

Nov. 26, 1946.

J. P. LAICO

2,411,548

ELECTRON DISCHARGE DEVICE

Filed May 31, 1941

2 Sheets-Sheet 1

FIG. 1

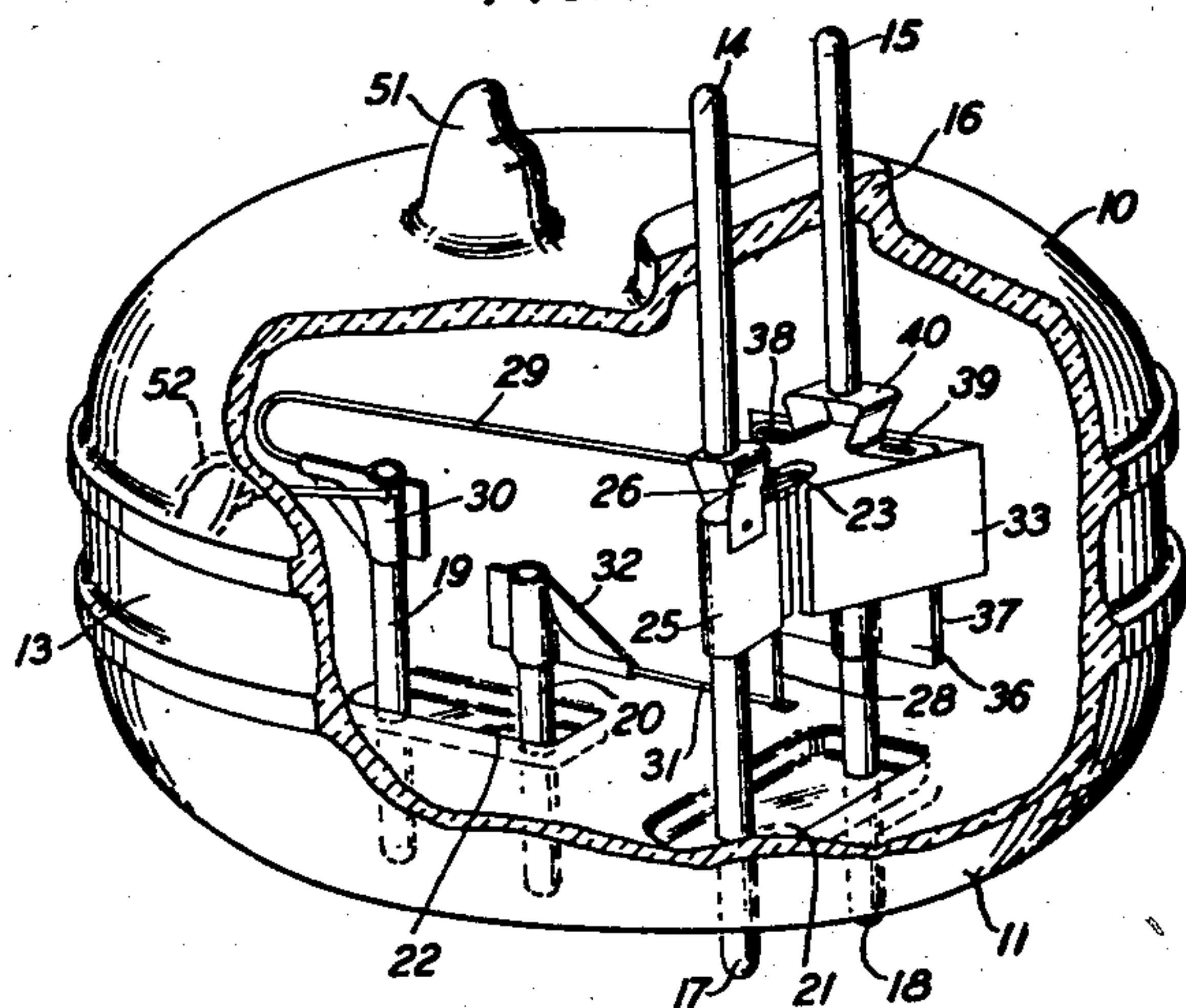


FIG. 2A

