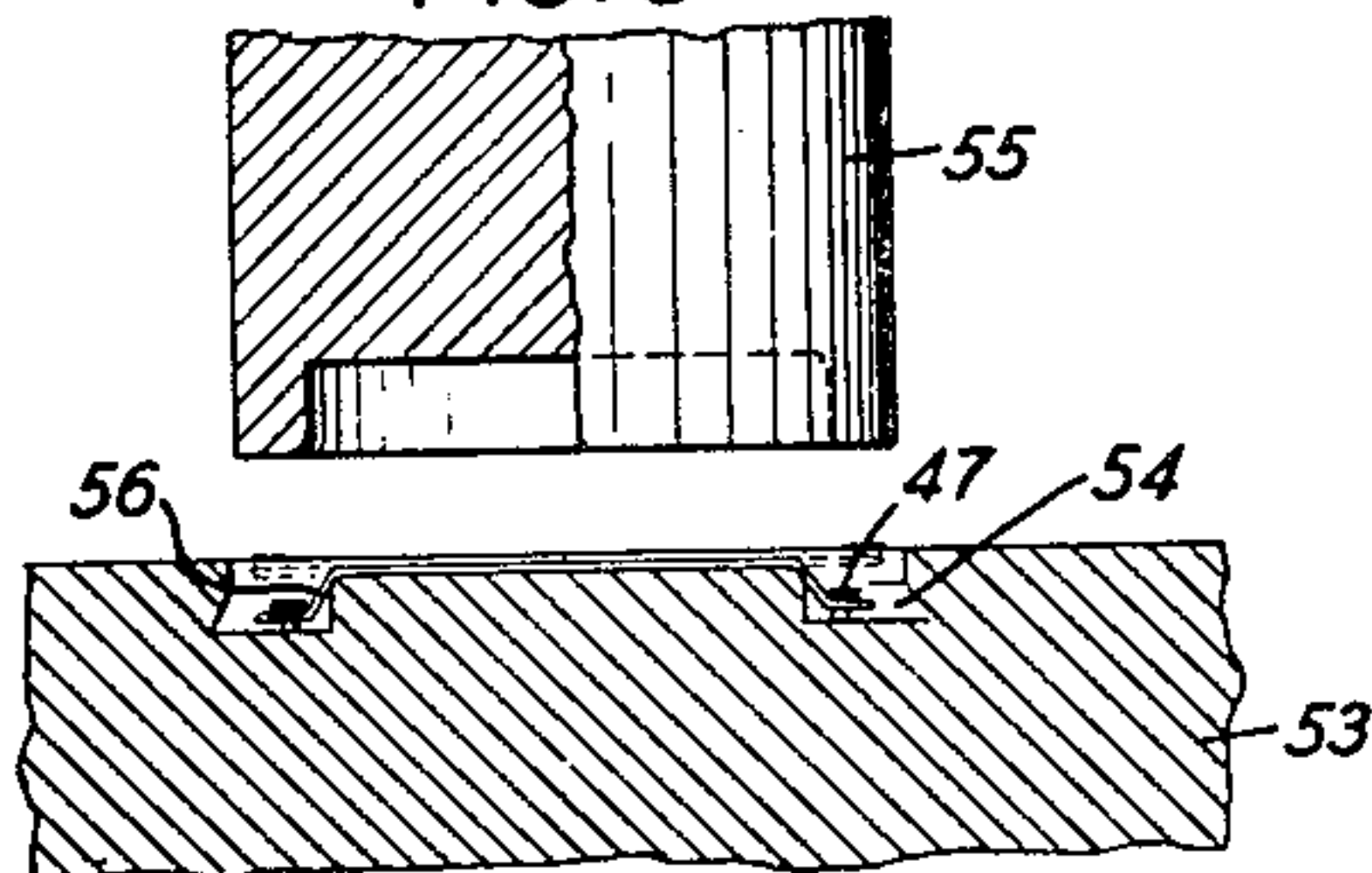


FIG. 7

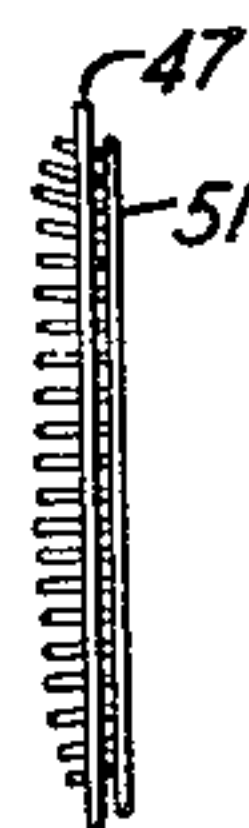
