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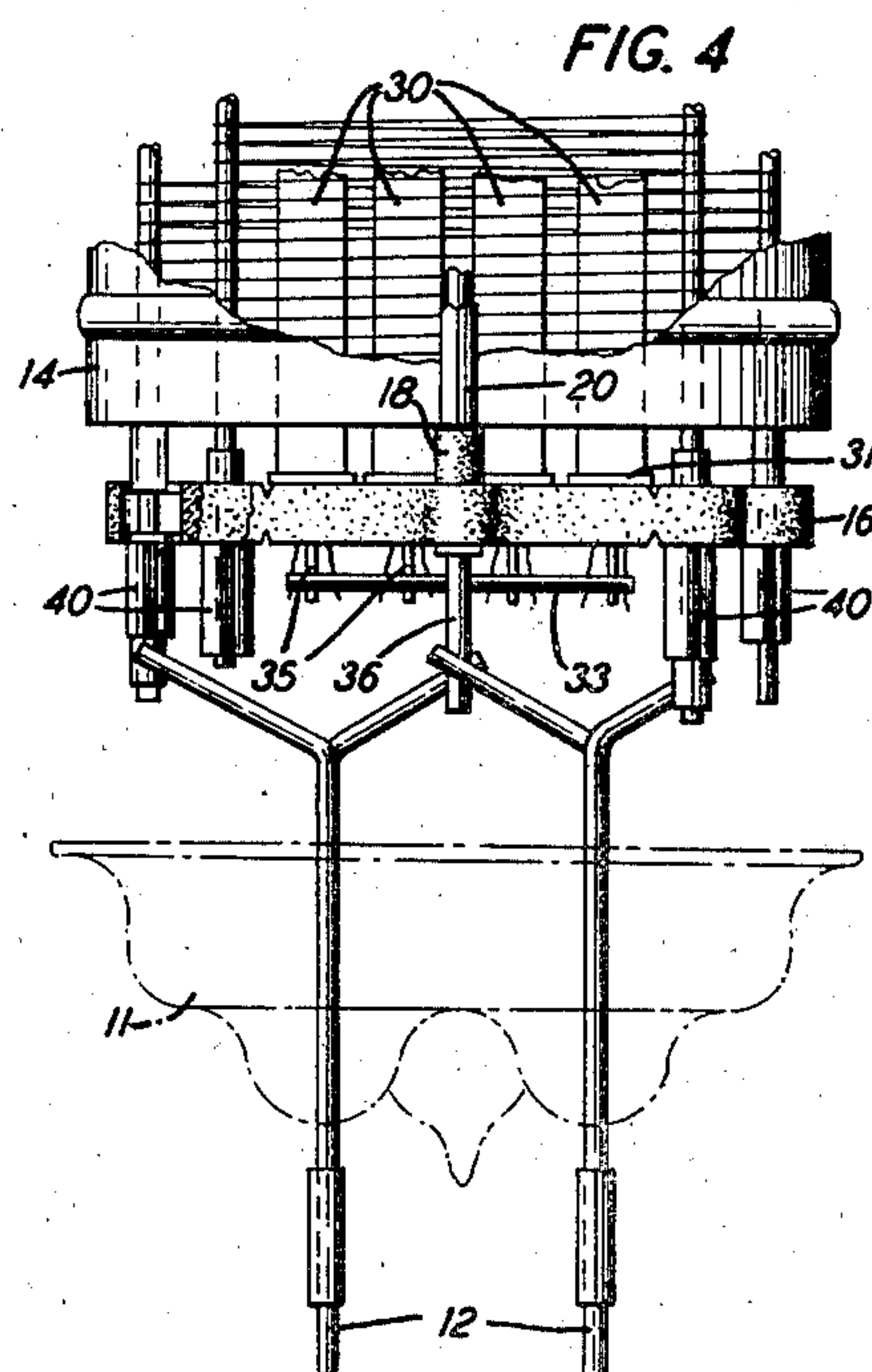
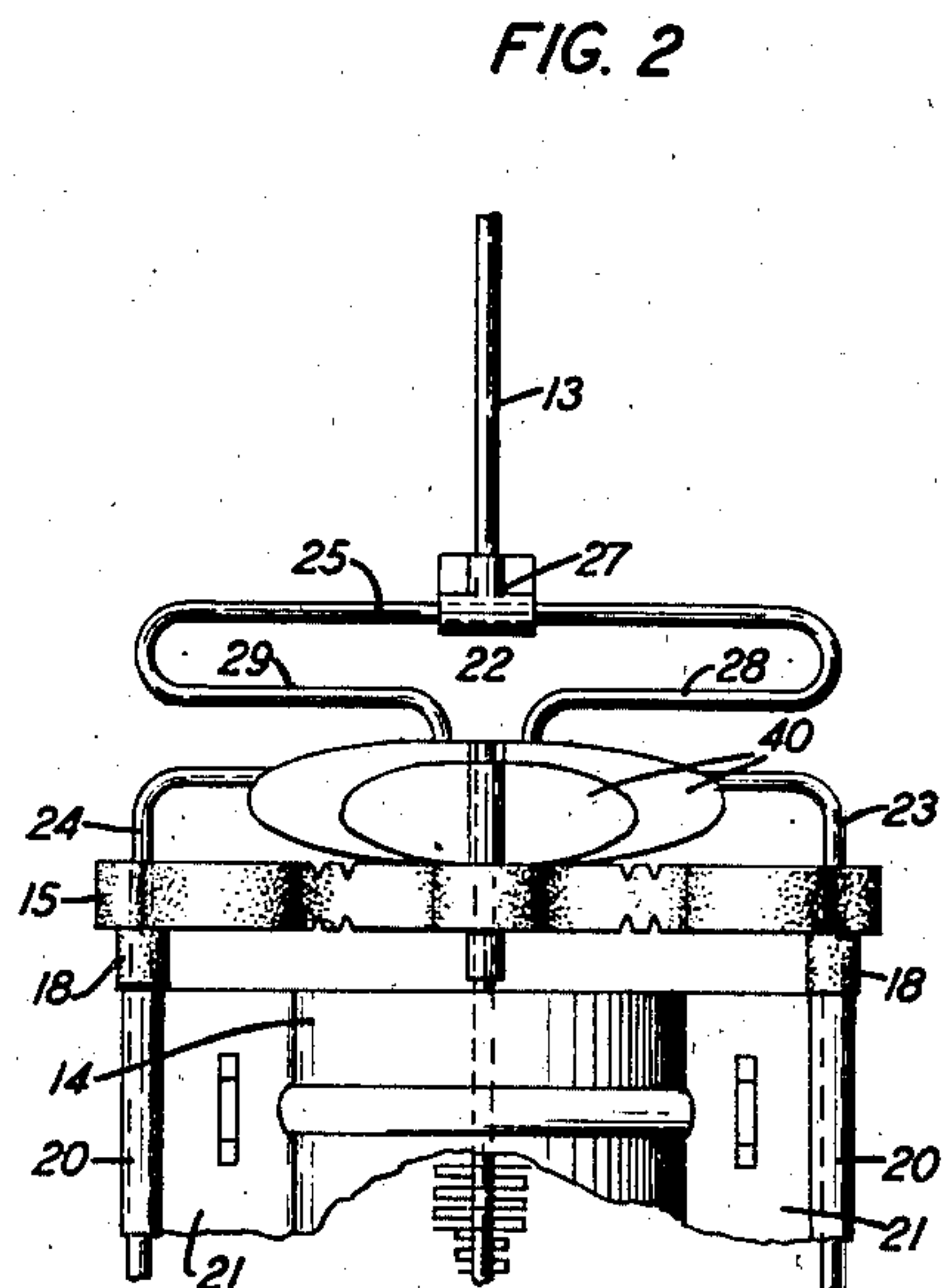