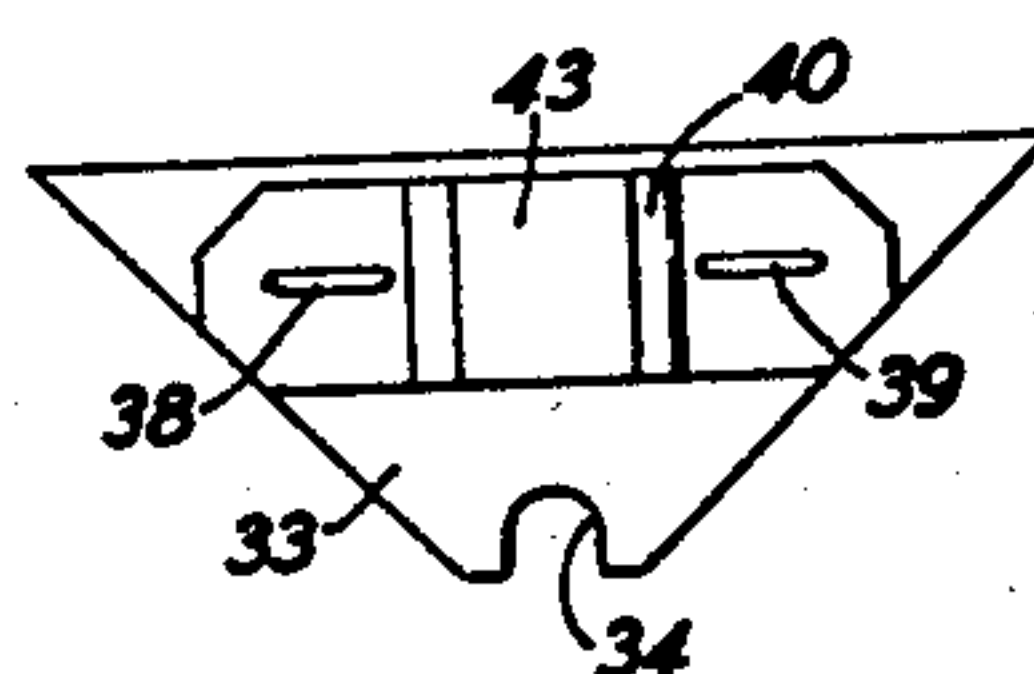


FIG. 2

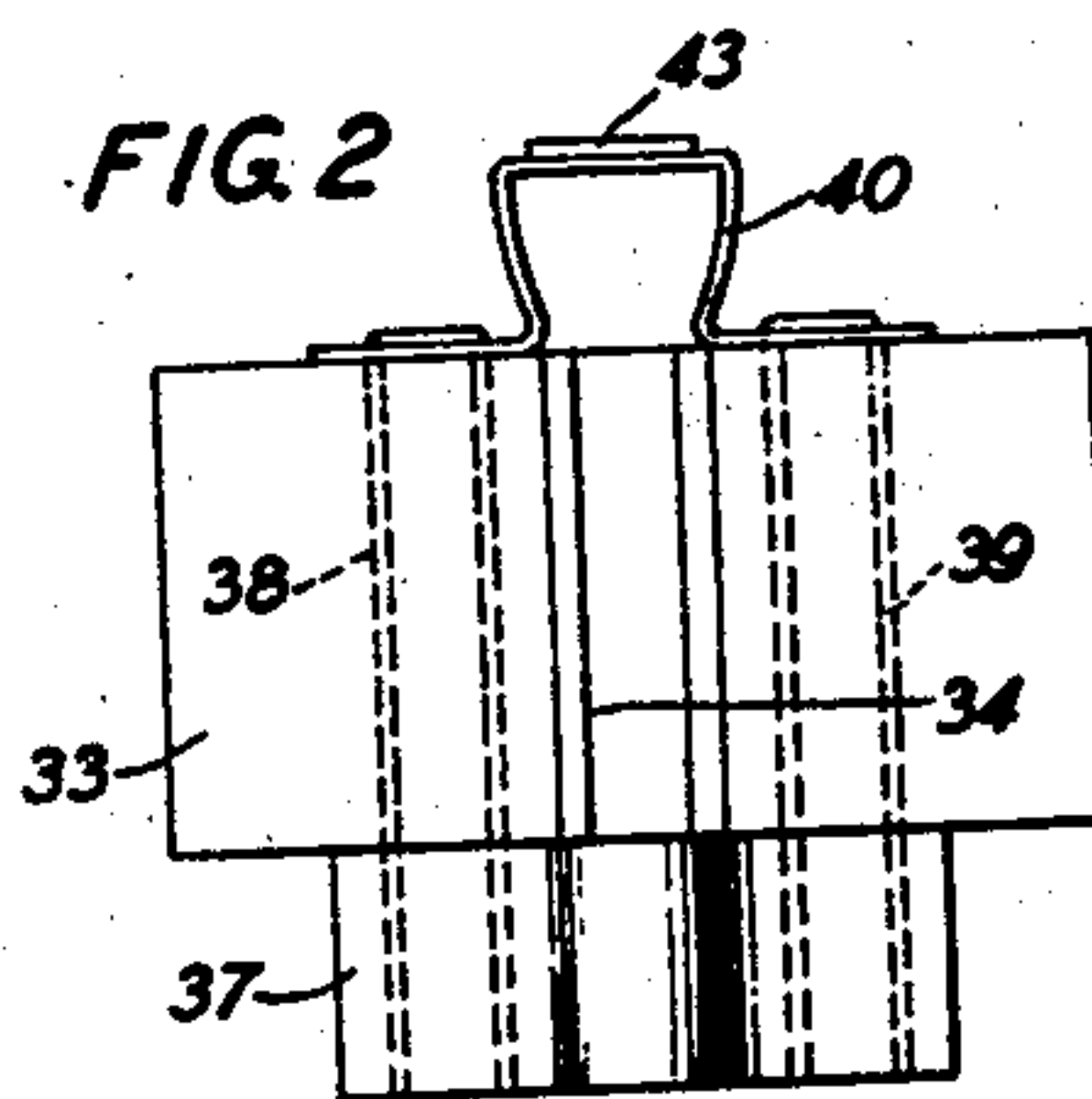


FIG. 4

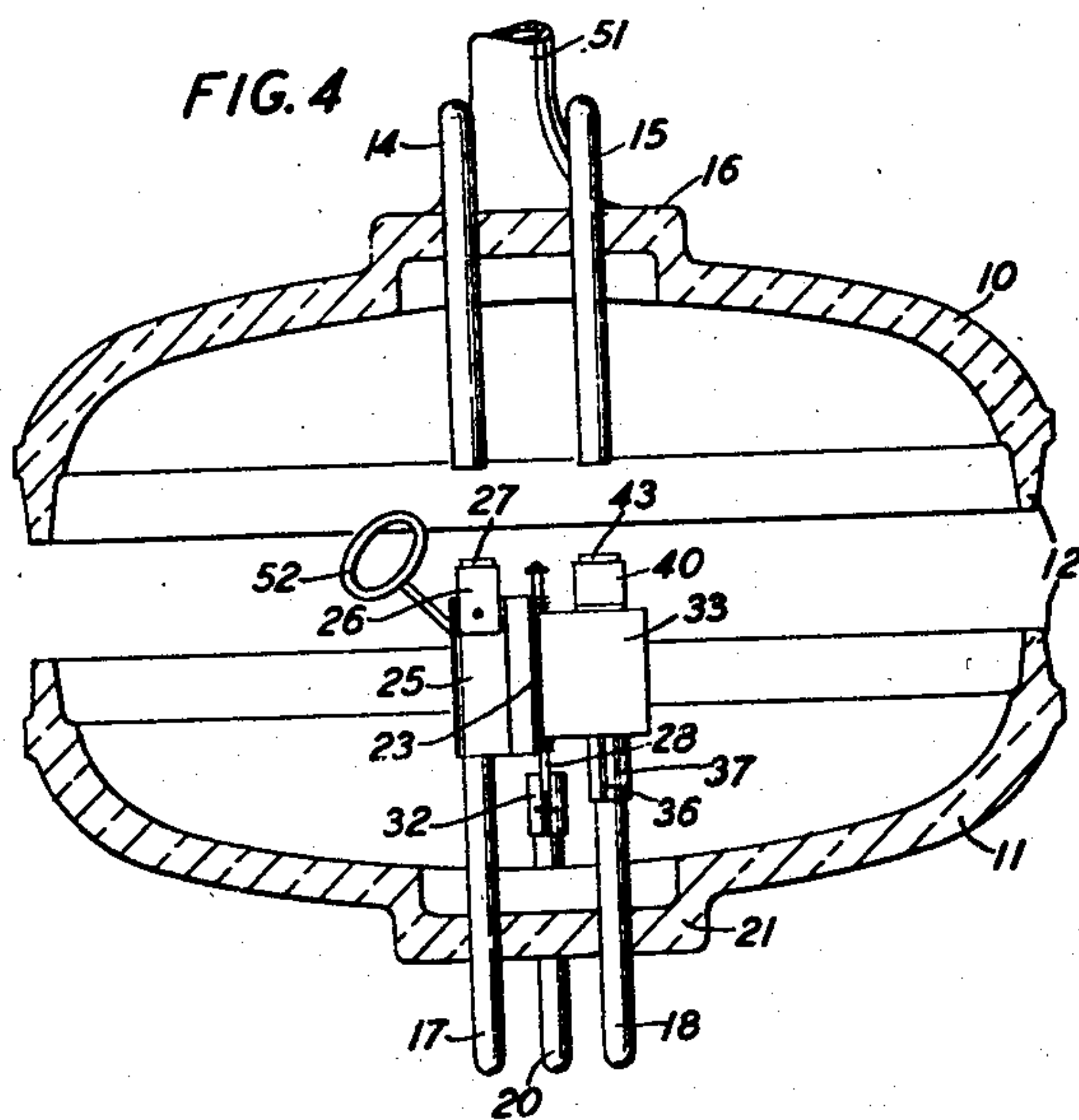
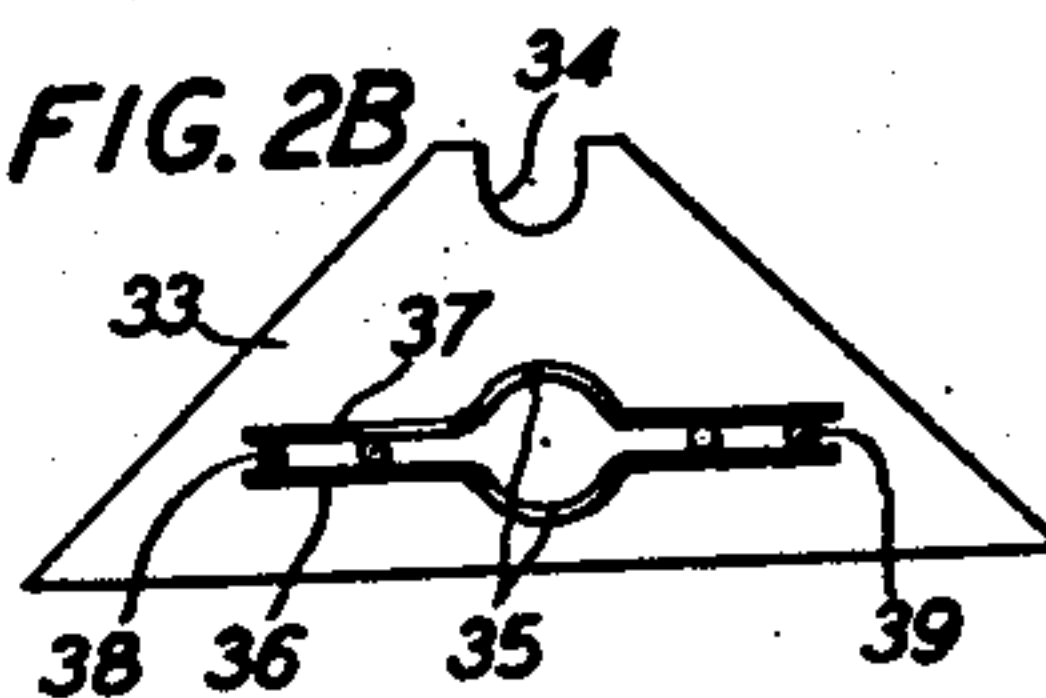


