Dec. 25, 1962 R. L. JEPSEN 3,070,719

CATHODES FOR MAGNETICALLY-CONFINED GLOW DISCHARGE APPARATUS

Filed Oct. 11, 1960 2 Sheets-Sheet 1

FIG. 1

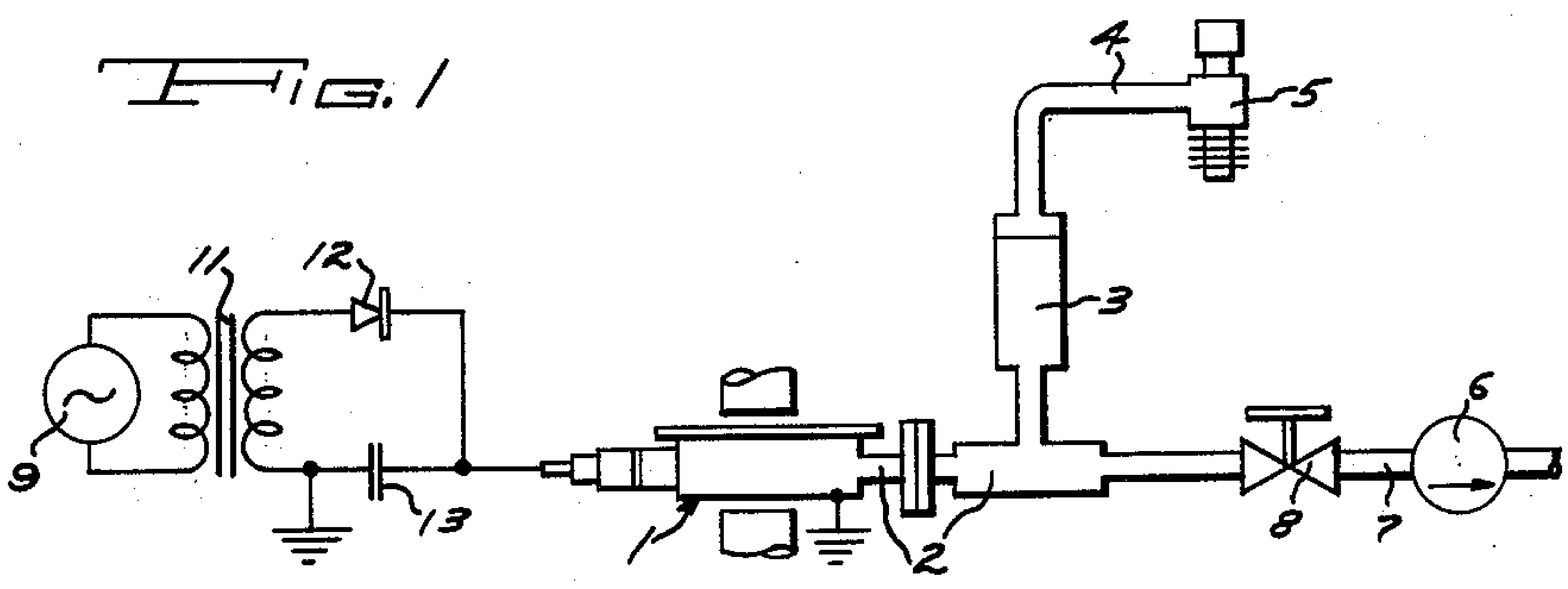


FIG. 2

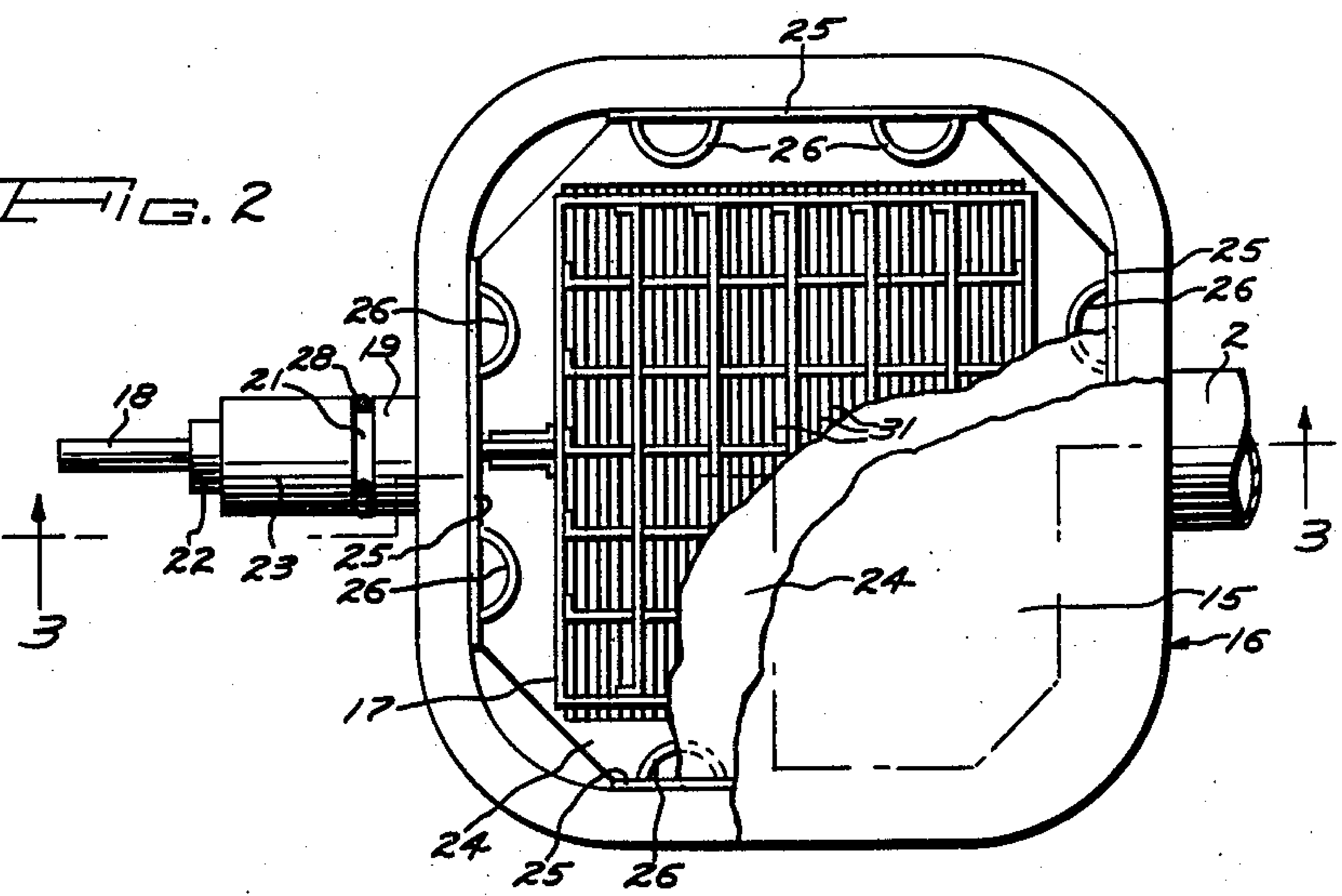
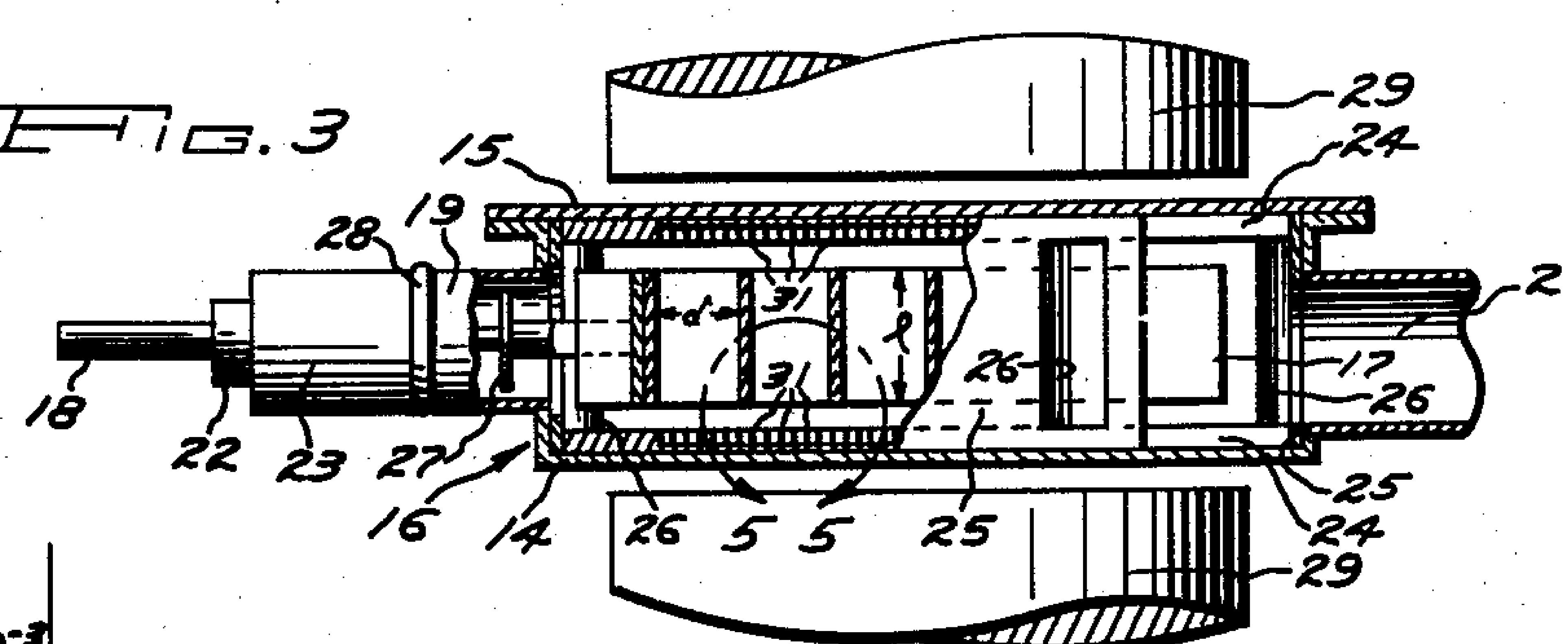