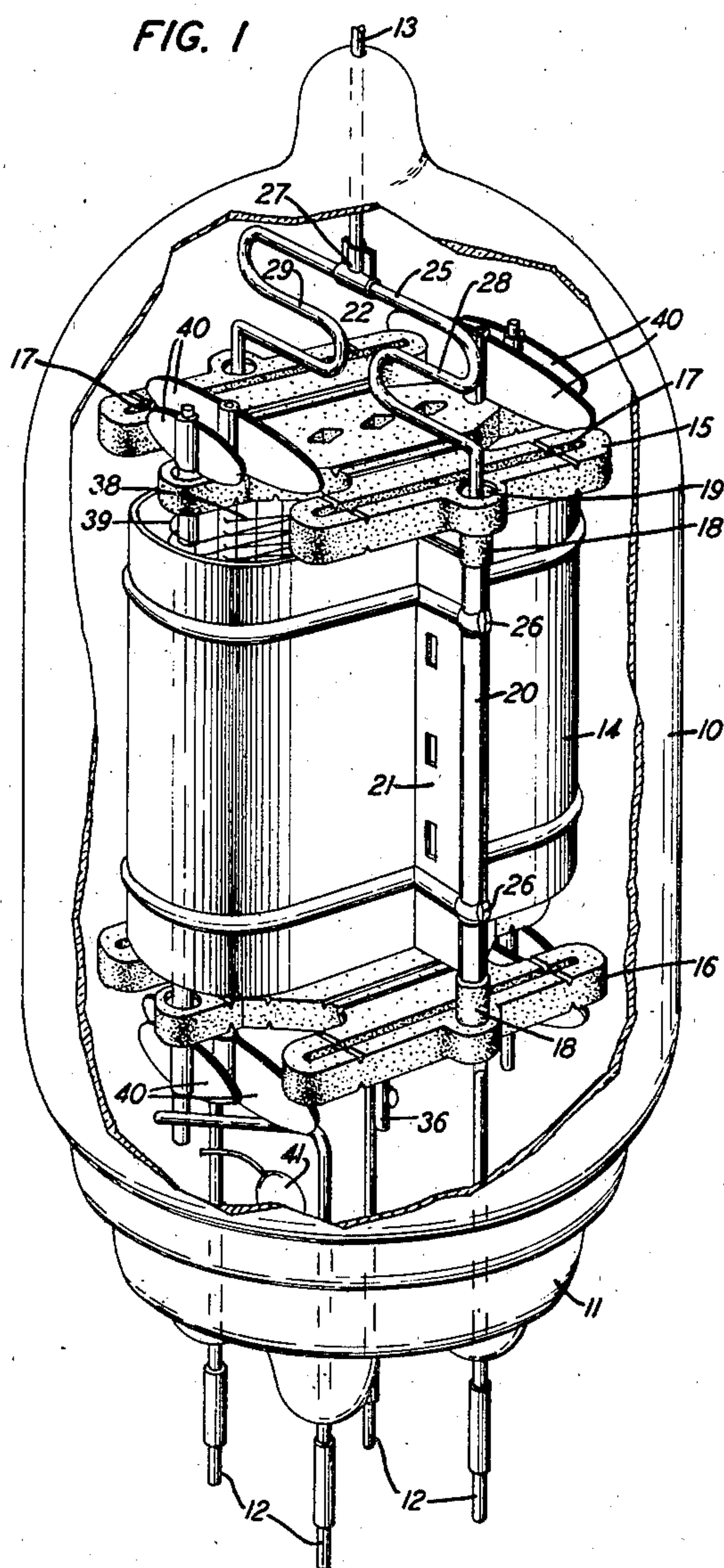
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2,414,500