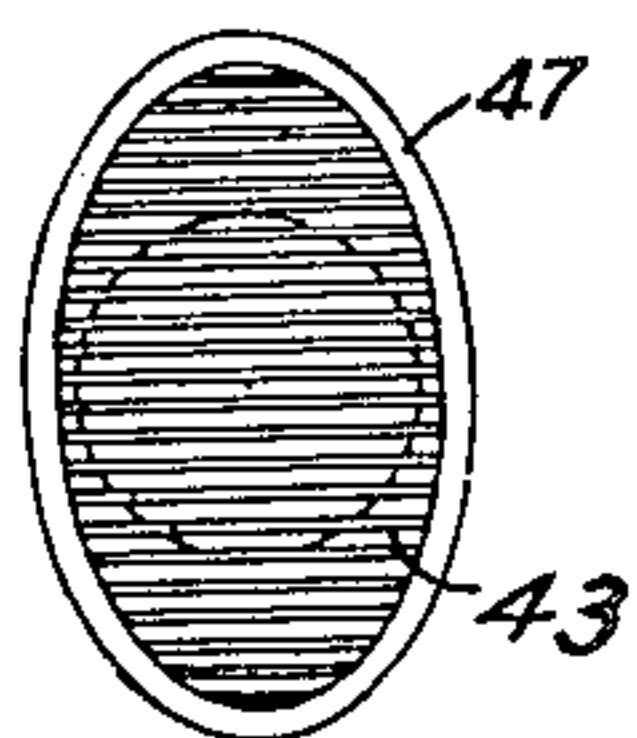
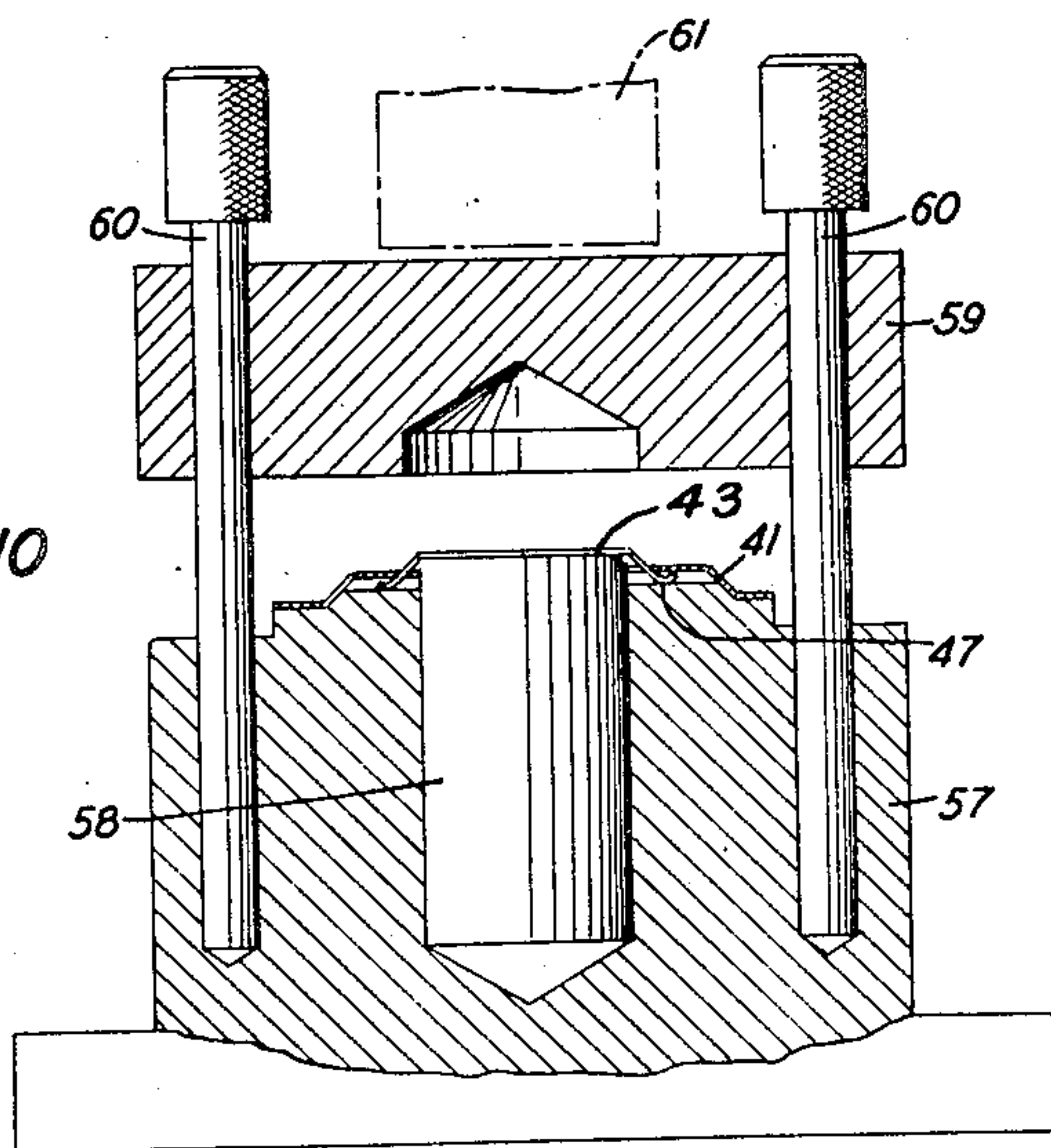