FIG. 3



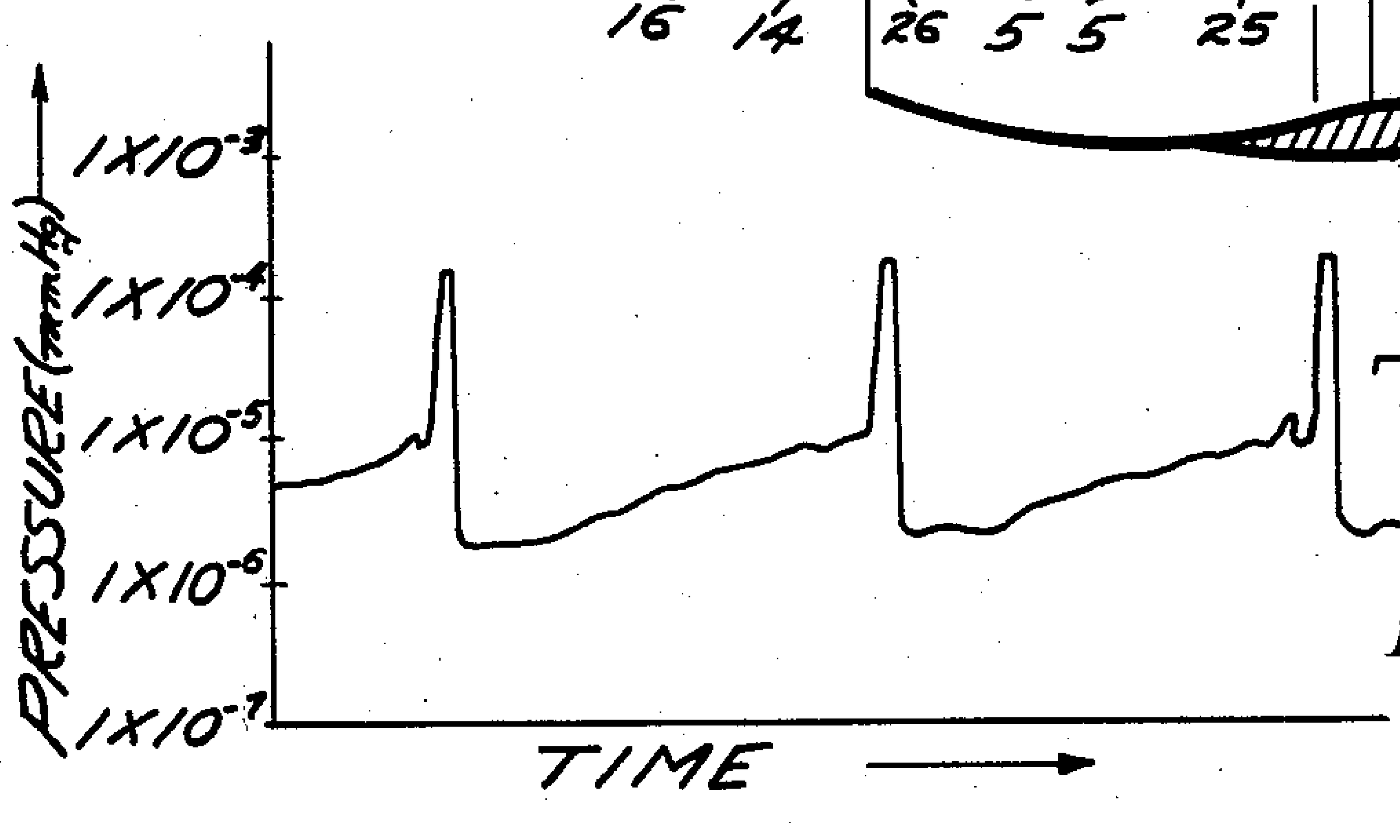


FIG. 4

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CATHODES FOR MAGNETICALLY-CONFINED GLOW DISCHARGE APPARATUS