ELECTRON DISCHARGE DEVICE

Filed March 20, 1943

2 Sheets-Sheet 1



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FIG. 3

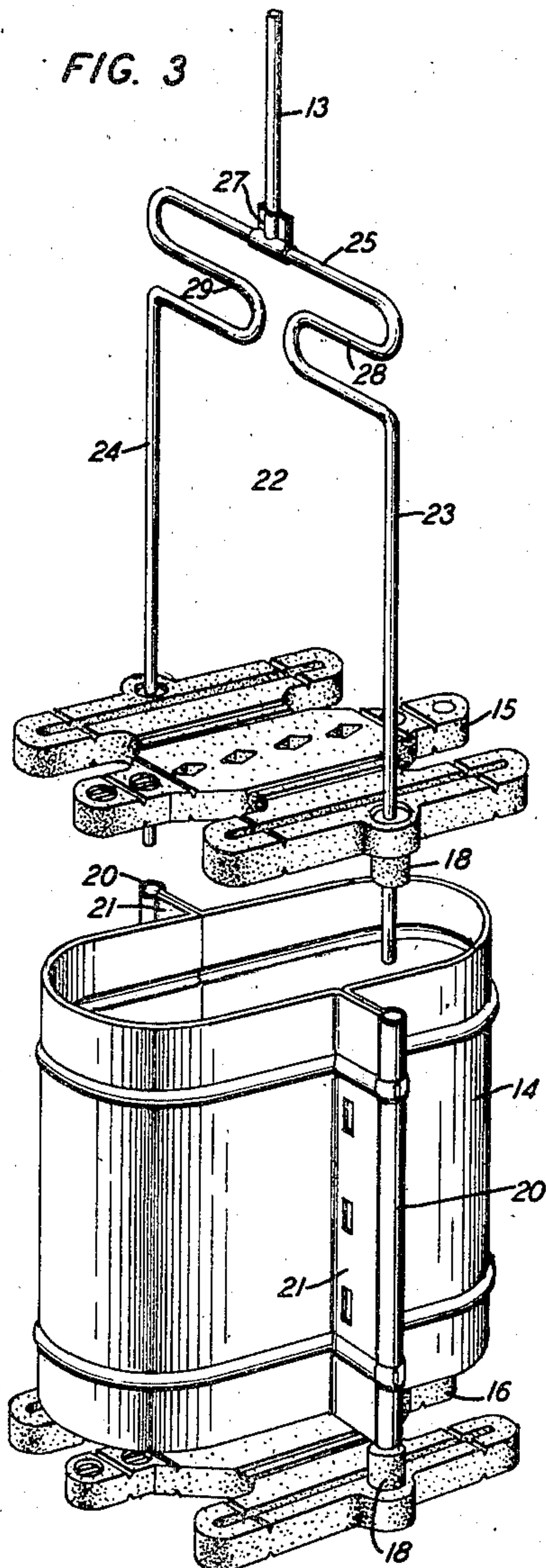


FIG. 5

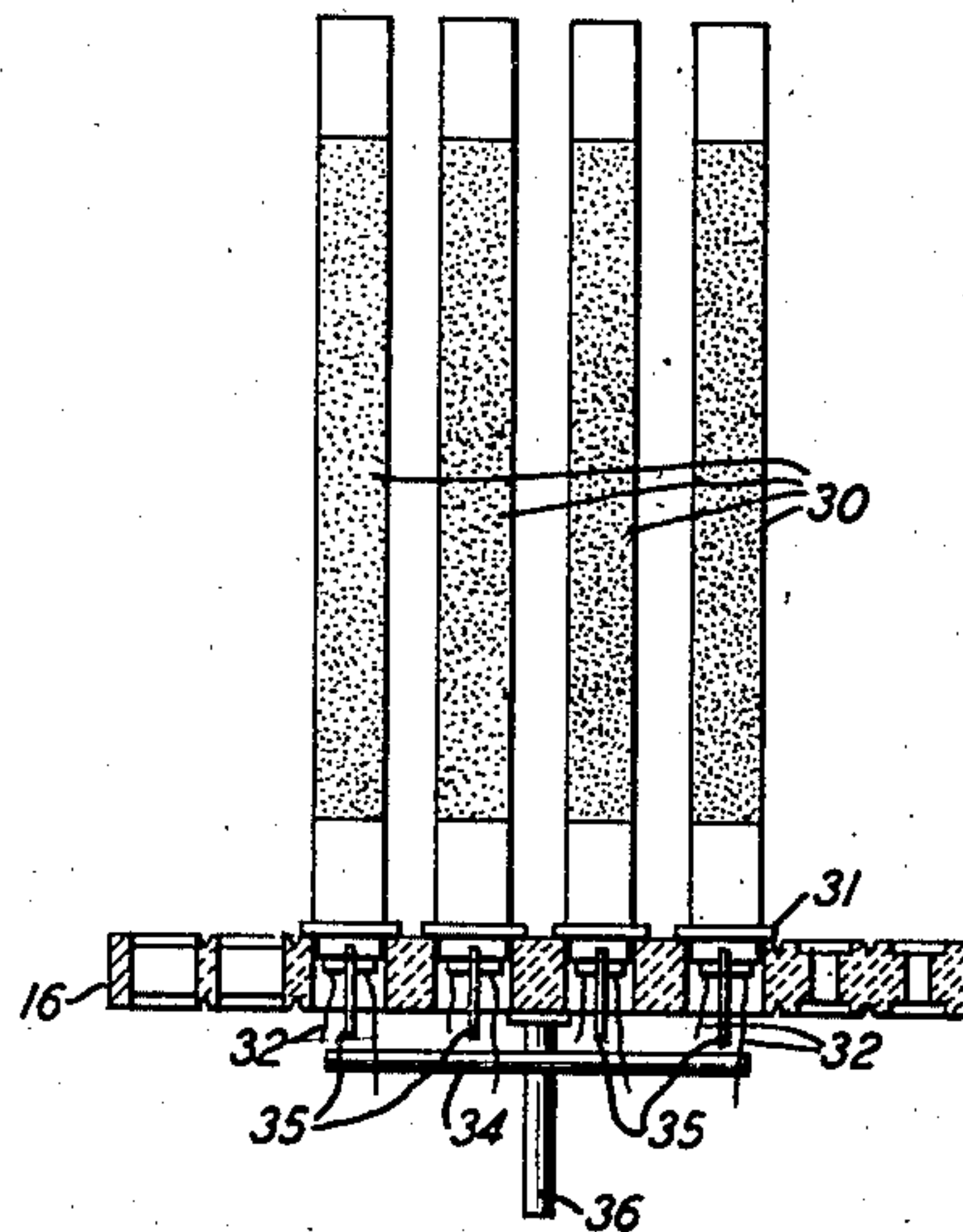
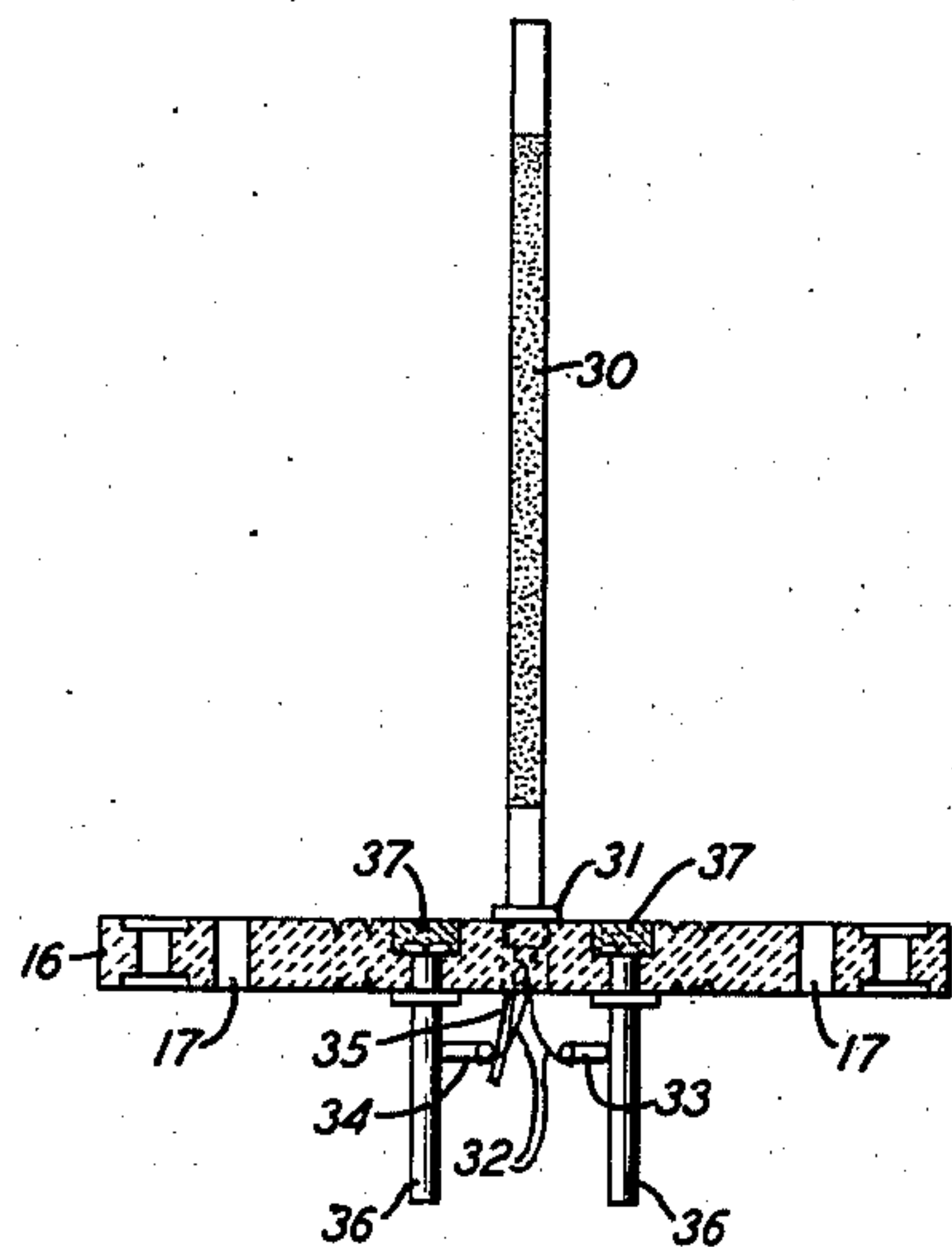


FIG. 6



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ELECTRON DISCHARGE DEVICE

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10 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to such devices capable of supplying a high power output at ultra-high frequencies.