FIG. 8

FIG. 10



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ELECTRON DISCHARGE DEVICE

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Application February 12, 1942, Serial No. 430,550

14 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and methods of forming electrodes therefor and, more particularly, to such devices capable of efficient operation in the centimeter range of ultra-high frequencies.

In order to meet the exacting requirements of operation in the range of frequencies of the order of ten to fifty centimeters, it is essential to maintain the interelectrode spacings constant to eliminate changes, however small in magnitude, in the relative spacing of the electrodes and thus prevent variations in the electrostatic and dynamic characteristics of the device. These changes are apt to occur most frequently in connection with the lateral wires of auxiliary electrodes and particularly the control electrode or grid, which because of frailness are normally subject to distortion stresses, during processing and operation, causing variation in spacing. Since the operating interelectrode spacing is relatively small, being of the order of .008 inch, it will be realized that even the slightest variation will materially alter the capacitance and impedance of the device.

The primary object of this invention is to insure interelectrode spacing of absolute constancy both in the process of manufacture and during operation.

Another object of the invention is to facilitate the manufacturing technique whereby accurate space relation is maintained between the electrodes.

A further object of the invention is to prevent temperature changes from causing distortion in the laterals of the control electrode and other associated electrodes in the device.

In accordance with one embodiment of this invention, an electron discharge device, capable of operation as an amplifier, oscillator or modulator at frequencies corresponding to ultra-short wave-lengths of the order of 50 centimeters, comprises a cylindrical casing having a flat anode at one end, a flat cathode at the other end, and one or more flat grids such as control and auxiliary electrodes interposed in close spaced relation between the cathode and anode. The anode is supported by an insulating closure carried by an annular member attached to one end of the casing and the cathode is supported by a similar assembly at the opposite end of the casing.

A feature of this construction relates to a cathode assembly in which the active surface enclosing an insulated heater element is supported by a tubular extension coaxially mounted in a baffle shield member, the cathode being sup-

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ported thereby through the intermediary of tangentially arranged resilient bridging wires. The shielded cathode assembly is attached to a cup-shaped shield, which screens the active cathode surface from disturbances affected by the heater element terminations connected to conductors in the vessel closure, the latter shield aiding in supporting the cathode assembly in the device.

A further feature of the invention involved in the construction of the cathode assembly relates to the baffle shield member which limits thermal movement of the active surface of the cathode due to the light bridging wires and the lower thermal state of the shield member. The shield member also forms a capacitive coupling with respect to the cathode extension which effectively reduces impedance to radio frequency currents.

Another feature of the invention relates to the support of one of the grid electrodes on the same closure as the anode while the grid closest to the cathode is carried by the casing of the device.