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FIG. 5

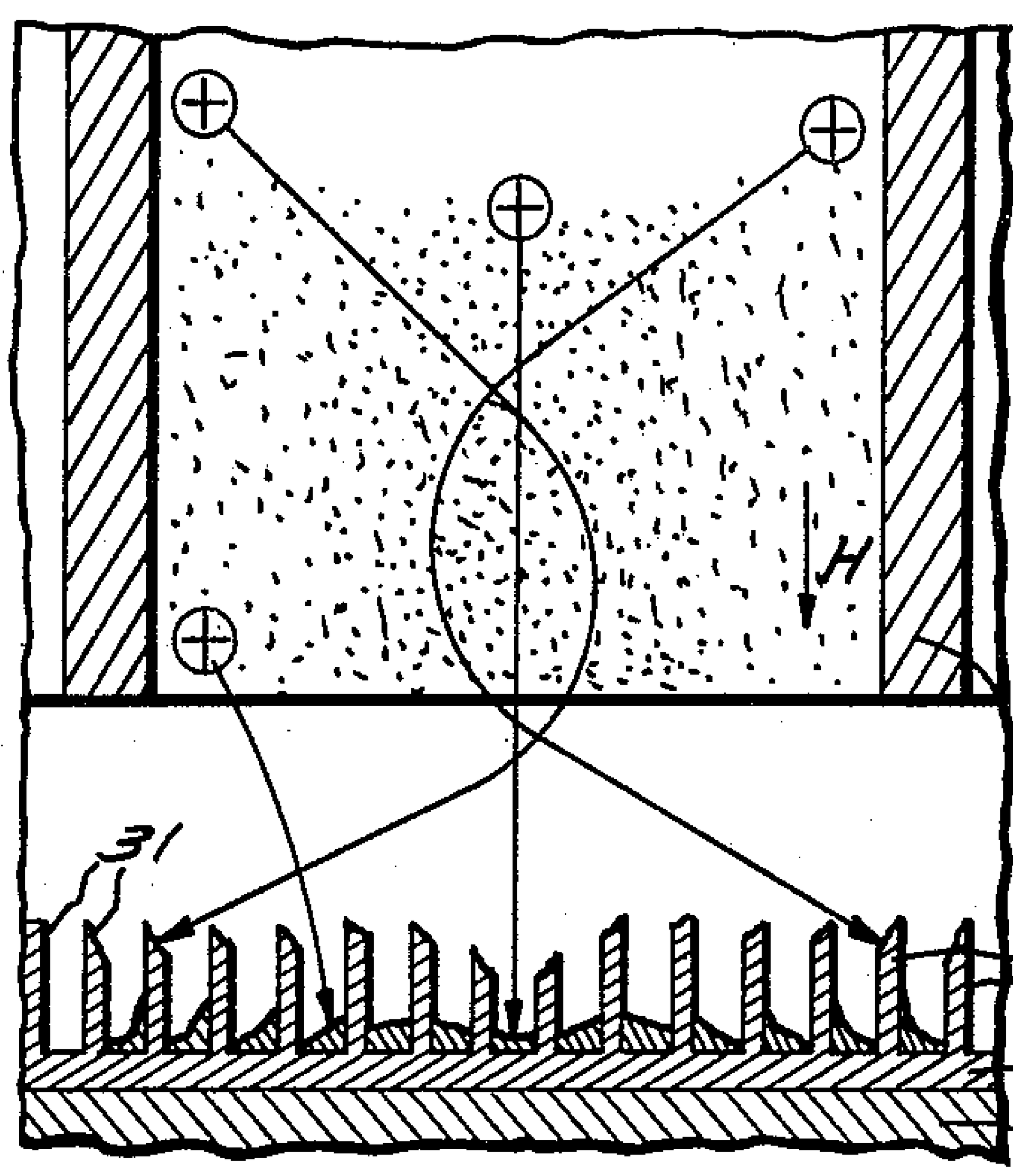


FIG. 6

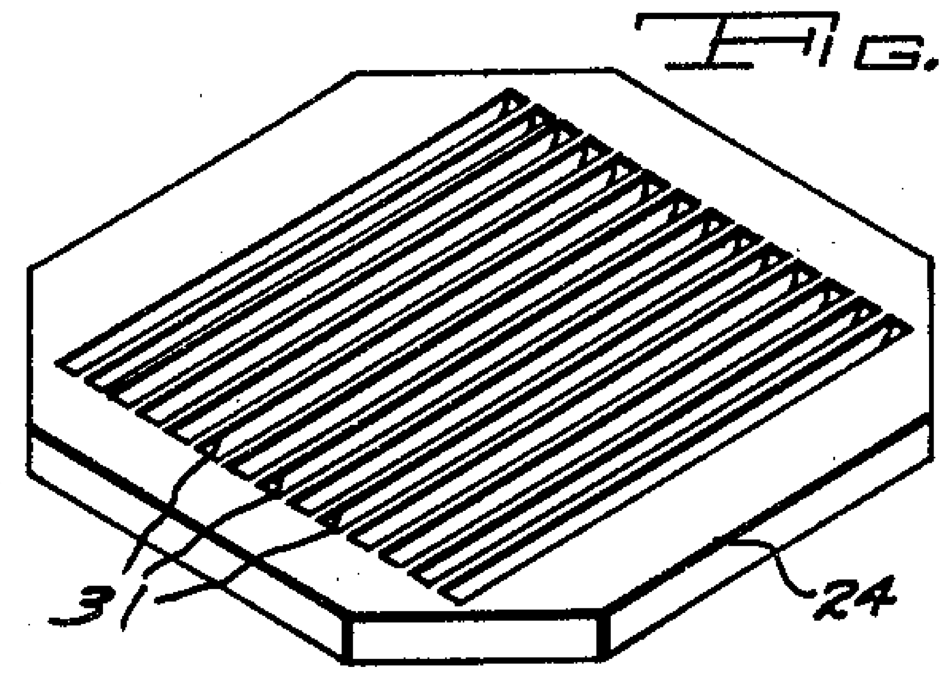


FIG. 7

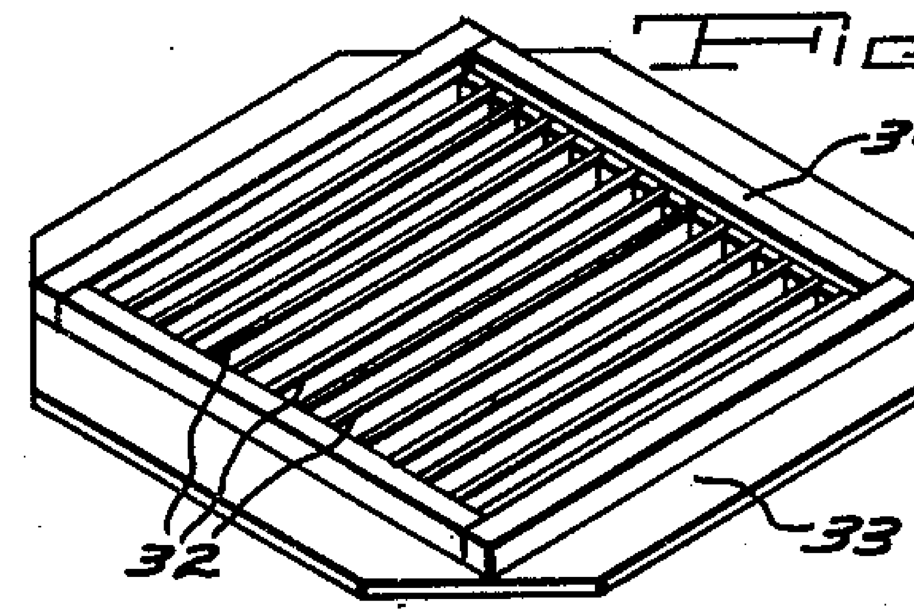