In electronic discharge devices utilized to generate undistorted power in the frequency range of a centimeter or less it is primarily desired to confine the electrodes to a compact assembly in order to limit the transit time of the electron flow between the electrodes. This is usually accomplished by mounting the electrodes in a unitary mount including rigid refractory insulating spacers at opposite ends of the electrodes to insure adequate leakage resistance between the respective electrodes and to maintain the insulation properties of the spacers constant.

Another requirement of such devices is to segregate the high potential anode voltage from the low potential sources for the other electrodes in order to realize high efficiency. This is usually accomplished by providing an anode conductor which extends through the top of the enclosing vessel while the other electrode conductors are mounted in the opposite end of the vessel, the connection of the anode to the conductor being substantially a rigid supporting member.

Another requirement of such devices is the support of the unitary mount in the vessel to efficiently withstand external shocks and vibration which would affect the uniform space relationship between the respective electrodes. However, the rigid coupling between the mount and the conductors imposes a number of disadvantages in the structural assembly of the device, such as cracked or broken insulators, leakage in the glass seal if precautions are not provided to compensate for differences in expansion and contraction of the glass and metallic connections and high resistance contact between the anode and metallic connection coupled to the anode leading-in conductor.

One object of this invention is to overcome the various disadvantages enumerated above and to produce an efficient supporting assembly of the mount in the enclosing vessel.

A further object of the invention is to provide two-dimensional compensation for the coupling between the mount and the enclosing vessel to eliminate fractures and excessive strains in the rigid insulators.

Another object of the invention is to prevent spurious arcing between the electrodes and the supports in a rigid insulator adjacent the low potential terminals of the device.

A further object of the invention is to eliminate

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high resistance contact between the anode and the coupling supporting member thereof while providing sufficient flexibility in the coupling to compensate for longitudinal expansion of the electrode mount.

Another object of the invention is to facilitate the fabrication of the mount with a minimum of shrinkage loss due to broken insulators and to compensate for differences between the tolerance limits of the mount and the coupling member.

The high power electron discharge device of this invention comprises a plurality of parallel electron emitting electrodes or cathodes surrounded by two grid electrodes and an oval anode, all of the electrodes being mounted between a pair of rigid end insulating members for maintaining the electrodes in uniform spaced relation and to combine the assembly into a unitary mount. The cathodes and the grids are attached to a plurality of rigid conductors sealed in a stem of an enclosing vessel to support the mount at one end thereof.

To prevent the mass of the electrode mount being dislocated from the normal position in the vessel, due to shocks or continual vibration, the opposite end of the mount is secured to the vessel by a yoke member which is joined to a conductor extending through the top thereof. This member is formed of highly refractory metal to withstand excessive shock impact which would ordinarily deform a less refractory metal yoke. This property while commendable for its intended purpose deprives the yoke support of the necessary yieldability to compensate for minute differences in tolerance between the legs of the yoke and the distance between the openings in the insulating spacers and the sockets in the anode of the mount.

In accordance with one aspect of this invention the difference in tolerance limits between the yoke member and the insulators is compensated by forming parallel reverse bends or gooseneck portions on the yoke member closely adjacent the cross-bar or link section so that these bends impart limited springiness to the yoke member in transverse directions to compensate for expansion forces in an axial direction and to compensate for dimensional differences between the legs of the yoke and the insulating apertures which receive them.

The stability of the mount assembly in accordance with this invention is not affected by the reverse bent portions, since the mount is capable of withstanding an impact of high concentrated

force without detrimental effect. However, slight dimensional stresses which are centered at the junction of the yoke and insulating spacers are neutralized by the slight yielding property imparted by these bent portions so that fractures and breaks in the insulators are substantially eliminated and the leakage resistance of the insulators preserved.

Another advantage gained by this construction is the positive elimination of loose contact between the legs of the yoke and the anode since these legs are rigidly affixed to the anode thereby preventing the establishment of a high resistance component between the potential supply conductor and the anode.

A further feature relates to the increased production and high efficiency attainable with the improved yoke since slight differences in dimensional distances between the legs and the apertures of the insulator may be disregarded without jeopardizing the friable insulator because of the slight spring imparted to the yoke leg by the reverse bent portions in a direction transverse to the axis.

Another feature of the invention relates to the fabrication of the electrode assembly to form a self-contained mount which may be affixed to the conductors in the vessel without excessive strain being placed on the conductors or the insulating spacer members. In this construction the anode is rigidly affixed to the yoke member and the other associated electrodes are mounted between the insulating spacer members on opposite ends of the anode, the assembly being consolidated into a unitary mount by parallel transverse heat shields secured to the ends of the grid electrodes exterior to opposite ends of the mount. The coupling elements of the unit therefore distribute the stresses uniformly over the whole area of the mount so that expansion forces do not accumulate at the weakest point to cause fracture of the insulators or distortion in the electrodes.

Another feature of the mount assembly relates to the preservation of the insulating properties of the insulators by providing a rough coating of a highly refractory insulating material on the insulators and incorporating a distinctive stable dye therein to insure the attainment of a uniform thin coating on the insulating surface to counteract conductive material inadvertently deposited thereon. This is accomplished by adding a cobalt compound to the insulating substance to impart a distinctive color to the coating which will not be affected by high temperatures encountered in the processing treatment of the device or during operation and which will not introduce deleterious matter to affect the operation of the device.