A further feature is concerned with methods of fabrication of the grid assembly in which the frail lateral wires are initially distorted prior to insertion in the device to produce a permanent set in the wires whereby they are prevented from varying from their normal operating plane between the electrodes.

In accordance with these methods, the grid is formed on a flat annulus or ring with a retaining ring secured over the wires and the flat ring is distorted to an elliptical or oval shape, whereby expansion bends are provided at the ends of the laterals while the long lateral wires are uniformly flat and free from possible elongation due to large temperature changes. The central portion of the grid assembly is surrounded by a ring support, the ring forming a mask for the distorted end laterals of the grid. This construction and forming process for the grid insures constant flatness in the grid laterals so that the minute interelectrode spacing may be maintained constant.

These and other features and advantages of this invention will be more apparent from the following detailed description when considered with the accompanying drawings:

Fig. 1 is a greatly enlarged view in cross section of an electron discharge device of this invention illustrating the relation of the elemental parts entering into the construction of the device;

Fig. 2 is an enlarged view partly in section

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showing the structure of the cathode or electron source employed in the device of Fig. 1;

Fig. 3 is a plan view of the cathode assembly of Fig. 1 with a portion broken away to illustrate the position of one of the flexible bridge members;

Fig. 4 shows the preliminary step in the winding and welding of the flat grid structure;

Fig. 5 is a plan view of the grid after the welding operation;

Fig. 6 illustrates the parts of a die for deforming the grid structure;

Fig. 7 is a plan view of the grid of Fig. 5 after the deformation thereof;

Fig. 8 is a side view of the grid of Fig. 7;

Fig. 9 shows the final form of the grid assembly to be incorporated in the ring support as shown in Fig. 1; and

Fig. 10 illustrates in cross-section a tool for supporting the parts of the grid during the welding operation.

Referring to Fig. 1, the preferred embodiment of this invention is illustrated in an electron discharge device capable of operating in the ultra-high frequency range and is embodied in an outer metallic casing, shell or vessel 15, formed of copper, iron or other suitable metal, and provided with outwardly extending annular flanges 16 and 17 at opposite ends. One end of the cylindrical casing is provided with a closure composed of a double flanged ring 18, the outer flange of which is welded to the flange 16 of the casing while the inner flange carries a tubular outwardly extending sleeve 19 having a flange welded to the inner flange of the ring 18, the sleeve 19 being formed of thin gauge copper or other metal suitable for sealing to glass. A molded vitreous stem 20, such as glass, in the form of a disc or button, is sealed to the inner surface of the sleeve 19 and a pair of small diameter conductors 21 and 22 are hermetically sealed in the disc on opposite sides of a central larger diameter conductor 23. The inner end of the conductor 23 is recessed and slotted to receive the shank 24 of a flat disc anode 25 formed of a refractory metal, such as tungsten or molybdenum, the shank being welded within the conductor 23 and the weld being reinforced by the frictional engagement of the slotted end of the conductor.

The opposite end of the cylindrical casing is similarly sealed by another closure assembly including a flanged ring 26 joined to an outwardly extending sleeve 27 which carries a molded stem 28 provided with a central cavity which is sealed off at 29 after the evacuation of the interior of the casing. The stem 28 also carries a pair of conductors 30 and 31 substantially in alignment with the conductors in the opposite stem 20, said conductors serving as electrical connections for the terminations of an internal heater element 32, shown in Fig. 2, within the cathode assembly. The heater is formed of tungsten wire having a pair of opposed bifilar sections to form a self-supporting helix which is coated with an insulating covering, such as aluminum oxide. The heater is enclosed by a nickel sleeve or shell 33 having a flanged rim 34 at the top which forms a seat for a disc closure 35 adapted to serve as the electron source of the device by being provided with a coating of emissive material, such as barium and strontium oxides. The cathode sleeve is surrounded by a metallic shield 36 of magnetic material, such as iron or steel, and the shield is provided with a flanged shelf 37, the shield and shelf being coaxially mounted with respect to