FIG. 9

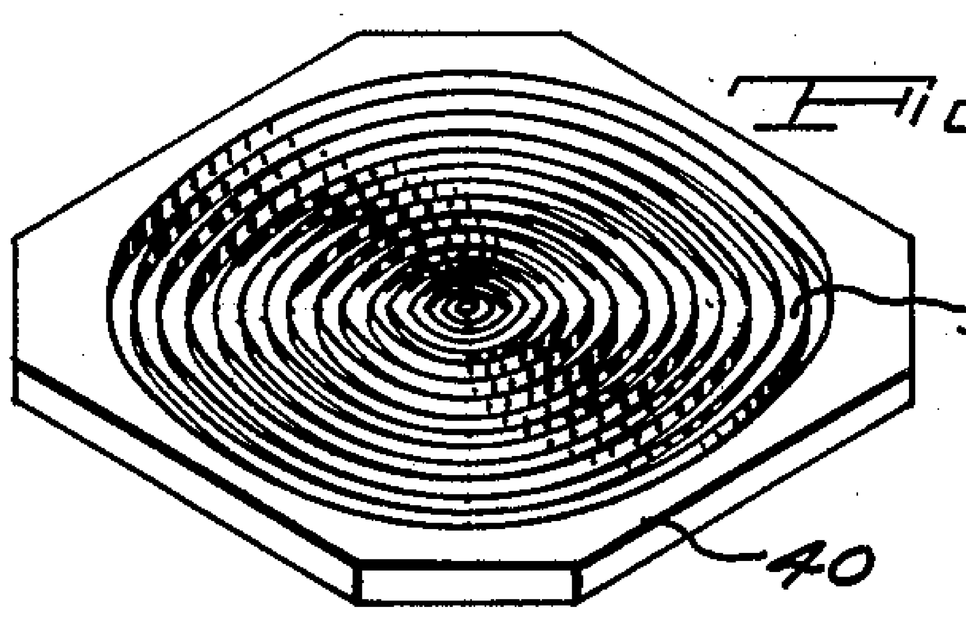


FIG. 8

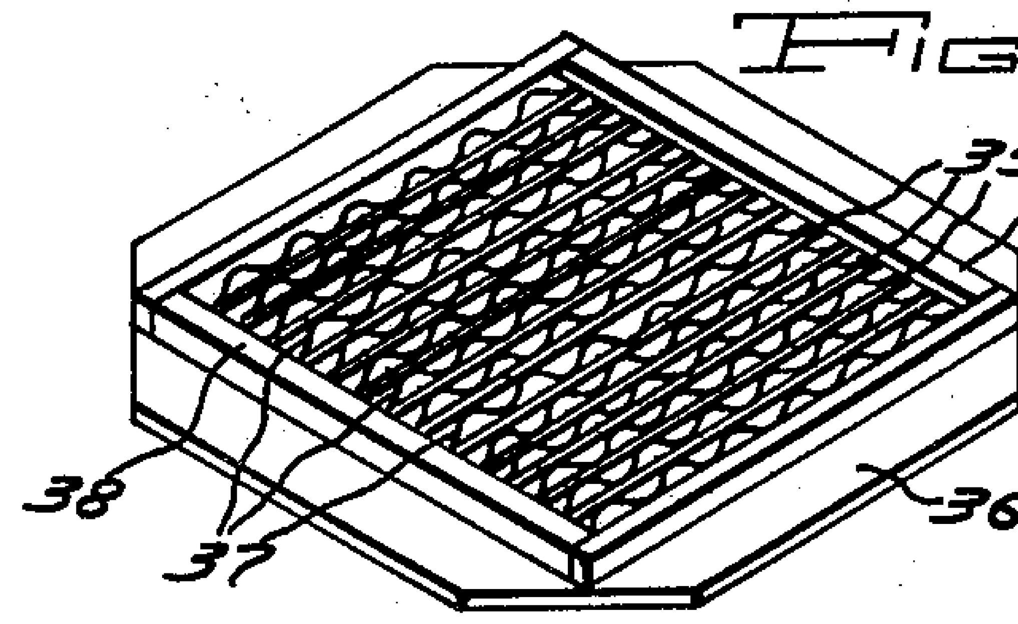


FIG. 10

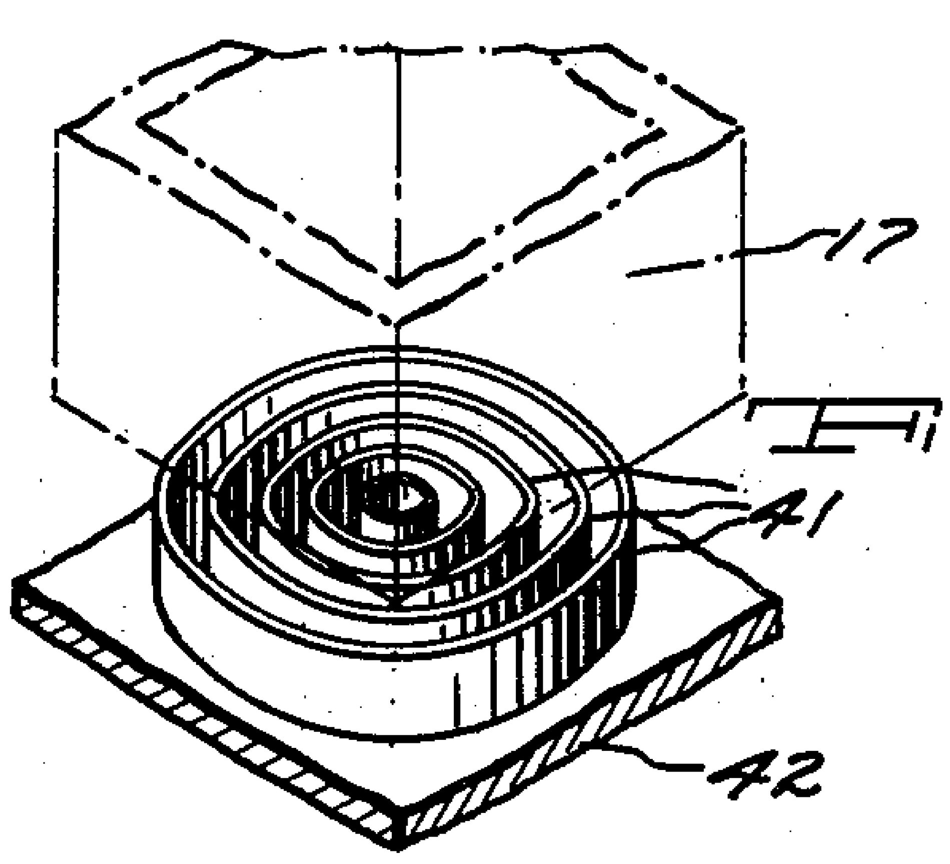
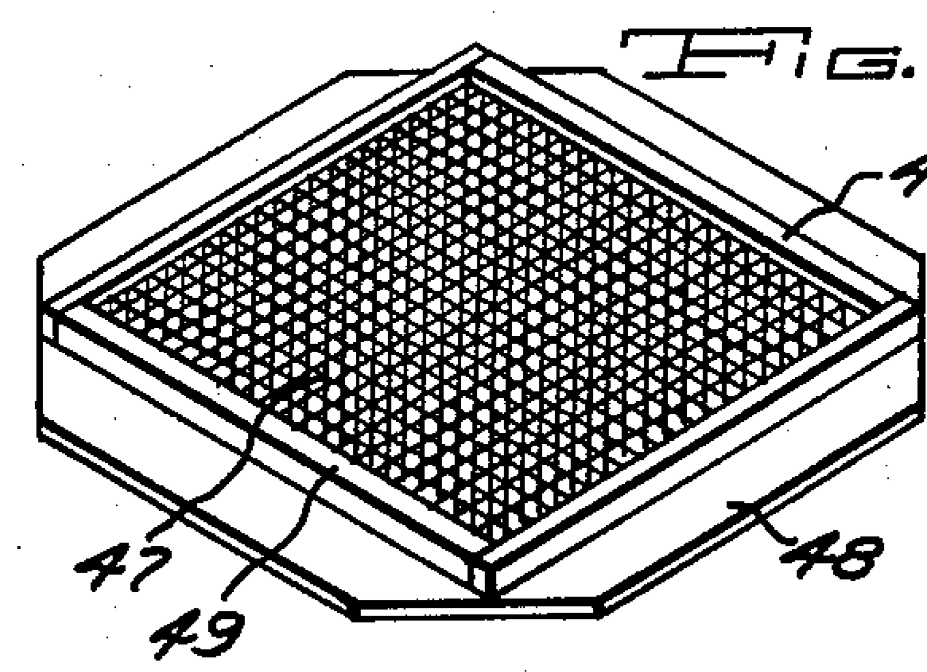