Another feature of the invention relates to the prevention of arcing between the anode and various supports in the insulator for the low potential electrodes. This arrangement comprises the mounting of studs in the lower insulator for supporting bus bars for the multiple cathodes and heater elements and staking the studs in countersunk apertures which are filled with an insulating composition to mask or shield the studs from exposure to an arcing effect from the high potential anode.

These and other features and advantages of the invention will be revealed in the following detailed description which together with the accompanying drawings represent a complete disclosure of this invention:

Fig. 1 is a perspective view of one embodiment of the invention as applied to a high power discharge device with a portion of the enclosing vessel broken away to illustrate the assembly of the electrode mount supported therein;

Fig. 2 is a fragmentary view in elevation of the upper portion of the electrode mount removed from the vessel to show the improved yoke member in relation to the mount;

Fig. 3 is a perspective view of the principal coupling elements of the mount in exploded fashion to illustrate the cooperation of the elements to facilitate the unification of the electrodes in the mount;

Fig. 4 shows a fragmentary view of the lower portion of the mount of Fig. 1 and the support of the mount in the stem of the vessel which is shown in phantom relation;

Fig. 5 illustrates in elevation the multiple cathodes of the device of Fig. 1 and the coupling of the connections to the supports in the lower insulating spacer which is cross-sectioned; and

Fig. 6 is a side elevation view of the structure shown in Fig. 5 to illustrate the detail mounting of the shielded studs for the cathodes.

Referring to the drawings and particularly to Fig. 1, the electron discharge device of this invention comprises an enclosing vessel 10 having a dish stem 11 having a plurality of conductors 12 sealed therein at the corners of a rectangle and a central conductor 13 sealed in the top of the vessel. The enclosing vessel which is highly evacuated forms a receptacle for an electrode mount or a unitary electrode assembly including a hollow oval-shaped metallic anode 14, preferably of molybdenum, which is coated on the exterior with a heat dissipating layer, such as zirconium. A pair of refractory insulating blocks or spacer members 15 and 16 extend across opposite ends of the anode and are provided with aligned apertures across one diameter to receive a plurality of cooperating electrodes which are uniformly spaced with respect to the anode to constitute the power generating elements of the mount. The insulating spacer members 15 and 16 are formed of highly refractory or friable material, such as "lavite" or "isolantite" and molded into a particular form to achieve the greatest insulation resistance between the various electrodes and to segregate the low potential electrodes from the high potential electrode. This is accomplished by forming the insulator into a molded mass having three parallel sections or arms joined together at the center by spacing sections and the center arm being longer than the end arms. The center arm is also provided with a plurality of diamond-shaped apertures in series relation along the central portion of the arm and circular recessed apertures near the ends of the arm for the various electrodes mounted in the unit. The end arms are provided with recessed apertures at the center which lie in a plane at right angles to the series apertures in the center arm. In addition, the insulating blocks are provided with elongated slots 17 in the end arms which extend along the length of the arms and the connecting sections of the block are provided with wedge-shaped grooves parallel to the slots and similar shaped grooves along the ends of the arms transverse thereto, the grooves being provided on opposite sides of the insulating blocks and together with the slots increasing the over-all area between the various electrodes as a group and between adjacent electrodes in the center arm.

A rough coating of highly refractory material is applied, preferably by spraying, over the entire surface area of the block to increase the leakage path almost 100 per cent due to the hill and dale effect produced by the roughened surface on the block. In order to obtain this effect it is essential to apply the coating as a very thin layer so that the particles individually are separated uniformly over the surface area of the block. A highly refractory insulating material is employed as the coating substance, such as aluminum oxide which is mixed in a binder of sodium silicate or water glass, to form the spraying mixture. Due to the achromatic similitude of the spraying mixture and the background of the insulating block on which it is applied there is considerable eyestrain imposed on the operator in an attempt to secure uniformity in the spraying application to the block. This is overcome by mixing a stable dye with the spraying mixture, such as cobalt aluminate, which imparts a blue tint to the coating mixture so that when the mixture is sprayed on the white background of the insulating block the spraying operation can be easily controlled to secure the uniform thin surface layer without severe eyestrain of the operator. Cobalt aluminate is employed because of its stable characteristics even at relatively high temperatures which are encountered during the heat treatment of the electrodes in the device and the subsequent high temperature conditions within the vessel during the normal operation of the device. The dye is a completely inert compound and does not generate any deleterious substance which would discolor the glass or impair the high vacuum of the enclosing vessel nor poison the active coating on the various electrodes embodied in the unitary mount of the assembly. Furthermore, the identifying tint of the coated insulating block readily distinguishes the coated insulators from uncoated insulators so that blunders are guarded against in the assembly of the insulators in the mount. The insulating blocks 15 and 16 are spaced from opposite ends of the anode 14 by "lavite" bushings 18, similarly coated with the dyed spraying mixture, the bushings being aligned with recessed apertures 19 in the end arms of the insulators and interconnected by a tubular socket 20 projecting from the end of the flanged portions 21 of the anode.

The end insulating blocks 15 and 16 and the respective bushings are held in aligned relation with the anode sockets by a metallic yoke member or support 22 having leg portions 23 and 24 joined together by a link portion 25, the leg portions extending through the apertures 19 of the insulating block, bushing 18 and sockets 20, the legs being welded in the anode sockets at the points marked 26. It will be noted that the insulating blocks and bushings are not rigidly affixed to the legs of the yoke member or connecting support as will be explained hereinafter. The yoke support is formed of highly refractory metal, such as molybdenum rod, to provide sufficient rigidity to the assembly and capable of sustaining severe shocks without being deformed. The link portion 25 of the yoke support is rigidly affixed to the central conductor 13 by a welded strap 27.