FIG. 2B



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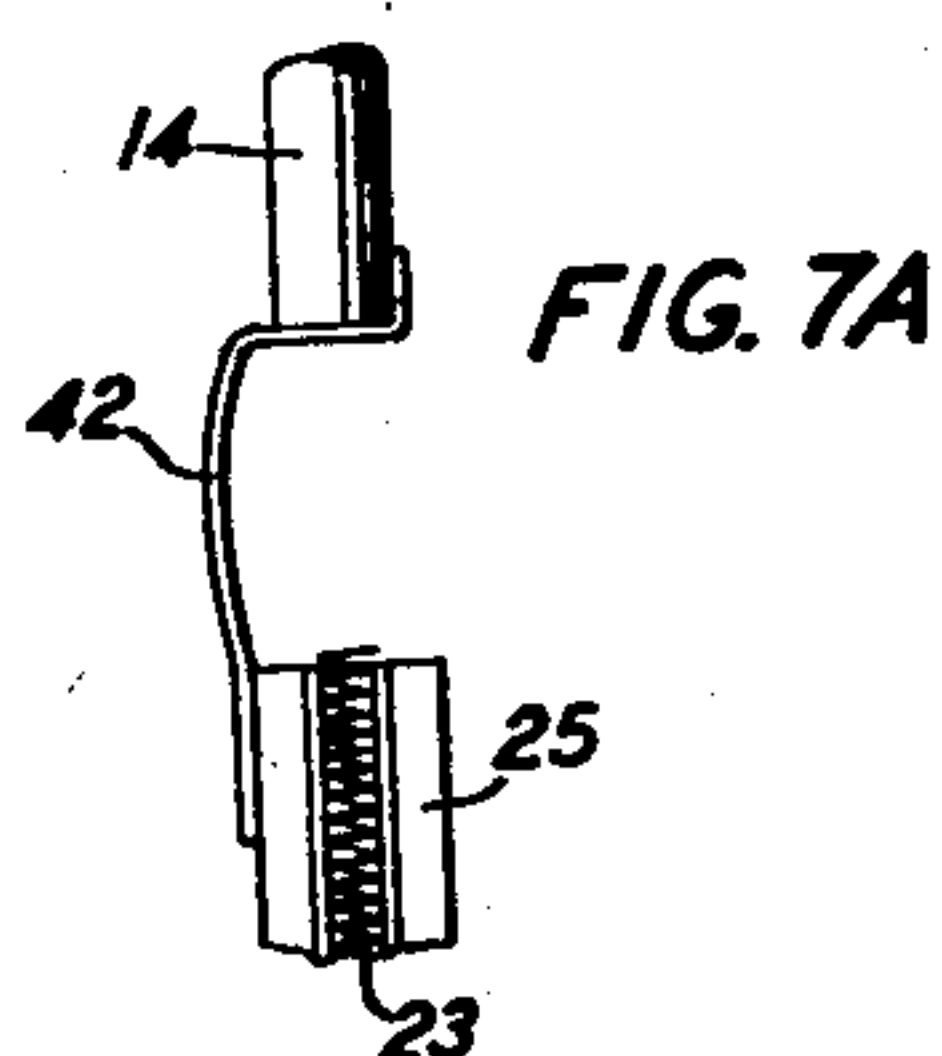
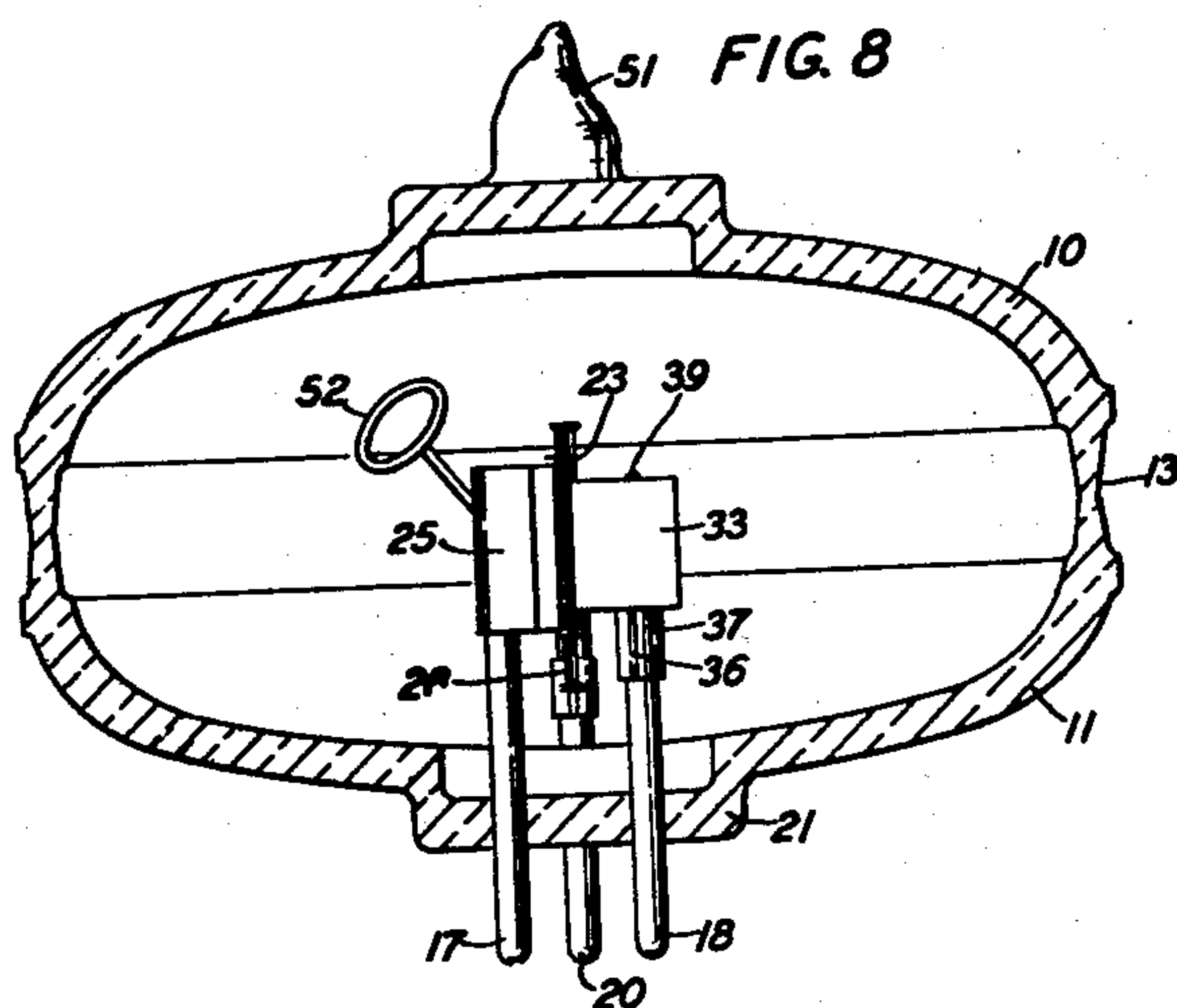