FIG. 14



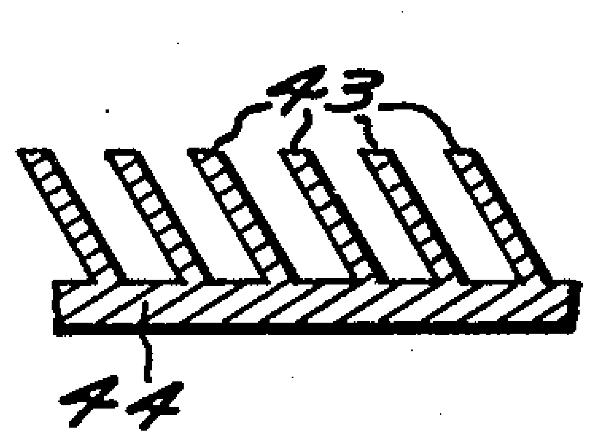


FIG. 11

FIG. 12

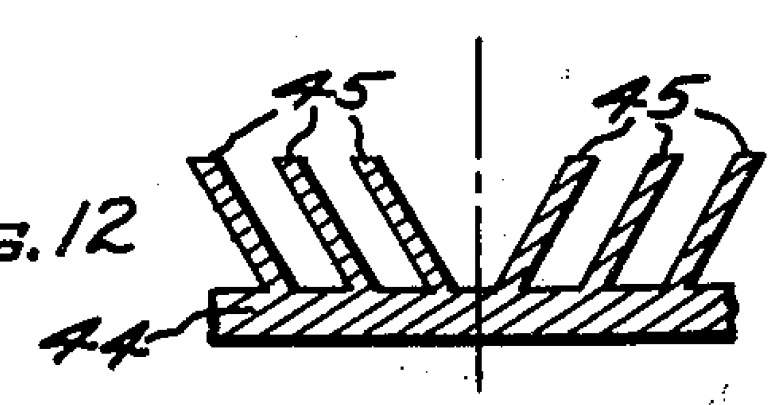
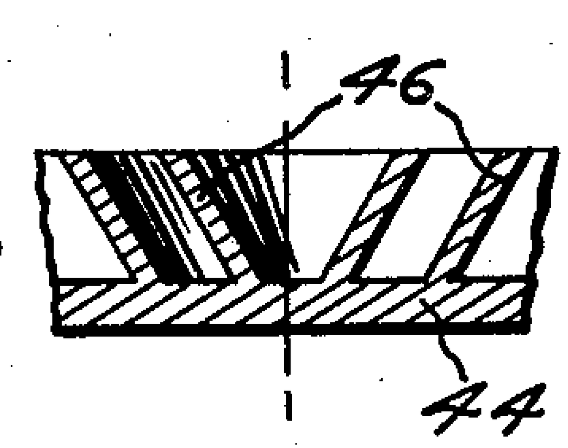


FIG. 13



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CATHODES FOR MAGNETICALLY-CONFINED GLOW DISCHARGE APPARATUS

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18 Claims. (Cl. 313—7)

The present invention relates in general to magnetically-confined glow discharge devices and more particularly to improved cathode configurations for such devices whereby the thermal conductivity, mechanical rigidity, and ease of fabrication of the cathodes are enhanced. These improved cathode configurations improve the operating performance of such devices utilizing magnetically-confined cold cathode glow discharge phenomenon such as, for example, getter ion vacuum pumps and Penning vacuum gauges.

Heretofore, in my copending application, U.S. Serial No. 673,816, filed July 24, 1957, titled "Electrical Vacuum Pump Apparatus and Method," and now issued into U.S. Patent 2,993,638, it is taught that the pumping performance of a cold cathode magnetically-confined glow discharge getter ion pump is enhanced by the provision of a sputter cathode grid. The aforementioned grid being typically formed, for example, by a plurality of closely spaced slats or a wire mesh forming the ion bombarded portion of the cold cathode.

The sputter cathode grid, of the prior art, was supported at its margins in spaced relation from the pump envelope and the anode such as to permit passage of certain of the ions and some sputtered cathode material through the cathode and to readily permit a flow of gas therethrough. With the aforementioned sputter cathode grid a substantial proportion of the ion bombarded surface portions of the cathode are disposed at glancing angles of incidence to the impinging ions whereby increased sputtering of the cathode material is ootained thereby enhancing the gettering action of the pump. Also, another inherent advantage of the sputter cathode grid is that it provides, within its interior, areas where there is a net build-up of sputtered cathode material. These net build-up areas are also subject to ion bombardment whereby the bombarding ions may be buried and covered over with subsequently sputtered material. This ion burial and covering over mechanism is especially beneficial when pumping noble gases such as, for example, argon, neon, krypton, and the like. Still another inherent advantage of the prior art sputter cathode grid is that it also eliminates argon instability because of its increased noble gas pumping speed, as compared with the pumping speed for flat cathode plates.

Argon instability is a name applied to describe a phenomenon occuring under certain conditions encountered while pumping against a continuous air leak when utilizing the more conventional diode type of getter ion pump having substantially flat cathode plates. Argon instability is characterized by periodic pressure fluctuations within the pump. Since these fluctuations are associated with argon, which normally accounts for approximately 1% of air, they have been given the name "argon instability." During an instability the pressure rises to a maximum value of about 2×10^{-4} millimeters of mercury. For leak rates such that the pressure between instabilities is less than about 2 to 3×10^{-5} millimeters of mercury, this maximum pressure is independent of leak rate. Time intervals between the pressure fluctuations are typically several minutes at a pressure of 1×10^{-5} millimeters of mercury, and vary approximately inversely with leak rate for pressures in the range of 5×10^{-7} to 2×10^{-5} millmeters of mercury.

The present invention provides an improved sputter cathode grid wherein the cathode slats or wire mesh or the like are supported from a base member and preferably joined thereto along the bottom edges of the aforementioned slats or mesh. The base member increases thermal conductivity from the slats, mesh, or the like, assures mechanical rigidity, and facilitates fabrication of the sputter cathode grid. In a preferred embodiment of the present invention, the sputter cathode grid is formed by slotting the cathode plate with a milling machine thereby forming, in the surface of the cathode, a plurality of closely spaced, parallel-directed cathode slats.

The principal object of the present invention is to provide an improved magnetically-confined glow discharge device having an improved sputter cathode grid configuration which offers ease of fabrication and/or stabilizes the current versus pressure characteristics of the glow discharge device.

One feature of the present invention is the provision of a sputter cathode grid including a plurality of closely spaced slat portions outwardly extending from a cathode base member whereby the thermal conductivity, mechanical rigidity and ease of fabrication of the cathode are enhanced.

Another feature of the present invention is the same as the preceding feature wherein the outwardly extending cathode slat portions are formed by milling a plurality of closely spaced slots in the cathode base member.

Another feature of the present invention is the same as the first feature wherein alternate spaced parallel-directed linear cathode slat portions are spaced apart by cathode slats provided with periodic transversely directed corrugations therein. The corrugations serve to provide a certain transverse spacing between alternate spaced apart linear cathode slats and lend additional mechanical rigidity and thermal conductivity to the sputter cathode grid.

Another feature of the present invention is the same as the first feature wherein the cathode slat is shaped in the form of a spiral.

Another feature of the present invention is the same as the first feature wherein the cathode slat portions are formed by a plurality of closely spaced coaxially disposed rings, successive rings being of slightly greater diameter.

Another feature of the present invention is the same as the first feature wherein the planes of the individual slat portions are disposed at a substantial angle to a perpendicular extending outwardly from the cathode base member.

Another feature of the present invention is the same as the preceding feature wherein the outwardly extending slat portions are formed by concentrically disposed hollow frustoconical ring segments, successive ring segments being of greater diameter.

Another feature of the present invention is a provision of a wire mesh or screen carried from a cathode base member for assuring mechanical rigidity, and thermal conductivity of the sputter cathode grid formed by said mesh or screen.