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the cathode sleeve and provided with tangentially arranged resilient bridge wires or fingers 38, secured to the outer surface of the cathode sleeve 33 at points 120 degrees apart, while the free ends of the wires are secured to the shelf 37 of the shield. The resilient bridging wires insure absolute concentricity of the cathode in the shield while permitting the cathode to expand and contract due to temperature changes. The fine bridging wires also provide a barrier to heat loss from the cathode tubing to the enclosing sleeve, the latter, by its reflecting ability, also preventing the same loss. The magnetic shield 36 is also provided with an annular cup shield section 39 which is secured to the lower end of the shield 36 and substantially masks the terminations of the heater element 32 extending from the bottom of the cathode assembly. The cup shield 39 is rigidly fastened to the conductor 31 to support the cathode assembly within the vessel. This construction insures limited axial movement of the active cathode surface, since the shield member 36 is relatively cool and therefore not subjected to large temperature changes due to expansion and contraction. Furthermore the shield forms a capacitive coupling with the cathode sleeve to reduce impedance of radio frequency currents flowing between the elements in the device. A cylindrical flanged ring or partition 40 is mounted within the casing 15 intermediate the ends thereof and carries a grid ring 41 supporting a flat grid member 42 provided with lateral wires 43 in planar relation with respect to the cathode surface 35. The normal spacing between the cathode and grid wires is approximately .012 inch while under operating conditions, due to the temperature expansion of the cathode the spacing is normally .008 inch. A similar grid electrode 44 which functions as the screen electrode is supported by a flanged ring 45 adjacent to the anode surface and this assembly is supported by a flanged cylinder 46 welded to the conductors 21 and 22 in the stem 20.

The device shown in Fig. 1 is purposely greatly enlarged to clearly disclose the details of the assembly, the actual dimensions as applied to the casing 15 being an inside diameter of .935 inch and a length of .840 inch. The electrodes mounted therein are necessarily of minute dimensions, and close spacing, as indicated above in connection with the normal and operating spaced relation between the cathode and the control grid, must be maintained. These requirements are essential to efficient operation in the centimeter range of high frequency. Such close spacing is extremely hazardous to the functional operation of the device unless the spacing can be maintained constant, and when it is realized that the laterals 43 of the grids, such as 42 and 44, are composed of molybdenum wire of .001 inch having 250 wires per inch in the plane of the grid, it will be evident that such frail wires can be easily distorted by high temperature treatment, such as is involved in the treatment to remove occluded gases in the metal to attain a high degree vacuum. This distortion of the frail wires produces a permanent set therein which cannot be remedied and the device necessarily fails to function as intended.

Since the cathode and anode surfaces are sufficiently rigid to withstand the excessive temperatures involved in the pumping and heat treating processes incident to manufacture, the fine grids employed in the device of Fig. 1 present a problem in the maintenance of flatness, particularly dur-

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ing the outgassing heat treatment and also during normal operation of the device in service. To compensate for differential thermal expansion, it is necessary to provide bends on the ends of the wire laterals, similar to larger grid electrodes in standard radio tube technique, whereby flexing at the bends prevents permanent distortion of the frail laterals. In order to insure this flexing action in the bends in the usual grid structure, it is stretched on a former whereby suitable elongation takes place in the laterals of the grids. This procedure is not desirable in the flat grid of this invention, since the laterals are formed of highly refractory metals, such as molybdenum and tungsten, which can withstand the temperature conditions in the device of Fig. 1. Such highly refractory wires, particularly of small diameter such as .001 inch, have an elongation factor limited to approximately 15 per cent so that any elongation stress greater than the safety factor causes rupture of the wire.

However, according to this invention the grid laterals are maintained in absolute coplanar relation and the flatness permanently realized so that distortion cannot occur to change the operating characteristics of the device. This is accomplished in accordance with various steps as shown in Figs. 4 to 10, inclusive.