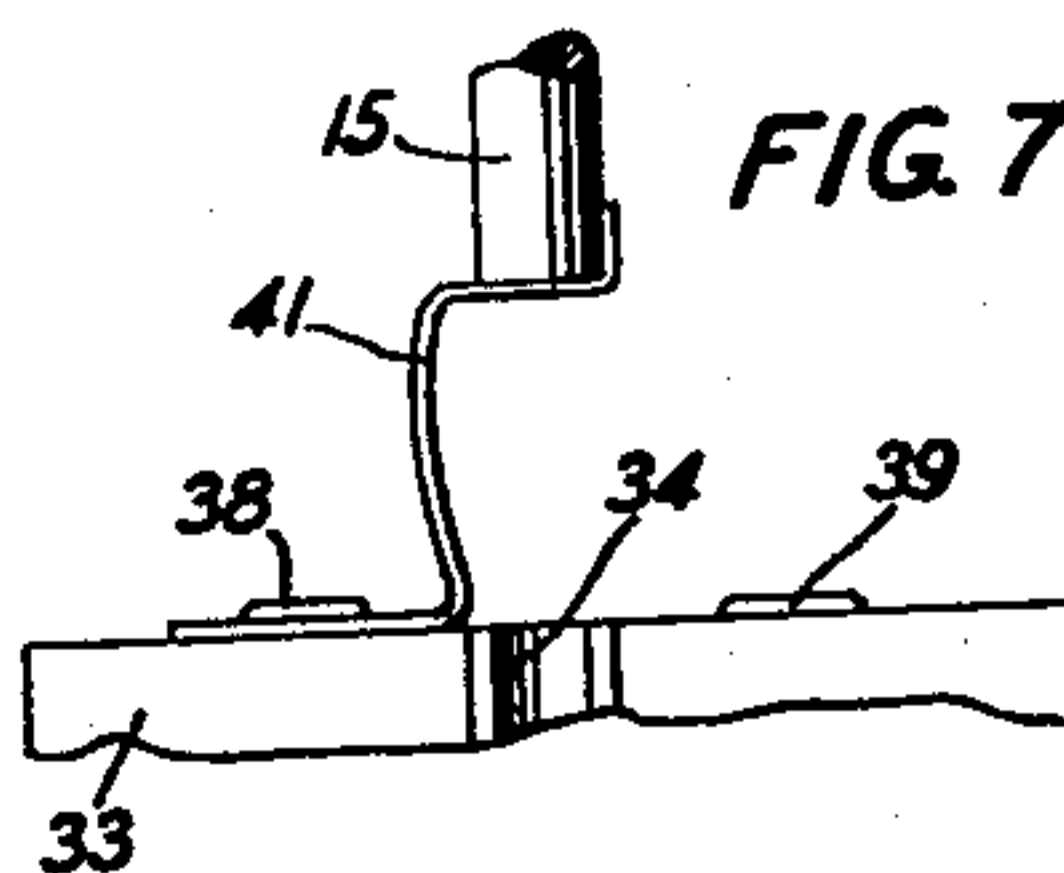
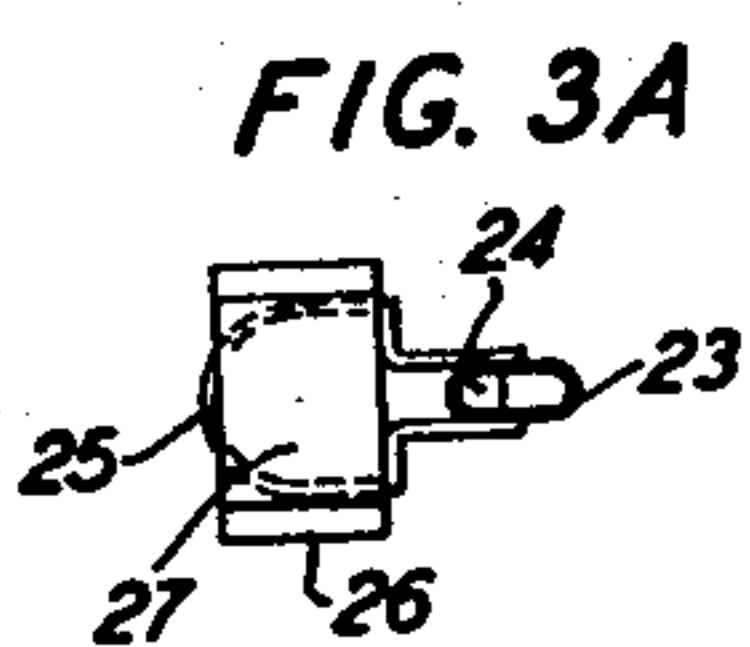
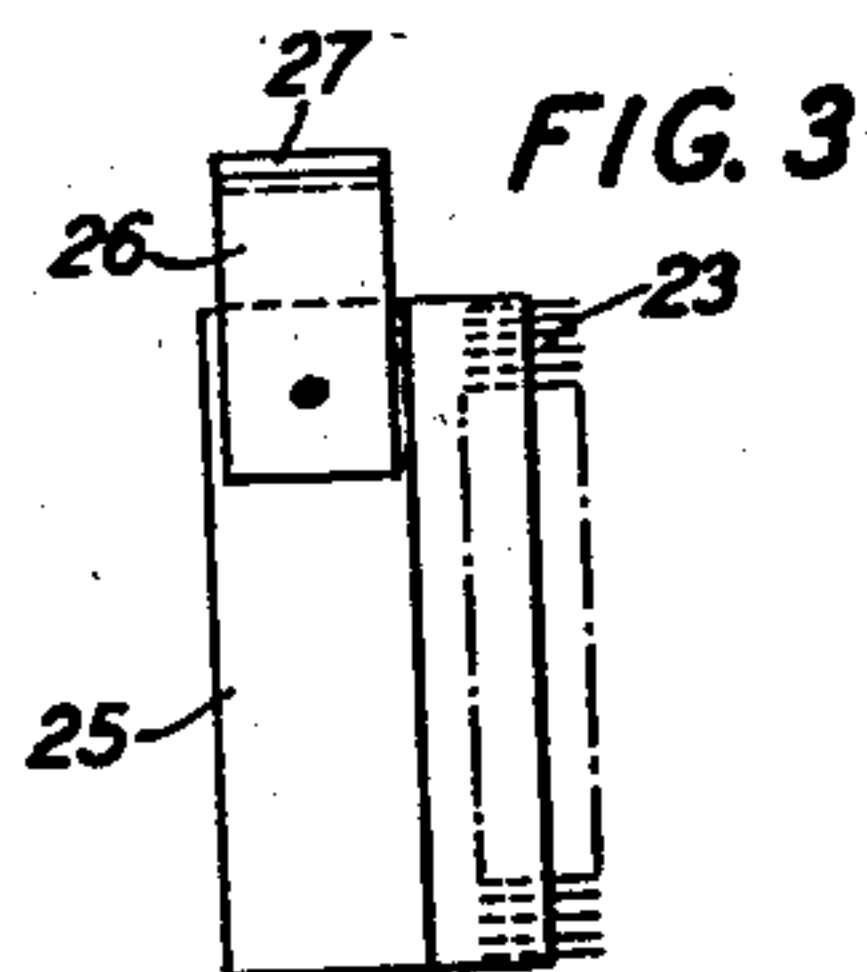