Other features and advantages of the present invention will become apparent upon a perusal of the specification taken in connection with the accompanying drawings wherein,

FIG. 1 is a schematic block diagram depicting a typical evacuation system utilizing a vacuum pump employing the novel features of the present invention,

FIG. 2 is a plan view, partly in cross section, of an electrical vacuum pump apparatus employing an improved slatted cathode of the present invention,

FIG. 3 is a cross-sectional view of the structure of FIG. 2 taken along line 3—3 in the direction of the arrows,

FIG. 4 is a graph of pressure versus time depicting argon instability encountered utilizing the prior art flat cathode plates,

FIG. 5 is an enlarged detail view of a portion of the structure of FIG. 3 delineated by line 5—5 and showing in schematic form the pumping mechanism,

FIG. 6 is an isometric view of a slatted cathode of the present invention formed by a plurality of closely spaced linear slots milled in the surface of the cathode plate,

FIG. 7 is an isometric view of a slatted cathode embodiment of the present invention wherein the individual spaced linear cathode slats are held in a frame member and the frame and slats are supported from a cathode base plate,

FIG. 8 is an isometric view of a slatted cathode embodiment of the present invention wherein the cathode slats are alternately spaced linear and corrugated slat members secured in a frame and supported from a cathode base member,

FIG. 9 is an isometric view of a slatted cathode embodiment of the present invention wherein the cathode slat portions are formed by an outwardly spiraling slot cut in the surface of the cathode plate,

FIG. 10 is an enlarged isometric fragmentary view, partly in phantom, depicting a slatted cathode embodiment wherein concentrically disposed ring slats are disposed in alignment with the axis of the anode cells and supported from a cathode base member,

FIG. 11 is a detailed, cross-sectional, fragmentary view of a portion of a slatted cathode member wherein the plane of the slats are slanted at an angle to a perpendicular extending from the plane of the base plate,

FIG. 12 is an alternative embodiment of the structure of FIG. 11 wherein certain of the cathode slats on one side of the anode cell center line are disposed at one angle to the perpendicular from the base plate and certain other slats on the other side of the center line are disposed at another angle to the perpendicular, and

FIG. 13 is an enlarged, detailed, cross-sectional, fragmentary view of a slatted cathode embodiment wherein the slats are concentrically disposed frustoconical ring members.

Referring now to FIG. 1 there is shown a schematic block diagram for an electrical vacuum pump embodiment of the present invention as utilized for evacuating a given structure. More specifically, an electrical vacuum pump **1** is connected via a hollow conduit **2** to a compression port **3** and thence via a hollow conduit **4** to the structure **5**, which it is desired to evacuate. The compression port **3** serves to provide a connecting mechanism whereby the structure **5** and associated conduit **4** may be removed and replaced by another structure and conduit for successive evacuation of a plurality of structures **5**. A mechanical vane vacuum pump **6** is also connected to compression port **3** via conduit **7** and pinch-off valve **8**. To evacuate the structure **5**, the mechanical vane pump **6** is put into operation serving to reduce the pressure within the structure **5** to between 5 and 20 microns, at which point, valve **8** is closed and the electrical vacuum pump **1** started.

Pump **1** is supplied with operating potentials from a source **9** as, for example, a 60 cycle power line via transformer **11**. The secondary of transformer **11** is provided with a rectifier **12** and shunting smoothing capacitor **13** whereby a D.C. potential may be applied between anode and cathode members of the electrical vacuum pump **1**, which will be more fully described below. Although a preferred pump embodiment utilizes a D.C. potential, A.C. potentials are also operable.

Referring now to FIGS. 2 and 3 a shallow rectangular cup-shaped member **14** as of, for example, stainless steel is closed off at its flanged open end by a rectangular closure plate **15** welded about its periphery to the flanged portion of member **14** thereby forming a substantially rectangular vacuum tight envelope **16**.

A rectangular cellular anode **17** as of, for example, titanium is carried upon the end of a conductive rod **18** as of, for example, stainless steel which extends outwardly of the rectangular vacuum envelope **16** through an aperture in a short side wall thereof. The conductive rod **18** is insulated from and carried by the vacuum envelope **16** through the intermediaries of annular insulator frames **19**, **21** and **22** as of, for example, kovar and cylindrical insulator **23** as of, for example, alumina ceramic. The free end of the rod **18** serves to provide a terminal for applying a positive anode voltage with respect to two substantially rectangular slatted cathode plates **24**, more fully described below.

The slatted cathode plates **24** are mechanically locked in position against the large flat side walls of the vacuum envelope **16** via the intermediary of two cathode spacer plates **25**. The cathode spacer plates **25**, as of stainless steel, are provided with semi-cylindrical ears **26** struck therefrom for assuring proper spacing between the cathode plates **24**. In a preferred embodiment, the anode to cathode spacings lies within the range of between 0.1" and 0.5". The cathode plates **24** may be made of any one of a number of reactive cathode metals such as, for example, titanium, chromium, zirconium, gadolinium, and iron. However, it is desirable, in order to prevent flaking of the condensed sputtered layer of cathode material, to make the anode **17** and cathodes **24** of the same material. The improved slatted cathode plates **24** are more fully described below.

Another side wall of the vacuum envelope **16** is apertured to receive the hollow conduit **2**, which may be of any convenient inside diameter commensurate with the desired pumping speed. The hollow conduit **2** communicates with the structure **5** which it is desired to evacuate and is provided with a suitable mounting flange, not shown.

A circular radial shield **27** as of, for example, molybdenum is carried transversely of conductive rod **18** and is disposed inside the first frame member **19** for shielding the insulator **23** from sputtered cathode material which might otherwise coat the insulator **23** and produce unwanted voltage breakdown or current leakage thereacross. An annular spring **28** is positioned circumscribing the frame member **21** to provide a quick disconnect connection between the power connector, not shown, and the pump **1**.

A horseshoe shaped permanent magnet **29** is positioned with respect to the shallow rectangular vacuum envelope **16** such that the magnetic field H of the magnet **29** threads through the individual cellular elements of the anode **17** in substantial parallelism to the longitudinal axis thereof. Although a D.C. magnetic field is utilized, in a preferred embodiment of the present invention, A.C. magnetic or time varying D.C. magnetic fields may be utilized. For example, the fringing time varying magnetic field of a circular particle accelerating machine, such as the Bevatron, may be used.

In operation, a positive potential of 0.5 kv. or more is applied to the anode **17** via conductive rod **18**. The vacuum envelope **16** and therefore the cathode plates **24** are preferably operated at ground potential to reduce hazard to operating personnel. With these potentials applied, a region of intense electric field is produced between the cellular anode **17** and the cathode plates **24**. This electric field produces an electrical breakdown of the gas within the pump thereby forming a plurality of closely spaced glow discharge columns extending in the direction of the magnetic field and grouped transversely of the magnetic field. The glow discharge columns are disposed within separated glow discharge passageways defined by the margins of the anode openings or walls of the cellular compartments in the anode **17**. In a preferred embodiment the anode cells have a length, *l*, greater than their diameter, *d*.

Positive ions produced in the glow discharge strike the cathodes, which, in a preferred embodiment, are made of titanium. When pumping air, ionized molecules of N_2 and O_2 and Ar produce, upon striking the cathode **24**, appreciable sputtering of titanium or titanium compounds from the cathode **24** onto the anode **17**. Most of the pumped N_2 and O_2 thus ends up in chemical combination with titanium at the anode **17** of the pump.

Noble gases, such as argon and helium, because of their lack of chemical activity, are pumped primarily by ion burial in the cathode plates **24**. In the absence of subsequent diffusion into the cathode interior, pumping by this mechanism should cease when the rate of sputtering out of previously buried gas atoms becomes equal to the rate of which ions are being buried. Thus, after many hours of operation, a pumping speed saturation effect occurs for argon. Since argon amounts to approximately 1% of air it can give rise to argon instability, when using flat cathode plates. Argon instability phenomenon, as sometimes encountered with the prior art magnetically-confined cold cathode glow discharge getter ion pumps utilizing flat cathode plates, is depicted in FIG. 4.

However, continued pumping of the noble gases does occur in regions of certain cathode configurations where there is ion burial in regions of net build-up of sputtered cathode material. Therefore, it has been found that the prior art sputter cathode grid, which is characterized by increased sputtering and regions where there is both a net build-up of sputtered cathode material and ion burial, provides the needed increased pumping speed for noble gases, over that obtained by a flat cathode, and thereby eliminates, when pumping air, any tendency for argon instability to occur.

