Nov. 16, 1965 W. KNAUER 3,217,973

DUAL SURFACE IONIC PUMP WITH SHIELDED ANODE SUPPORT

Filed Nov. 23, 1962 2 Sheets-Sheet 1

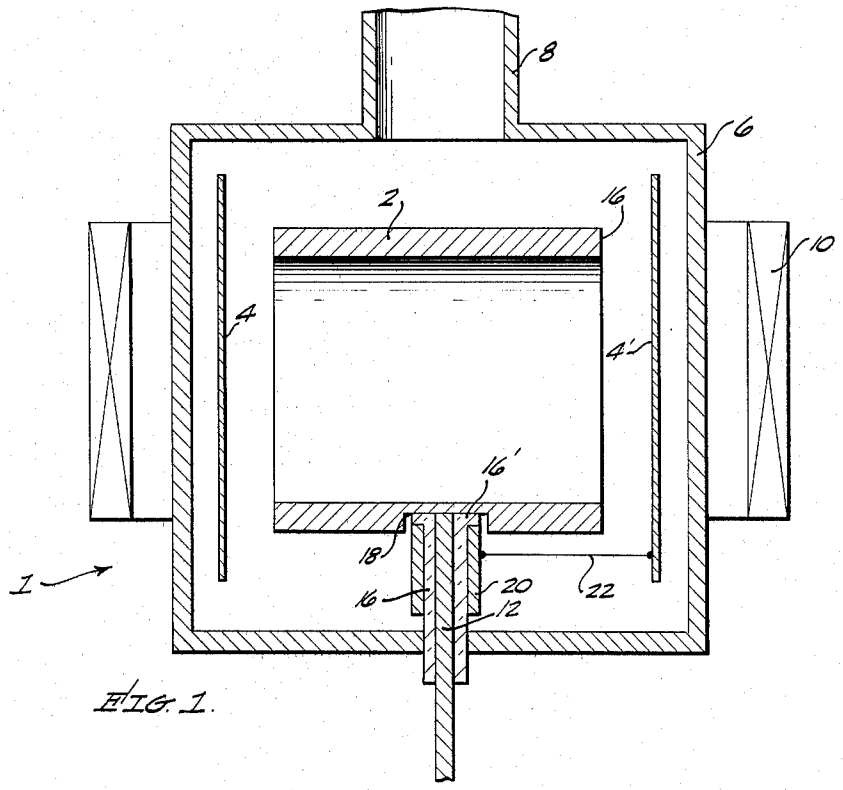


FIG. 1.

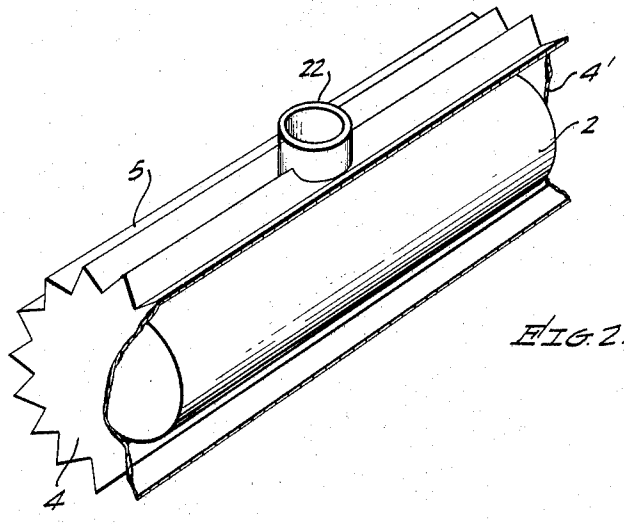


FIG. 2.

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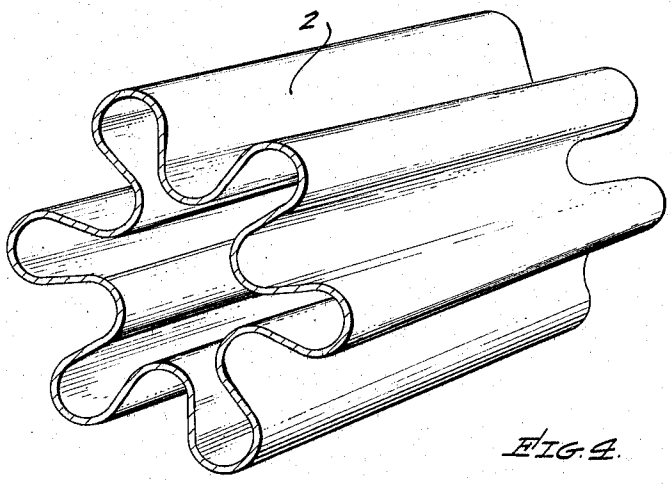


FIG. 4.