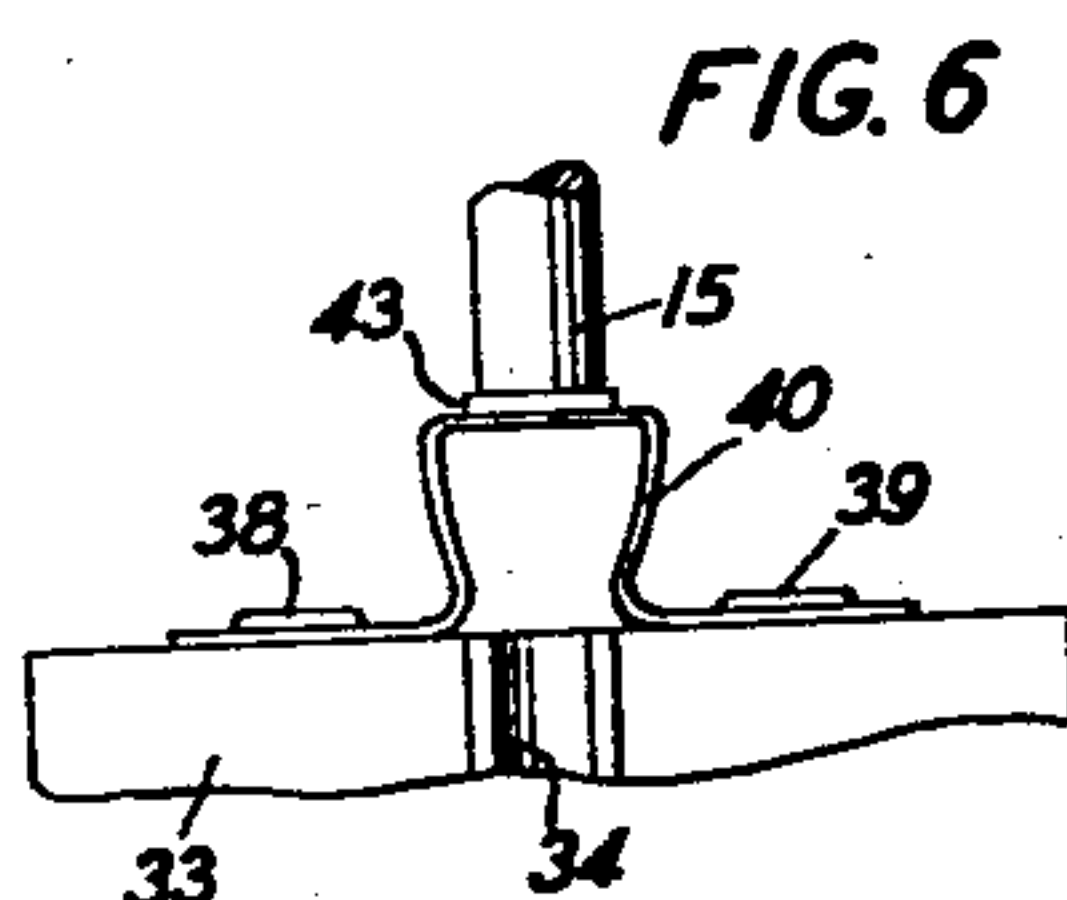
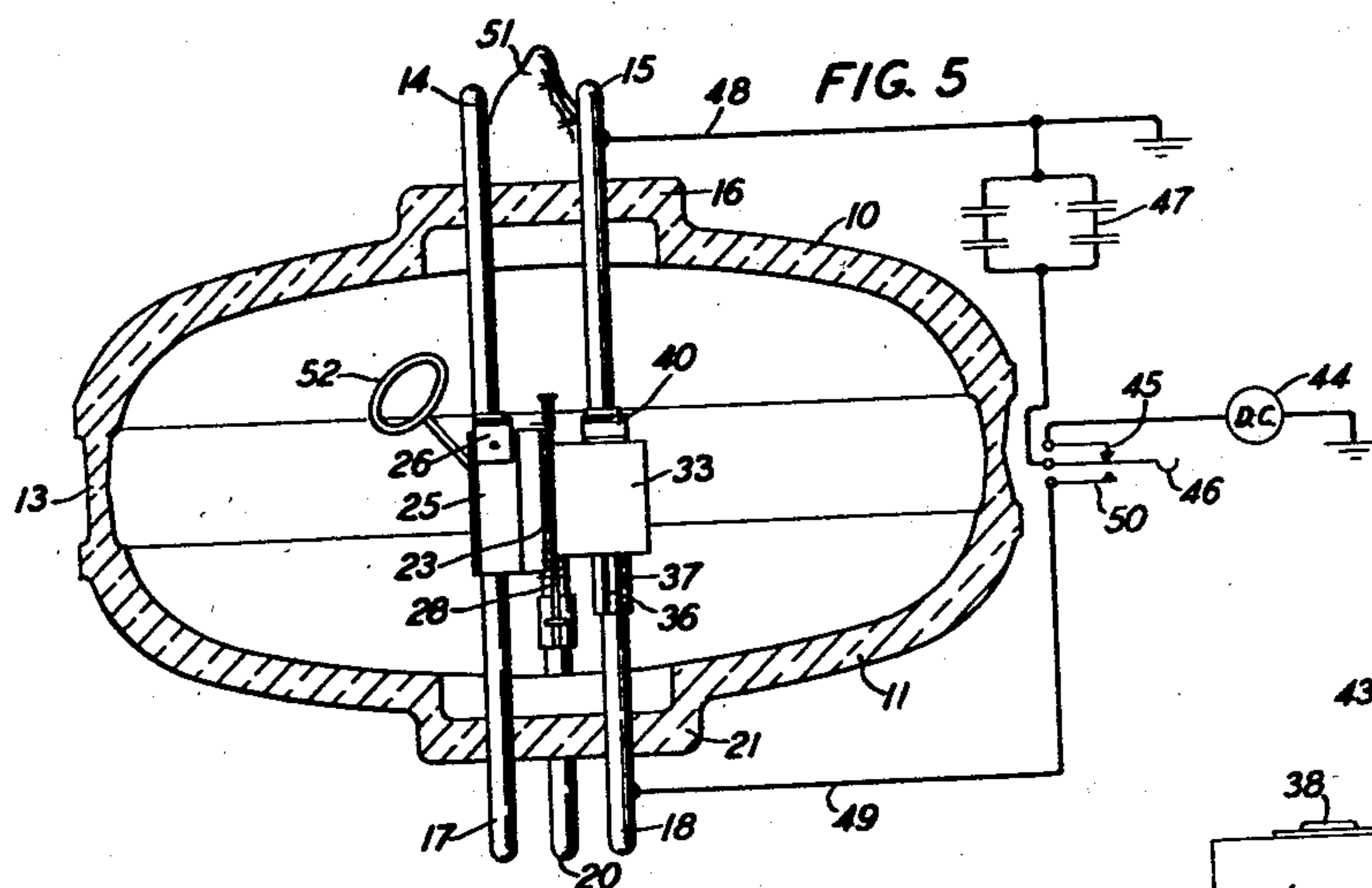
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2 Sheets-Sheet 2