Referring now to FIG. 5 there is shown a preferred improved sputter cathode grid design of the present invention. More specifically, the face of the cathode plate **24** which is disposed adjacent the open ends of the anode cells is provided with a plurality of closely spaced parallel-directed linear slots thereby forming a plurality of closely spaced cathode slats **31** in the land region between adjacent slots. The cathode slats **31** may be readily formed by cutting slots in the cathode plate with a ganged slotting saw employed on a milling machine.

The distance between adjacent slats should be small in comparison with the diameter *d* of an anode cell and the width of the slat should be smaller than the distance between slats. The depth of the slot should be larger than its width. In a preferred embodiment of the present invention, the slat width is approximately 0.012″; the slot width is approximately 0.028″; the slot depth is approximately 0.090″; the cathode plate thickness, including the height of the slats **31**, **24** is approximately 0.125″; and the anode cell diameter *d* is approximately 0.5″.

The pumping mechanism for the improved slatted cathode grid is shown in FIG. 5. More specifically, some high energy positive ions, which are generated near the inner side walls of and well within the individual cellular anode compartments **17**, are attracted toward the negative space charge core of the glow discharge column. The positive ions are acted upon by both an axial and a radial electric field to produce a radial oscillation superimposed on the axial component of the trajectory directed toward the cathode thereby causing these high energy positive ions to intercept the slatted cathode plate **24** on the free ends of the cathode slats **31** and at a substantial angle to the perpendicular extending outwardly from the cathode plate. Some of these ions will collide with the cathode plate **24** at a substantial radial distance from the point where the axial center line of the anode cell intercepts the cathode plate **24**. Some of the cathode material sputtered from the free ends of the cathode slats **31** will be deposited further down in the cathode slots resulting in a net build-up of sputtered material within the bottom of the slots.

Other ions will be created essentially within the core of the glow discharge column and therefore will have very little radial component to their trajectories. These ions are focused to bombard the cathode plate **24** in substantial alignment with the axis of the individual cellular compartments **17** and consequently produce a substantial amount of erosion of the cathode in these localized regions.

Still other ions will be produced in places where they will have trajectories to intercept the cathode plate **24** in regions thereof where there is a net build-up of sputtered cathode material as found in the bottoms of the cathode slots. These ions will be buried in the built-up material and will be subsequently covered over with additional sputtered cathode material. This burying and covering over mechanism accounts for the increased pumping action for noble gases and permits elimination of argon instability encountered with the prior art flat cathode plates.

By placing the cathode slats **31** in good thermal contact with the cathode base plate **24**, increased thermal conductivity is obtained over the prior art cathode slats wherein the slats were held in a frame member substantially only at the ends of the slats. Increased thermal conductivity of the cathode slats **31** permits heat, generated by ion bombardment of the slats **31**, to be readily conducted to the base plate **24** and thence to the pump envelope **15** where it may be readily dissipated. If the temperature of the cathode slats **31** becomes too great, gases which have been buried in the cathode material will be driven out, deleteriously affecting the pumping performance of the pump. In addition, excessive heating of the cathode slats **31** will cause warping thereof thereby destroying the aforementioned preferred cathode geometry and conseqently deleteriously affecting the pumping action of the slatted cathode. Therefore, by rigidly connecting the cathode slats **31** to the cathode base member **34**, along their abutting edge portions, both the mechanical rigidity and thermal conductivity of the cathode slats is increased over the prior art framed cathode slats. In addition, when the cathode slats are formed by milling, as in the preferred embodiment of the present invention, the cathode plates are more easily fabricated than when individual cathode slats are inserted, at their ends, in a frame member.

FIG. 6 is an isometric view of the slatted sputter cathode grid structure substantially as shown in FIGS. 2, 3 and 5.

FIG. 7 is an isometric view of an alternative slatted cathode embodiment of the present invention wherein the cathode slats **32** approximate the slats **31** of FIGS. 5 and 6 and are formed by metallic tapes having dimensions of, for example, 0.012″ thick and 0.090″ wide laid edgewise, in parallel linearly directed spaced apart relationship, on a cathode base plate **33**. In a preferred embodiment the cathode slats **32** are brazed to the cathode plate **33** at their contacting side edges and the slats **32** are held at their ends in suitable slotted frame members **34** fixedly secured to the cathode plate **33**. Although the tape-like cathode slats **32**, in a preferred embodiment, are brazed to the cathode plate **33**, they will operate if they merely rest upon the base plate **33** or are spot welded at spaced intervals thereto, but the thermal conductivity and mechanical rigidity in such latter cases will not be as good as in the case where they are brazed to the base plate **33**.

Referring now to FIG. 8 there is shown another slatted cathode embodiment of the present invention. More specifically, a plurality of tape-like reactive metallic cathode slats are supported on their side edges from a supporting cathode base plate **36**. Alternate cathode slats are provided with transversely directed corrugations, the corrugations being periodically spaced lengthwise of the individual cathode slats. The corrugated cathode slats **37** are alternately spaced with noncorrugated linear slats **35** to provide proper spacing between alternate linear slats **35** to further increase the proportion of the cathode slat area where net build up of sputtered material and burial of gas molecules can take place. The corrugated slat members **37** also lend additional mechanical rigidity to the slatted cathode structure to prevent undesired warping. As in the previous embodiment, shown in FIG. 7, the individual cathode slats **35** and **37** are held at their ends by suitable frame member **38** fixedly secured to the base cathode plate **36**.

Referring now to FIG. 9 there is shown an alternative slatted cathode embodiment of the present invention wherein the cathode slat portions **39** are formed by milling a spiral slot in a cathode base plate **40** thereby providing an outwardly spiraling cathode slat **39**. The outwardly spiraling cathode slat embodiment, shown in FIG. 9, may offer, in certain instances, additional ease of manufacture, as the slot may be cut on a lathe.

Referring now to FIG. 10 there is shown an alternative cathode embodiment of the present invention wherein the cathode slats **41** are formed by a plurality concentrically disposed cylindrical ring members of increasing diameter affixed at their ends to a base supporting cathode plate **42**. In this embodiment, separate concentric slat arrays are disposed opposite and coaxial with the axes of individual anode cells. This particular slatted cathode geometry tends to optimize the cathode regions of net build-up of sputtered cathode material and burial of gas molecules therein due to the symmetry of the cathode slats with respect to the ion trajectories of the discharge.

Referring now to FIG. 11 there is shown an alternative slatted cathode embodiment of the present invention wherein a linear array of parallel-directed cathode slats **43** extend outwardly from a cathode base plate **44**. The planes of the cathode slats **43** are slanted at an angle to a perpendicular directed outwardly from the plane of the cathode base plate **44**. This particular cathode configuration has certain performance advantages over the configuration as shown in FIG. 5 wherein the slats **31** extend perpendicularly outwardly from the cathode base plate **24**. Slanting of the cathode slats **43** allows more of the ions having trajectories, other than normal to the base plate, to pass further down into the regions of a net build-up of cathode material to be buried therein and covered over by subsequently sputtered cathode material.

Referring now to FIG. 12 there is shown an alternative embodiment of the slatted cathode shown in FIG. 11 wherein the free end portions of the cathode slats **45** are outwardly slanted from the center line of the glow discharge columns thereby further increasing symmetry of the cathode structure with respect to the glow discharge columns to enhance burial of gas molecules in the regions of net build up of sputtered cathode material.

Referring now to FIG. 13 there is shown an alternative embodiment to the cathode structure depicted in FIG. 12 wherein the cathode slats **46** are formed by concentrically disposed frustoconical ring segments of increasing diameter, the free ends of the frustoconical segments forming the base of said frustoconical segments. The axes of the coaxially disposed frustoconical slats **46** are disposed in substantial alignment with the center lines of the individual anode cells, whereby enhanced symmetry of the slatted cathode structure is obtained with respect to the impinging ion trajectories to enhance burial of gas molecules in the cathode regions of net build up sputtered cathode material.