Referring to Fig. 4, the grid 42 of this invention is formed by placing a nickel or other metallic ring or annulus 47 on a flat surface of an arbor 48 and winding the fine wire 49 around the arbor at any suitable pitch to overlie the ring 47. The overlying laterals of the wound grid are then welded to the ring 47 by a welding electrode 50 being brought in contact with a wire ring 51, which is superimposed on the ring and wires of the grid, the retaining ring 51 being provided to prevent burning of the lateral wires of the grid and otherwise to improve the welding conditions. Grids of this general construction have been made employing .000216 inch wire wound with 250 turns per inch. After the welding operation is completed the arbor 48 is removed and the excess wire around the ring 47 may be trimmed to present a disc grid as shown in Fig. 5 with the fine lateral wires 43 securely held to the ring in parallel and coplanar relation. The formed grid is then placed in a die block 53, as shown in Fig. 6, provided with an undercut recess 54 and a cooperating die ram 55 compresses the grid structure seated in the die block. This method of forming the grid structure does not depend upon the amount of stretch obtained in the lateral wires 43 but the depth of the expansion bends 56, as shown in Fig. 6, is obtained by deforming the ring 47 from a circular configuration as shown in Fig. 5 to an oval or elliptical form as shown in Fig. 7. The resistance to change in shape of the ring provides a tensioning effect on the grid lateral wires keeping them straight over the central portion of the grid and forming the bends 56 in the ends of the lateral due to the contraction of the ring 47 or decrease in diameter thereof in the dimension across the longest laterals while the ring tends to increase in diameter at right angles to the length of the laterals so that the end laterals of the grid are bowed toward the circumference of the ring, as shown in Fig. 8. Since the central portion of the grid laterals, as shown in Fig. 7 by the dotted outline, are accurately parallel this portion of the grid will serve the requirements in the device of Fig. 1. It is a simple matter to mask the distorted end turns, as shown in Fig. 9, wherein a large diameter ring 41 is superimposed

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on the grid structure of Fig. 7 so that only the parallel grid wires are exposed in the assembly.

The reformed grid is welded to the supporting ring 41 in a welding tool, shown in Fig. 10, which comprises a block 57 provided with a central pin 58 to form a seat for the grid and this pin projects from the block a sufficient distance to support the laterals 43 while the distorted ring 47 is supported on the block. The supporting ring 41 is then placed over the deformed grid and a cooperating piece 59 clamps the grid and the supporting ring in place, the clamping part of the tool being held in alignment with the block 57 by guide pins 60. The entire tool is then placed in a large welder and the grid tack-welded to the ring 41 by a welding electrode 61, the guide pins being removed during the welding operation. The welded grid is then placed in another tool similar to the welding tool of Fig. 10 except the parts are made of stainless steel and the part 59 is made purposely heavy so that the weight tends to clamp or compress the ring 41 between the two parts of the tool and the laterals 43 of the grid become taut. The entire tool is then placed in an oven and heated to 800° C. for five minutes while introducing hydrogen to the oven. This operation sets the grid unit into a permanent flattened state so that the grid laterals 43 will not be distorted in any later heat treatment.

While this invention has been disclosed with respect to a specific type of construction for an electron discharge device and a particular method of offsetting distortion in flat type grids, it is, of course, understood that various modifications may be made in the assembly of the device and the various steps of the method herein disclosed without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising a metallic casing, insulating closure members at opposite ends thereof, an electron source having a flat active surface extending within said casing from one of said closure members, an electron receiving surface disposed opposite said source and extending within said casing from said other closure member, a flat control electrode having passageways therein interposed in planar relation between said source and said receiving surface, and a ring supporting said electrode in engagement with said casing to restrict the discharge between said source and said receiving surface to a path limited by the area of the passageways in said control electrode, the remainder of said ring support and casing forming separate compartments for said source and said receiving surface, respectively.

2. An electron discharge device comprising a metallic casing, insulating closure members at opposite ends thereof, an electron source having a flat active surface extending within said casing from one of said closure members, an electron receiving surface disposed opposite said source and extending within said casing from said other closure member, a flat control electrode interposed between said source and said receiving surface in planar relation to said surfaces, a ring supporting said electrode in engagement with said casing, a perforated auxiliary flat electrode intermediate said control electrode and said receiving surface, and a support therefor extending through said closure adjacent said receiving surface.

3. An electron discharge device comprising a metallic casing, insulating closure members at opposite ends thereof, a cathode assembly having a flat active surface extending within said casing from one of said closure members, an anode disposed opposite said source and extending within said casing from said other closure member, a flat control electrode interposed between said cathode and anode and spaced in parallel relation to said electrodes, a ring supporting said electrode in engagement with said casing, a perforated auxiliary flat electrode intermediate said control electrode and said anode, and a cylindrical shield supporting said auxiliary electrode, said shield enclosing said anode.