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ELECTRON DISCHARGE DEVICE

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Application May 31, 1941, Serial No. 396,001

14 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to micro-wave devices for ultra-high frequency generating and translating systems.

In ultra-high frequency amplifying systems, for example, the static and dynamic characteristics and the micro-wave-length limits of such devices are dependent on the coupling facilities between the electrodes of the device and the tuned circuits of the amplifier. Some important factors determining such coupling are the internal impedance of the leading-in conductors for the several electrodes in the device, which must be low, and their insulating relation with respect to each other, which should be high. To attain low impedance and high insulation it is desirable that the conductors be held to the shortest possible length and that their internal resistances be negligible.

An object of this invention is to facilitate the coupling of the internal elements of electron discharge devices to eliminate high impedance in the tuned circuits associated therewith.

Another object of the invention is the fabrication of relatively short conductors to the elements of the device in an evacuated container to materially reduce the internal resistance of the coupling connections.

A further object of the invention is to increase the operating stability and power capacity of ultra-high frequency translating devices.

Another object of the invention is to compensate for differential expansion and contraction between the electrodes and the conductors whereby accurate spacial relation between cooperating electrodes is maintained uniform and dangerous stresses are eliminated in the seals of the conductors.

Another object of the invention is to decrease the evacuation process time for completion of the device by a method of assembly in which the removal of occluded gases in the vessel and fabricated parts is facilitated.

These objects are attained in accordance with one aspect of the invention in which the electrodes, such as the cathode, grid and anode, are mounted within a pre-cast vitreous vessel of the clam-shell type with short conductors sealed in one section and extending parallel to the axis of the vessel and linear conductors for the anode and grid are aligned in the other section and welded to the respective electrodes after the sections are sealed together. This arrangement increases the linkage of the input and output electrode couplings to tuned circuits and materially decreases the internal impedance of the electrodes

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associated with these circuits so that stable operation is realized and lower limits in micro-wave transmission may be attained.

A feature of the invention relates to the fabrication of the control electrode and anode whereby expansion and contraction of the electrodes is compensated without inducing strains on the conductors or the seals of the vessel. This is accomplished by providing yieldable links between the electrodes and the conductors sealed in the stem portions of the vessel.

Another feature of the invention relates to a method of assembly in which the conductors extending through the top of the vessel are rigidly attached to the electrodes before or after the two sections of the vessel are completely sealed together. This is accomplished by mounting the electrodes in the lower section of the vessel, aligning the conductors in the upper section with the respective electrodes, then sealing the sections together and finally rigidly securing the conductors in the upper section to the yieldable links of the electrodes by passing a condenser discharge through the individual electrodes and conductors to provide a low resistance coupling between the conductors and the links attached to the electrodes.

Another feature of the invention relates to the alignment of the electrodes with the linear conductors in opposed sections of the vessel to facilitate the assembly and fabrication of the individual elements of the device. This is achieved by forming extensions on the electrodes which act as sockets for the conductors to rigidly fasten the electrodes to their respective conductors.

Another feature is concerned with the anode assembly in which connector members extend through the anode formed of a solid block, the members coupling the yieldable link and the socket to opposite ends of the anode.

A further feature of the invention relates to the construction of the control electrode in which a large heat radiating body is attached to the control electrode to strengthen the assembly, to efficiently dissipate the heat so that the grid operates at a low temperature to prevent secondary emission and to aid in the rigid support of the control electrode to maintain accurate space relation with other cooperating electrodes.

Another feature is concerned with the specific assembly of the grid or control electrode in which a fine wire helix is wound on a two-section mandrel and welded to one of the sections while the other section is removed, the formed grid being held between lateral wings of a hollow radiator member.

These and other features of the invention will be more clearly understood from the following detailed description taken in connection with the accompanying drawings.

Fig. 1 is a perspective view of one embodiment of this invention with a portion of the enclosing vessel broken away to clearly show the internal elements of the device;

Figs. 2, 2A and 2B are different enlarged views of the anode assembly shown in the device of Fig. 1.

Figs. 3 and 3A are side and end views, respectively, of the grid or control electrode assembly on an enlarged scale;

Fig. 4 is a view in elevation of the elemental parts of the device with the vessel sections shown in cross section and the position of the respective parts shown prior to the sealing of the vessel;

Fig. 5 shows the position of the elemental parts of Fig. 4 after the sealing of the vessel and the connection of the upper conductors to the respective electrodes in which the welding equipment is shown schematically;

Fig. 6 is an enlarged fragmentary view of the anode and coupling means connected to its respective conductor;

Figs. 7 and 7A are enlarged views of modifications of the anode and control electrodes, respectively, showing a different form of the yieldable link or coupling between the electrodes and the conductors extending through the top of the vessel; and

Fig. 8 shows a modification of the invention in cross section illustrating an embodiment in which the electrodes are supported by conductors in one section of the enclosing vessel.

Referring to the drawings and particularly to Figs. 1 to 4, inclusive, the discharge devices of this invention embody an enclosing vessel formed of two similar dished sections 10 and 11, of clam-shell form, each section being of pre-cast vitreous material, such as low expansion glass, and each section being provided with a ring lip portion 12 which forms an accurate indexing surface for sealing the conductors in the sections prior to the assembly of the electrodes. The lip portions 12 also insure positive compression of the upper conductors against the electrodes during the sealing of the vessel to decrease the internal resistance during the welding of the conductors to the yieldable links of the electrodes. The ring lips 12 form a circular band 13 intermediate the two sections of the vessel after the sealing operation is completed and materially improves the form of the seal and the appearance of the device.

The assembly of the device is initiated by preparing the two sections of the vessel in which conductors 14 and 15 are sealed in a depressed cup portion 16 offset from the vertical axis of the section 10, the conductors being positioned in accurate relation by a suitable jig fitted into the cavity of the section, the jig being registered with the indexing surface of the lip 12. Two pairs of conductors 17, 18 and 19, 20 are similarly sealed in the section 11, the conductors 17 and 18 being positioned in a depressed cup portion 21 in alignment with the cup portion 16 in the upper dished section 10 and the conductors 19 and 20 being sealed in a depressed cup portion 22 arranged at right angles to the cup portion 21 and offset on the opposite side of the axis of the section with respect to the cup portion 21.