Referring now to FIG. 14 there is shown an alternative sputter cathode embodiment of the present invention. In this embodiment, a plurality of wire screens **47** are supported from and stacked, with their apertures in alignment, on a cathode base plate **48**. The screens **47** are preferably spot welded together at spaced intervals and are preferably fixedly secured to the base cathode plate as by brazing and held thereto at their margins via suitable frame members **49**. The stacked screens **47** provide a plurality of cathode cellular compartments for enhancing areas of net build-up of sputtered cathode material within the interior of the cathode compartments formed by the stacked cathode screens **47**.

Although the above described sputter cathode configurations have been described for use in connection with getter ion vacuum pumps they also have special utility in magnetically-confined cold cathode glow discharge vacuum gauges such as, for example, Penning gauges. The slatted and stacked screen cathode configurations allow a higher secondary emission yield because of the glancing incidence of the impinging ions and further reduce electron recapturing process, by the cathodes, because of the roughness of the cathode surface thereby providing more avalanche generating electrons permitting the gauge to measure down to lower pressures and increasing the linearity of the ion current versus pressure characteristics of such gauges at lower pressures. In the gauge embodiments the slatted or screened cathodes are preferably made of a material which is difficult to sputter, such as aluminum or magnesium.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A cold cathode structure for magnetically-confined glow discharge apparatus wherein portions of the cathode structure are subject to ion bombardment including, means forming a cold cathode base plate, means forming a cold cathode grid, portions of said grid means being subject to ion bombardment in use, and said grid means being supported in contiguous abutting relationship from a face of said cathode base plate, whereby mechanical rigidity and thermal conductivity of said cathode grid means is enhanced.

2. The apparatus according to claim 1 wherein said cathode grid means includes at least one slat, and said slat being supported from said base plate means along one of the thin side edges of said slat.

3. The apparatus according to claim 1 wherein said cathode grid means is formed by a land portion remaining between spaced slot portions provided in the face of said cathode base plate means, and said spaced slot portions being both wider and deeper than the thickness of said land portion.

4. The apparatus according to claim 1 wherein said cathode grid means includes, a grid structure formed and arranged with respect to the bombarding ion trajectories to sputter off portions of said cathode grid structure onto other portions of said grid to produce regions therewithin where there is both net build-up of sputtered material and burial of bombarding ions in said regions of net build up of sputtered material whereby pumping of noble gas ions is enhanced.

5. The apparatus according to claim 1 wherein said cathode grid means includes, a grid structure having a plurality of spaced apart slat portions being supported from said face of said cathode base plate means along the thin side edges of said slat portions.

6. The apparatus according to claim 5 wherein said slat portions include parallel-directed spaced apart substantially linear slat portions.

7. The apparatus according to claim 5 wherein the planes of said slat portions are disposed at a substantial angle to the plane of said slat supporting face of said base plate means.

8. The apparatus according to claim 5 wherein said slat portions are formed by a spiral slat.

9. The apparatus according to claim 5 wherein said slat portions include a plurality of spaced apart concentrically disposed rings of successively increasing radius.

10. The apparatus according to claim 5 wherein said

slat portions include a plurality of spaced apart concentrically disposed frustoconical ring segments of successively increasing radius.

11. The apparatus according to claim 5 wherein said slat portions include a plurality of alternately disposed linear and transversely corrugated slats, said corrugated slats abutting at periodic intervals with adjacent linear slats and serving to provide the spacing between said linear slats.

12. A cathode structure for magnetically-confined glow discharge apparatus wherein portions of the cathode structure are subject to ion bombardment including, means forming a cathode grid having a front face portion subject to relatively intense ion bombardment by ions produced by the glow discharge and having a back face portion subject to less intense ion bombardment, means for mechanically rigidly supporting said cathode grid from said back face portion and for providing a path of thermal conduction from said grid to prevent overheating and warping thereof in use.

13. The apparatus according to claim 12 wherein, said cathode grid means includes a plurality of stacked screens, said grid supporting means includes a base plate, and wherein the stacked screens are supported at the bottom of the stack from a face of said base plate.

14. A getter ion vacum pump apparatus for evacuating an enveloped structure including means forming a cathode contained within the enveloped structure for positive ion bombardment to remove matter in the gaseous state and hence reduce the gas pressure in the enveloped structure, said cathode means including a grid means formed and arranged with respect to the bombarding ion trajectories to sputter off portions of said cathode grid means onto other portions of said grid means to produce regions within said grid means where there is both a net build-up of sputtered cathode material and burial of bombarding ions in said net build-up of sputtered cathode material whereby pumping of noble gas ions is enhanced, said cathode grid means having a front face portion subject to relatively intense ion bombardment and having a back face portion subject to less intense ion bombardment, means for rigidly supporting said cathode grid means from said back face portion of said grid means and for providing a path for thermal conduction from said grid means to prevent overheating and warping thereof in use, means forming an anode disposed within the envelope, means for applying a positive potential to said anode means with respect to said cathode means for producing a glow discharge therebetween and for bombarding said cathode means with positive ions, means for producing and directing a magnetic field through said anode means, said anode means having a plurality of openings therein the openings being distributed transversely to the direction of the magnetic field threading said anode, and the openings in said anode means defining a plurality of glow discharge passageways extending in the same direction as the magnetic field and distributed transversely of the magnetic field direction for containing therewithin a plurality of separated simultaneous glow discharge portions in use.

15. The apparatus according to claim 14 wherein said cathode grid means includes a plurality of spaced slat portions, and said cathode grid supporting means includes a cathode base plate supporting said cathode slat portions from a face of said plate abutting the thin side edges of said slat portions.

16. The apparatus according to claim 15 wherein the spacing between adjacent cathode grid slat portions is greater than the thickness of said slat portions.

17. A getter ion vacuum pump apparatus for evacuating an enveloped structure including, means forming a cathode contained within the enveloped structure for positive ion bombardment to produce sputtering of the cathode material and to remove matter in the gaseous state and hence reduce the gas pressure in the enveloped structure, said cathode means including a cathode plate, a plurality of adjacent land portions formed on a face of said plate, the thickness of individual of said land portions being less than both the height of and the distance between said land portions, and the height of said land portions being greater than the distance between said adjacent land portions, to produce within said cathode plate regions where there is both a net build up of sputtered cathode material and burial of bombarding ions in said build-up of sputtered cathode material whereby pumping of noble gas ions is enhanced, means forming an anode disposed within the envelope, means for applying a positive potential to said anode means with respect to said cathode means for producing a glow discharge therebetween and for bombarding said cathode means with positive ions, means for producing and directing a magnetic field through said anode means, said anode means having a plurality of openings the openings being distributed transversely to the direction of the magnetic field threading said anode, and the openings in said anode means defining a plurality of glow discharge passageways extending in the same direction of the magnetic field and distributed transversely to the magnetic field direction for containing therewithin a plurality of separated simultaneous glow discharge portions in use.

18. A vacuum gauge apparatus for measuring the gas pressure within a partially evacuated enveloped structure including, means forming a cathode contained within the enveloped structure for positive ion bombardment to produce an ion current which is a function of the gas pressure within the enveloped structure, said cathode means including a cathode plate, a plurality of adjacent land portions formed on a face of said plate the thickness of individual of said land portions being less than both the height of and the distance between said land portions, and the height of said land portions being greater than the distance between said adjacent land portions, whereby recapture of avalanche initiating secondary electrons produced by ion bombardment of said cathode means is minimized to improve the low pressure linearity of the current versus pressure characteristics of the vacuum gauge, means forming an anode disposed within the envelope, means for applying a positive potential to said anode means with respect to said cathode means for producing a glow discharge therebetween and for bombarding said cathode means with positive ions, means for producing and directing a magnetic field through said anode means, said anode means having at least one opening therein the opening defining a glow discharge passageway extending in the same direction as the magnetic field for containing therewithin a glow discharge column, and means for measuring the ion current to obtain a measure of the gas pressure within the enveloped structure.

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