4. An electron discharge device comprising a containing vessel having a closure of molded insulating material, conductors sealed therein, a cathode assembly within said vessel having a hollow metallic member with a flat end portion, a heater element within said hollow member, the terminations thereof being connected to said conductors, a tubular shield surrounding said hollow member, means supporting said hollow member coaxially within said shield, and a cup shield extending outwardly from said tubular shield and masking the terminations of said heater element from said flat end portion of said cathode.

5. An electron discharge device comprising a containing vessel having a closure of molded insulating material, conductors sealed therein, a cathode assembly within said vessel having a hollow metallic member with a flat end portion, a heater element within said hollow member, the terminations thereof being connected to said conductors, a tubular shield surrounding said hollow member, resilient tangentially arranged arms extending between said shield and said hollow member, and a cup shield extending outwardly from said tubular shield and masking the terminations of said heater element from said cathode.

6. An electron discharge device according to claim 4, wherein the cathode assembly has the cup shield connected to one of said conductors.

7. An electron discharge device comprising an evacuated vessel, cooperating electrodes supported therein, one of said electrodes comprising a cathode sleeve having an emissive coating on a portion thereof, a heater element within said cathode, a cylindrical shield spaced from and surrounding said cathode sleeve, resilient arms on said shield supporting said cathode within said shield, and an annular cup shield attached to said cylindrical shield adjacent the terminations of said heater element and masking the terminations of said heater element from said cathode.

8. In the fabrication of an electrode composed of a plurality of parallel wire elements secured at their ends to an apertured metallic supporting base having a continuous boundary, the method of permanently setting said wire elements in coplanar relation which comprises, distorting said base to deform said wire elements without elongation, and offsetting the center portion of said elements in a plane parallel to the plane of said base.

9. In the fabrication of an electrode composed of a plurality of parallel wire elements secured at their ends to an apertured metallic supporting base having a continuous boundary, the method of permanently setting said wire elements in coplanar relation which comprises, distorting said base and simultaneously compressing said wire

elements to bend the end portions adjacent said base at an angle with respect to said base and center portions, and heating said electrode while under compression to produce a permanent set in the center portions of said elements so that they are maintained in uniform planar relation.

10. In the fabrication of an electrode composed of a plurality of parallel wire elements secured at their ends to an apertured metallic supporting base having a continuous boundary, the method of permanently setting said wire elements in coplanar relation which comprises, distorting said base to bend the end portions adjacent said base at an angle with respect to said base and center portions, heating said electrode in hydrogen to 800° C., and compressing said center portions during the heating.

11. In the fabrication of a flat grid electrode composed of a plurality of parallel wires secured to a circular ring support, the method of permanently setting said wires in coplanar relation which comprises, changing the shape of said ring to an oval configuration whereby the wires in the central portion thereof are bowed outwardly from the plane of the ring and the end portions are arched angularly therefrom, compressing said wires so that all of said wires are positioned in a plane parallel to said ring, each wire having bent end portions extending between the separate planes, and heating said wires while under compression to permanently set them so that distortion from the set plane is prevented under subsequent heating conditions.

12. In the fabrication of a flat grid electrode composed of a plurality of parallel wires secured to a circular support, the method of permanently setting said wires in coplanar relation which comprises, deforming said support to decrease the dimension across the longest laterals and to increase the dimension at right angles to the length of said laterals, offsetting the laterals to form expansion bends between the laterals and said support, compressing the laterals to a coplanar state parallel to said support, heating the electrode to set the wires, and applying an apertured mask support to said circular support to expose the central parallel wires but screen the arched end wires.

13. The method of forming a flat type grid electrode which comprises, affixing parallel wires to a ring support, deforming the wires and ring by pressure, whereby the central laterals are offset from the ring and the end laterals are bowed toward the circumference of the ring, heating the grid under compression to set the laterals in their reformed condition, and applying an additional ring support over the deformed grid to expose the central parallel laterals and mask the bowed end laterals.

14. The method of forming a flat type grid electrode which comprises, applying a ring support to a flat arbor, winding a continuous wire around said arbor and ring, superimposing a wire ring on said wire in contact with said ring support, welding said ring and wire to said support, removing said arbor, trimming said ring support to remove excess wire, compressing and distorting said ring support and wire laterals to offset the laterals from said support, and heating said grid electrode in a hydrogen atmosphere to permanently set said laterals in coplanar relation.

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