The necessity for sealing the conductors in the glass sections 10 and 11 prior to mounting the

electrodes in the vessel is the consequent oxidation of the conductors by the intense heating of the glass to form the seals. This oxidation must be removed by cleaning the conductors with a strong alkaline solution in order to facilitate the subsequent removal of gases during the heat treatment of the electrodes and the evacuation of the vessel. Otherwise, it would be difficult to free the conductors of occluded gases if the electrodes and the conductors were sealed directly into the enclosing vessel. The conductors or terminals exterior to the dished sections are silver plated after cleaning to overcome oxidation, thereby insuring positive contact of the terminals with associated apparatus.

After the dished sections are completed, the control or grid electrode is mounted on rigid conductor 17 within the dished section 11. This electrode is shown in Figs. 3 and 3A and comprises a flattened cylindrical helix 23 which is wound on a two-pieced mandrel formed of a nickel piece or support 24 and an aluminum piece (not shown), the helix being secured to the nickel piece by welding or swedging the wire on the curved surface thereof and the aluminum piece is removed, preferably by dipping in a sodium hydroxide bath, to etch out the aluminum metal without attacking the helix 23 or the support 24. The formed helix is mounted between parallel longitudinal arms of a heat radiator 25, preferably of carbonized nickel, which forms a closed loop with the grid support 24, the arm being welded over the lateral wires of the grid and being secured to the support 24. The arms may extend slightly beyond the flat face of the support 24 or be flush with the face to strengthen the grid helix while the closed loop of the radiator 25 is dimensioned to receive conductor 17 in the curved portion thereof so that it forms a socket for rigidly supporting the grid. The small effective dimensions of the hollow grid which are approximately .020 inch width and .030 inch at right angles to the width, necessitate a large radiating surface to offset secondary emission effect and the cooling fin construction as above described efficiently dissipates the heat acquired by the grid. Furthermore, the closed construction of the radiator facilitates the direct coupling of the grid assembly to the conductor sealed in the dished section, thereby decreasing the internal resistance and inductance of the electrode and reducing the length of the lead-in conductor which is particularly desirable for high frequency operation. Prior to mounting the grid on conductor 17, an inverted U-shaped link or yoke member 26, of resilient or yieldable metal, such as molybdenum or spring steel, is welded to the sides of the radiator 25 and extends across the top of the radiator, the flat surface of the yoke member being faced with a nickel tab 27 to facilitate welding of a conductor to the link.

A tungsten filament 28, of the thoriated type, is mounted in the axis of the curvature of the open grid helix 23 and is secured at the top by a long crook spring tension member 29 which is attached to a metallic clip 30 embracing conductor 19. The lower end of the filament is secured to an arm 31 connected to a clip 32 surrounding conductor 20, the arm being in alignment with the spring member 29 to insure uniform spacial relation of the filament with the grid.

An anode or output electrode 33 is provided to cooperate with the filament and grid and comprises a carbon or graphite block of triangular shape in cross section having its apex attenuated by a deep recess or groove 34 to substan-

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tially surround the open helix 23 of the grid, the curve of the recess being equidistant from the grid helix throughout the length thereof. The anode 33 is mounted in spacial relation to the grid by conductor 18 which is seated in the central curved portion 35 of two opposed metallic straps 36 and 37, which form a socket member abutting against the lower surface of the anode. These straps embrace a pair of hairpin connectors or support wires 38 and 39 extending through pairs of drilled holes in the block anode, the wires being positioned on opposite sides of the recess 34 and toward the rear or base of the anode. The hairpin wires also are employed to attach a resilient or yieldable yoke or link member 40 to the upper surface of the anode, the member having a substantially U-shaped central portion and a pair of outwardly extending ear portions, the closed end of the hairpin wires 38 and 39 passing through the ear portions to fasten them to the top of the anode.

The resilient link members on the top of the anode and the grid may be modified as shown in Figs. 7 and 7A in which single leg members or flexible links such as 41 and 42 are attached to one side of the anode and grid respectively, the other end of the members being bent parallel to the top surface of the electrode. The resilient link for the anode may be provided with a nickel tab 43, similar to the grid, which is welded to the top of the central U-shaped portion of the resilient member.

The principal objects of this invention are to decrease the internal resistance of the input and output electrodes and to facilitate the coupling of the electrodes to their respective conductors to efficiently transmit ultra-high frequencies, particularly for coaxial line operation, where the external connections to the electrodes must be as short as possible in order to operate within a definite low wave-length range. Furthermore, it is essential to produce devices which can be fabricated under mass production methods yet capable of meeting exacting requirements as to reproducibility, efficiency and stability. This is accomplished by the construction of the electrode assembly and the fabrication of the device in enclosing the electrodes in the vessel according to the following method.

As shown in Fig. 4, the lower dished section 11 of the vessel has the electrodes mounted therein while the upper dished section 10 has the conductors 14 and 15 aligned with the conductors 17 and 18, so that they are accurately positioned to engage the resilient yoke members 26 and 40 on the grid and anode respectively. The two sections of the vessel are then sealed together as shown in Fig. 5 so that the ring lip portions 12 are fused together to form the circular band 13 between the outer ridges in the dished sections. The fusion of the lip portions causes a slight compression of the members 26 and 40 by the conductors 14 and 15 to insure a positive contact of the conductors therewith. After the vessel is completely sealed, the conductors 14 and 15 are rigidly secured to the yoke members by welding to achieve a low resistance engagement between the conductors and the respective electrodes. The conductors may also be connected to the yoke members prior to sealing the vessel. This is accomplished by producing a condenser discharge at the contact point of the conductor and yoke member to rigidly weld these elements together.

A direct current source 44 of 250 volts having

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a grounded connection is coupled to a closed contact 45 of a switch 46 which is connected to a multiple bank of electrolytic condensers 47, which is grounded. The bank of condensers is provided with a connection 48 which is attached to a conductor of the anode, for instance conductor 15, while the conductor 18 of the anode is attached to the connection 49 leading to an open contact 50 of the switch. When the switch is operated, to engage the contact 50, the bank of condensers, previously charged through the source 44, immediately discharges at the point of high resistance, namely, the junction of the conductor 15 and the yoke member 40. This discharge produces a momentarily intense spark to weld the conductor to the yoke member, which results in an efficient low resistance coupling of the anode to the conductor 15. A similar procedure is performed in welding the conductor 14 to the yoke member 26 of the grid. This method of fabrication increases the efficiency of the electrode assembly and facilitates the coupling of the grid and anode to direct short conductors in linear alignment therewith at opposite ends of the electrodes, the coupling being achieved after the device is sealed and the welding being performed at a point difficult to reach by ordinary welding technique.

An advantage of the construction in addition to those heretofore described, is the compensating effect of the yieldable couplings of the grid and anode during operation whereby expansion and contraction of the electrodes are prevented from changing the electrode spacing and strains on the seals of the rigid conductors attached to the electrodes are relieved. The resilient yoke members 26 and 40 dissipate the forces acting on the conductors and the electrodes during expansion and contraction to protect the accurate spacial relation of the electrodes and the sealed joints of the conductors.