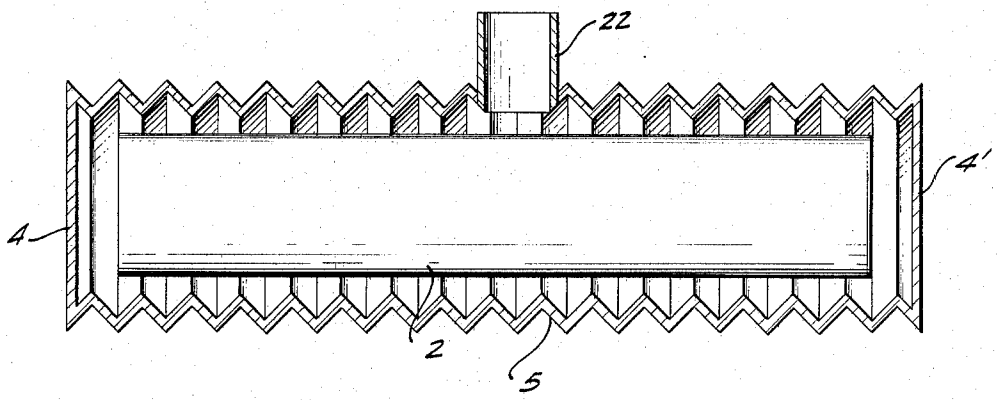


FIG. 3.

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DUAL SURFACE IONIC PUMP WITH SHIELDED ANODE SUPPORT

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9 Claims. (Cl. 230—69)

This invention relates to electrical vacuum pumps and more specifically to ionic vacuum pumps of the Penning discharge type.

Vacuum pumps of the Penning discharge type for creating high vacuums of the order of 10^{-6} torr are known and in general comprise a pair of parallel disks composed of a reactive cathode material and an open-ended hollow cylinder suitable for use as an anode. The cathode disks are slightly greater in diameter than the anode cylinder, and are placed at the respective extremities of and normal to the anode cylinder. The entire device is immersed in a magnetic field parallel to the axis of the anode, and enclosed in an envelope connected to the apparatus to be evacuated. When a high electric potential difference is applied between the cathode and anode members a discharge strikes. Positive ions from this discharge continuously bombard the reactive cathode elements, and sputter off some of the reactive material thereon. The sputtered material is deposited on other exposed surfaces within the envelope to be evacuated, particularly surfaces of the anode element. These deposits act as a getter; i.e., they remove gas molecules from within the envelope by adsorption. This adsorption is the primary pump action; however, some gases such as the noble gases and hydrogen are removed by direct ion burial in the cathode elements.

Investigation of the discharge mode in such ion pumps has revealed that the active discharge area is confined to a thin plasma layer which lines the inside surface of the anode cylinder. The present invention is based upon the discovery that under proper conditions such a discharge may also be made to occur on the outside surface of the anode. With simultaneous discharges on both the in and outside surfaces of the anode, the total discharge current, and hence also the bombardment rate and the pump speed is greatly increased. Furthermore, the fact that the discharge is in the form of a thin plasma layer at the anode surface means that the anode cylinder need not be restricted to either round or rectangular cross sections as used in conventional pumps but may have any desirable shape which may produce a maximum pumping rate.

It is therefore an object of the invention to provide an improved ion pump.

Another object of the invention is to provide an ion pump of increased pumping speed for a given physical size by establishing simultaneous discharges on more than one surface of the anode member.

Another object of the invention is to provide an ion pump with anode and/or cathode members whose geometric configurations optimize the rate of pumping and simplify the mechanical construction.

These and other objects and advantages of the invention are realized by the providing of a connection and/or support for an anode member which does not disrupt the electron motion within the plasma layer. This is achieved by securing the anode lead and/or support rod to the anode wall but surrounded by a shield maintained at cathode potential which effects a deflection of the plasma layer around the support shield without harm to the plasma. In addition, an anode cylinder with meander-type cross section may be employed in order

to provide the maximum anode surface to obtain maximum discharge current and pumping speed. Unlike anode structures of the conventional multi-cellular pumps, the meander-type anode of the invention can be manufactured from a single mold.

These and other features of the invention will be described in greater detail by reference to the drawings in which:

FIGURE 1 is a sectional view of a Penning discharge type pump utilizing a shield around the anode support rod;

FIGURE 2 is an orthogonal view of a corrugated cathode configuration having ridges and valleys extending radially to the major surfaces of the anode;

FIGURE 3 is a sectional view of a corrugated cathode with ridges and valleys extending parallel to the major surfaces of the anode; and

FIGURE 4 is an orthogonal view of a corrugated anode which provides maximal surface area for the total volume occupied by a given anode element.