Since the insulating block and the yoke support are made by different processes there is considerable difficulty in assembly due to the diversity of dimensional spacing between the legs of the yoke and the apertures in the insulating blocks. It is evident that even a slight differ-

tial between the legs and the apertures will cause considerable strain on the friable material of the block and such strains are considerably increased during expansion and contraction periods of the mount and torsional stresses engendered in the rigid yoke member. Consequently, the stresses imposed on the insulating block, particularly at the juncture of the yoke legs passing through the apertures of the block, create such forces which eventually fracture the friable material of the block or produce chipping or cracking which in turn cause some future failure in the device.

These difficulties, and other attendant difficulties to be hereinafter set forth, are overcome in accordance with this invention, by forming reverse bent portions or goosenecks 28 and 29 intermediate the leg portions and the link portion of the yoke support 22, the reverse bent portions extending within the confines of the yoke member and substantially parallel to the link portion and the upper insulating block 15. The twin bends offer sufficient springiness to the refractory metallic yoke so that inequality of the distance between the yoke leg portions and the apertures in the block is compensated by the yielding effect of the bent portions, thereby neutralizing the stresses on the insulating block. Furthermore, the losses due to rejects of insulating blocks which do not meet tolerance limits in the space relation of the apertures and also similar losses with respect to the yoke member are substantially eliminated and selective assembly which entails the absolute matching of the yoke legs with the distance between the apertures of the insulating block is avoided thereby materially increasing mass production in the assembly of the device. The twin bent portions of the yoke member further impart sufficient flexibility to the yoke during expansion of the mount by relieving the stresses at the juncture points of the insulating block, the expansion forces against the blocks being parallel to the axis of the device while the yielding effect of the yoke support is perpendicular to the axis so that strains are relieved at the point of the block adjacent the apertures and consequent fracture is avoided. However, the reverse bent portions do not detract from the rigidity of the yoke support in a vertical plane of the bends nor in a plane perpendicular thereto so that the upper end of the mount is sufficiently protected against transverse shock and the mount can withstand concentrated shock of high gravity force.

A plurality of oval-shaped cathode sleeves 30, as shown more clearly in Fig. 5, are mounted in the aligned rows of diamond-shaped apertures in the insulating blocks 15 and 16 along the center portion of the middle arms of the insulating blocks, the sleeves being supported in the lower insulating apertures by a seating ridge 31 formed thereon, to limit downward movement of the sleeves in the mount while the upper ends of the sleeves are slidably in contact with the diamond-shaped apertures, to permit expansion and contraction of the cathodes. Each cathode is provided with an internal heater element 32 embedded in an insulating sleeve extending within the cathode sleeve, the terminations of the multiple heater elements projecting through the apertures of the lower insulating block 16. The outer surfaces of the cathode sleeve are provided with a coating of electron emissive material, such as barium and strontium oxides, and due to the large area thereof presented to the anode surface

a copious emission of electrons is produced to effect a high power output to be utilized in the anode circuit of the device.

The quadruple cathodes and the associated heater elements are connected in multiple to a pair of parallel bus wires 33 and 34, as shown in Fig. 6, one end of each heater element being connected to wire 33 while the other end of each element is connected to wire 34 and all of the cathodes 30 are connected to the wire 34 by individual straps 35. These bus wires are supported on studs or rods 36 which are staked in recessed apertures in the lower insulator 16 in offset relation with respect to the row of cathodes to thereby rigidly anchor the terminations of the cathodes and heater elements in fixed relation to the electrode mount. While this arrangement forms an efficient connecting support in convenient relation to the cathodes and heater elements considerable difficulty was experienced with the formation of an arc between the high potential anode and the heads of the staked studs in the lower insulator. This is overcome by shielding or screening the staked studs where exposed to the anode high potential by sealing or filling the recessed apertures with an insulating compound or cement, such as aluminum oxide mixed with sodium silicate or other suitable binder, to form a pasty mass or cement mixture which will harden after removal of the binder. The shielding of the studs completely eliminated the effect of arcing and thereby materially increased the efficiency and stability of the device.

A pair of cooperating electrodes, in the form of wire wound grids 38 and 39, shown more clearly in Fig. 4, are interposed between the multiple cathodes and the anode, the grids being formed of molybdenum wire helically wound on copper upright supports to maintain the grids relatively cool and the upright supports being gold-plated to offset secondary emission. The upright supports of the grids extend beyond the ends of the insulating blocks 15 and 16 and the blocks are affixed to the grids and also to the anode by large area heat-radiating fins 40 which lie in parallel planes across the ends of the central arm of the insulator blocks, the fins conveying heat energy from the upright rods of the grids and dissipate the heat therefrom into the space in the vessel. The heat-radiating fins of the grids also distribute the strains on the insulators uniformly over the whole surface thereof and maintain the insulating blocks in relation to the anode so that the tension forces on the blocks are not concentrated at the weakest points of the blocks. Accordingly, expansion stresses incident to the heating of the high potential anode and the intense radiation of the cathodes will not adversely affect the insulating blocks since the strains incident thereto will be equalized or neutralized by the distribution of the compact assembly of the mount in the device. Furthermore, distortion of the fragile grid electrodes is prevented since they can expand longitudinally with the insulating blocks and also laterally due to the elongated slots in one side of the arms of the insulating blocks, as shown in Fig. 4. The assembly of the mount is completed by connecting two of the conductors 12 to individual upright rods of grids 38 and 39 while the remaining two conductors are connected to the studs 36 to supply energizing current to the heater elements and cathodes. A getter mounting 41 is attached to one of the lead-in conductors 12 within the vessel and may be flashed after the final evacu-

ation of the envelope to fix residual gases in the device.