When the fabrication of the electrode assembly is completed, the device may be connected to an exhaust station by the tubulation 51 to remove the gases in the device and the electrodes may be heated to a high temperature to remove occluded gases, either by bombardment or high frequency heating, during the pumping period, this operation being materially reduced in time by the preliminary cleaning treatment of the dish sections of the vessel after the conductors are sealed in the sections. The tubulation may be sealed off as shown in Fig. 1 after the proper degree of evacuation is achieved. The residual gases still remaining in the device may be absorbed in the usual manner by flashing a getter secured to a ring support 52.

A modification of the invention is shown in Fig. 8 in which the electrodes particularly the grid 23 and the anode 33 are supported from one dished section of the vessel by the rigid conductors 17 and 18, respectively, extending through the hollow radiator 25 and the socket member formed by the straps 36 and 37, as previously described.

While the invention has been described with respect to particular embodiments of the structural assembly of the electrodes and the cooperating conductors therefore, it is, of course, understood that various modifications may be made in the detail structures thereof without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising a

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container enclosing a plurality of electrodes including a cathode, a grid and an anode, conductors sealed in one end of said container and supporting said electrodes, a pair of conductors sealed in the opposite end of said container, and yieldable members attached to said grid and anode respectively and rigidly affixed to said pair of conductors.

2. An electron discharge device comprising a container enclosing a plurality of electrodes including an anode, conductors sealed in said vessel and connected to said electrodes, a flexible metallic yoke projecting from one end of said anode, and a separate conductor sealed in said vessel and rigidly secured to said yoke.

3. An electron discharge device comprising a container enclosing a plurality of electrodes including a grid and an anode, conductors sealed in said vessel and connected to said electrodes, other conductors sealed in said vessel in linear alignment with certain of said first conductors, and flexible means rigidly secured to said control electrode and said anode and said other conductors for relieving strains on the seals of said conductors and compensating for difference of expansion and contraction to prevent changes in the space relation of said electrodes.

4. In an electron discharge device containing electrodes and comprising an enclosing vessel of two hollow sections with conductors sealed in each section, the method of assembly which includes sealing the conductors in said sections, mounting the electrodes on the conductors in one section, mounting said sections together so that the conductors in the other section are in contact with certain of said electrodes, and fusing said latter conductors at the point of contact with said certain electrodes by passing a discharge current through said conductors and said electrodes.

5. In an electron discharge device containing electrodes and comprising an enclosing vessel of two hollow dished sections with conductors sealed in each section parallel to the axis thereof, the method of assembly which includes sealing the conductors in said sections, mounting the electrodes on the conductors in one section, securing said sections together by sealing their peripheral surfaces, the conductors in the other section being in contact with certain of said electrodes, and fusing said latter conductors at the point of contact with certain of said electrodes by a condenser discharge through said conductors and said electrodes after the vessel is sealed.

6. In an electron discharge device containing electrodes comprising an enclosing vessel of two similar dished sections with conductors sealed in each section, the method of assembly which includes sealing the conductors in said sections, mounting the electrodes on the conductors in one section, securing said sections together by sealing their peripheral surfaces, the conductors in the other section being in contact with certain of said electrodes, and welding said latter conductors at the point of contact with certain of said electrodes by the external application of a high current capacitive discharge through certain conductors and said electrodes.

7. In an electron discharge device containing electrodes and comprising an enclosing vessel of two similar dished sections with conductors projecting in each section parallel to the axis thereof, the method of assembly which includes sealing said conductors in said sections, removing surface oxidation from said conductors after

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the sealing operation is completed, mounting the electrodes on conductors in one section, securing said sections together by sealing their peripheral surfaces, the conductors in the other section being in contact with certain of said electrodes, and fusing said latter conductors at the point of contact with certain electrodes by passing a discharge current through said conductors and said electrodes.

8. In an electron discharge device containing electrodes, and comprising an enclosing vessel of two similar dished sections with conductors sealed in each section parallel to the axis thereof, the method of assembly which includes sealing the conductors in said sections, mounting the electrodes on the conductors in one section, affixing flexible yoke members to the opposite end of certain of said electrodes, sealing said sections together to enclose said electrodes and press said conductors in the other section against said yoke members, and fusing the latter conductors at the point of contact with said yoke members.

9. An electron discharge device comprising an enclosing vessel having conductors sealed therein, a linear filament supported by a pair of said conductors, a grid surrounding said filament, a heat radiator of looped cross section attached to said grid, said radiator embracing one of said other conductors, an anode cooperating with said filament and grid, supporting means engaging said anode, and a metallic socket member on one end of said anode securing said means to the remaining conductor.

10. In an electron discharge device, a block anode having pairs of drilled longitudinal holes in opposite portions thereof, a flexible yoke member extending across one end of said anode, a metallic socket member extending across the opposite end thereof, means within said drilled holes securing said yoke and socket members to said anode, and oppositely disposed conductors affixed to said yoke and socket members respectively.

11. A discharge device comprising an enclosing vessel of a pair of dished sections, a plurality of conductors sealed in one section, a linear filament supported between two of said conductors, a grid surrounding said filament and having a longitudinal hollow radiator secured to another of said conductors, an anode having a portion in cooperative relation to said filament and grid, supports extending through said anode, a socket member securing said supports to said anode and engaging the remaining conductor in said section, a pair of conductors in the other section in alignment with said grid and anode, and yieldable yoke members attached to said grid and anode and affixed to said aligned conductors.

12. A discharge device comprising an enclosing vessel of two molded dished sections, a plurality of conductors sealed in one section, a linear filament supported between two of said conductors, a grid surrounding said filament and having a longitudinal hollow radiator secured to another of said conductors, an anode having a portion in cooperative relation to said filament and grid, supports extending through said anode, a socket member securing said supports to said anode and engaging the remaining conductor in said section, a pair of conductors in the other section in alignment with said grid and anode, and substantially U-shaped flexible metallic strap members secured to said grid and anode and rigidly welded to said aligned conductors.

13. A high frequency discharge device com-

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prising an enclosing vessel formed of two similar molded dished sections, pairs of conductors sealed in opposite sections in aligned relation, a helical grid having a longitudinal hollow radiator embracing a conductor sealed in one section, 5 a carbon anode of triangular cross section having a longitudinal recess cooperating with said grid, a socket member secured to said anode and embracing the other conductor in one of said sections, a linear filament extending within said helical grid, a pair of conductors in one of said sections supporting said filament, and flexible 10 metallic yoke members attached to the opposite ends of said grid and anode respectively and rigidly secured to said aligned conductors in the other section. 15

14. A high frequency discharge device comprising an enclosing vessel formed of two similar molded dished sections, pairs of conductors sealed in opposite sections in aligned relation, a helical 20

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grid having a longitudinal hollow radiator embracing a conductor in one section, a flexible yoke member having a flat portion and downwardly extending portions affixed to said grid radiator, a carbon anode of triangular cross section having a longitudinal recess cooperating with said grid, a flexible yoke member having a flat portion and outwardly extending ears positioned on one surface of said anode, a socket member positioned on the opposite surface of said anode, hairpin connectors extending through said anode and securing said ears and said socket member in abutting relation to said anode, a linear filament extending within said grid, and a pair 15 of conductors in one of said sections supporting said filament, said aligned conductors in said other section being rigidly affixed to the flat portions of said yoke members.

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