While the invention has been disclosed in a particular embodiment, it is, of course, understood that various modifications may be made therein and one or more of the features may be adopted in a specific assembly without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising an evacuated envelope, a unitary mount within said envelope including an anode, a cooperating electrode and insulating spacer members at opposite ends of said anode for supporting said electrode in uniform space relation with respect to said anode, conductors for said electrodes projecting from one end of said envelope and supporting said mount therein, and supporting means engaging said anode and insulating spacer members, said means having yielding portions for two-dimensional compensation to neutralize longitudinal stresses due to expansion of said mount and diametrical stresses at the junction of said means and said insulating spacer members.

2. An electron discharge device comprising an enclosing vessel containing a unitary electrode mount having a hollow anode surrounding a cooperating element and insulating spacer members at opposite ends of said anode to support said cooperating element in uniform relation thereto, and a supporting yoke member connected to said vessel and extending into contact with said anode and spacer members, said yoke having twin reverse bent portions spaced from said mount to compensate for dimensional differences and temperature expansion of said mount.

3. An electron discharge device comprising an enclosing vessel containing a unitary electrode mount having a hollow anode surrounding a cooperating element and insulating spacer members at opposite ends of said anode to support said cooperating element in uniform relation thereto, and a yoke member of refractory metal rigidly secured to said anode and extending through said insulating members and having loop portions enabling said member to yield slightly under stresses in two dimensions and relieve excessive strain on said mount.

4. An electron discharge device comprising an enclosing vessel containing a unitary electrode mount having a hollow anode surrounding a cooperating element, and insulating spacer members at opposite ends of said anode to support said cooperating element in uniform relation thereto, and a yoke member of refractory metal secured to said mount and having twin reverse bent portions parallel to the plane of said insulating spacer members to compensate for dimensional differences between said yoke and said insulating members and temperature differences longitudinal to said dimensional compensation.

5. An electron discharge device comprising an evacuated envelope, a unitary mount within said envelope including an anode, a cooperating electrode, and insulating spacer members at opposite ends of said anode for supporting said electrode in uniform spaced relation with respect to said anode, conductors for said electrode projecting from one end of said envelope and supporting said mount therein, and a supporting yoke member projecting from the opposite end of said envelope and engaging said anode and said spacer members, said yoke having lateral bent portions parallel to another portion of said yoke forming

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springy sections to offset strain localized at the juncture points of said yoke and said insulating spacer members and to compensate for longitudinal expansion forces of said mount.

6. An electron discharge device comprising an evacuated envelope, a unitary mount within said envelope including an anode, a cooperating electrode, and insulating spacer members at opposite ends of said anode for supporting said electrode in uniform spaced relation with respect to said anode, conductors for said electrode projecting from one end of said envelope and supporting said mount therein, and a supporting yoke member projecting from the opposite end of said envelope and engaging said anode and said spacer members, said yoke member having double bend portions extending within the confines thereof to equalize torsional stresses in said insulating spacer member adjacent thereto.

7. An electron discharge device comprising an evacuated envelope, a unitary mount within said envelope including an insulator spacer block, a plurality of electrodes mounted thereon including an anode and a sleeve cathode, a heater element enclosed therein, said spacer block having recessed apertures adjacent said cathode, support rods staked in said apertures and connected to said cathode and said heater element, and an insulating material embedding the staked ends of said rods in said recessed apertures to shield said ends from said anode to prevent arcing.

8. An electron discharge device comprising an evacuated envelope, a unitary mount within said envelope including an insulating spacer member, a plurality of cathodes mounted therein in parallel relation, heater elements within said cathodes, said spacer member having recessed apertures in offset relation to said cathodes, support rods staked in said apertures, bus wires carried by said rods and connected to said cathodes and the terminations of said heater elements, and a filling of insulating material covering said staked rods in said recessed apertures.

9. An electron discharge device comprising a

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vessel having a dish stem with rigid conductors sealed therein, a central conductor sealed in the top of said vessel, an electrode mount positioned between said conductors, said mount including rigid insulating blocks, a hollow anode supported between and maintaining said blocks in spaced relation, a plurality of electrodes having their opposite ends extending through said blocks, a yoke member connected to said central conductor and having portions extending through said blocks and said anode, said portions being secured to said anode, the conductors in said stem being connected to said plurality of electrodes, and metallic heat shields engaging projecting ends of certain of said electrodes and abutting against the surfaces of said blocks on the opposite sides from said electrodes to rigidly hold said blocks in relation to said anode and said electrodes in relation to said blocks.

10. An electron discharge device comprising a vessel having a dish stem, rigid conductors sealed therein, a central conductor sealed in the top of said vessel, a cylindrical anode within said vessel, insulating spacer blocks extending across opposite ends of said anode, a plurality of tubular cathodes mounted in said spacer blocks along one diameter within said anode, individual heater elements within said cathodes, a pair of concentric grid electrodes interposed between said cathodes and anode having upright portions extending through and beyond said spacer blocks at opposite ends thereof, a metallic yoke member affixed to said central conductor having downwardly extending portions projecting through said blocks and said anode and reverse bent portions intermediate said anode and said central conductor, and parallel heat radiating fins attached to the ends of said upright portions and abutting against the outer surfaces of said blocks to complete the assembly of electrodes and blocks into a unitary mount, said grids, cathodes and heater elements being connected to the conductors in said stem to support said mount.

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