Referring now to FIGURE 1, a Penning discharge pump employing the invention is shown wherein an anode cylinder **2** is mounted between two cathode plates **4** and **4'**, which may be circular. These anode and cathode members are disposed within an envelope **6** which is adapted to be connected to apparatus to be evacuated by means of a connecting tube **8**. Magnetic means **10** are provided outside and adjacent the envelope **6** for establishing a magnetic field within the envelope parallel to the axis of the anode cylinder **2**. The anode cylinder **2**, the envelope **6**, and the connecting tube **8** may be of any desirable metal, for example, stainless steel. The cathode plates **4** and **4'** may be of a reactive material such as tantalum, for example. Anyone of a number of suitable materials may be employed for the cathode members such as molybdenum, titanium, tungsten, niobium, zirconium, barium, thorium, magnesium calcium and strontium. In practice it may be desirable to provide a film of reactive material on a base metal, such as stainless steel.

In the embodiment of FIGURE 1 electrical connection is made to the anode cylinder **2** in such a manner as not to disrupt the electron motion of the plasma sheet formed adjacent the anode walls during operation. The anode cylinder **2** is provided with electrical connection and/or support by means of an electrically conducting rod **12** which is welded or otherwise secured to one of the major surfaces such as the outside wall of the anode cylinder **2**. The rod **12** also extends through the envelope **6** and is electrically isolated therefrom by means of a glass or ceramic sleeve member **16** having a flanged end **16'**. The isolating sleeve member **16** extends along the length of the rod **12** between the anode cylinder **2** and the envelope **6**. In order to insure that the positive potential on the connecting rod **12** will not interfere with or disrupt the plasma sheath on the outside wall of the anode cylinder **2**, the cylinder **6** may be provided with a recessed portion **18** to the bottom of which the connecting rod **12** is secured. Around the isolating sleeve member **16** a conductive shield **20** is mounted and so positioned that one end thereof extends into the recessed portion **18** in the anode cylinder **2** and abuts the flanged portion **16'** of the sleeve **16** which flanged portion also rests against the bottom of the recess. The conductive shield **20** is maintained at cathode potential by means of a wire connection **22** from one of the cathode plates. In order to enable this connection **22** to be positioned clear of the plasma sheath around the outside wall of the anode cylinder **2**, a ratio of about 5:4 between the diameters of the cathode disks **4** and **4'** and the diameter of the anode cylinder **2** may be employed. This permits positioning the connection **22**

far enough away from the outside wall of the anode member 2 to prevent interference thereby with the plasma sheath.

In operation the pump 1 is connected to the apparatus to be evacuated by means of the connecting tube 8. A high electric potential is imposed between the cathode members 4 and 4' and the anode 2. A suitable potential for this purpose may be of the order of 3,000 volts. At the same time a magnetic field of the order of 1–2 kilogauss may be imposed across the pump in a direction parallel to the axis of the anode cylinder. A Penning discharge sheath will be established on both sides (inside and outside) of the anode member 6 to enhance the pumping speed as described heretofore.

In FIGURES 2 and 3 embodiments are shown wherein the inner surface of the envelope constitutes or provides a reactive cathode surface. The anode cylinder 2 is disposed between end cathode members 4 and 4' and within a cylindrical type cathode portion 5 which may be integral with or otherwise connected to the end cathode members 4 and 4'. This cathode configuration is designed to effect maximum pumping speed by the discharge action along the outer anode surface. In FIGURE 2 the cathode portion 5 is corrugated with relatively sharp folds extending parallel with the major surface of the anode cylinder 2. In FIGURE 3 the folds extend toward the major surfaces of the anode. These corrugated cathode surfaces may be employed to effect greater sputtering action (and therefore greater pumping speed) by providing a high angle of incidence of ions from the discharge along the outer anode surface. The anode may be supported or connected to a source of potential by the arrangements shown in FIGURE 1 and described in connection therewith. The cylindrical cathode portion may be provided with an outlet 22 for connection to the apparatus to be evacuated so that the gas to be pumped may be introduced into the space between the anode and cathode members.

In the embodiments described thus far the anode has been shown as a round cylinder. Since the anode current is proportional to the total anode area, and increase in the anode area as by a meander-type surface will result in an increase of the discharge current and therefore the pump speed as well. The only requirements are that the anode surface be closed or continuous and parallel to the magnetic field. In FIGURE 4 a corrugated type anode cylinder 2 is shown satisfying these requirements for use in the ion pump of FIGURES 1, 2, or 3. In order to permit the discharge to develop properly on both inside and outside surfaces of the anode cylinder the surface should not come closer to each other than twice the sheath width and the radii or curvature of the anode should not be smaller than one sheath width.

There thus has been shown and described an improved ion pump in which the Penning type discharge may be established and maintained on both sides of an anode member. In addition alternatives have been shown and described which in combination with the dual surface discharge capability of the anode permits an even greater pumping action.

What is claimed is:

1. An ionic pump comprising an envelope adapted to be connected to apparatus to be evacuated, means for establishing a magnetic field within said envelope, an anode member within said envelope and having at least two major surfaces parallel to said magnetic field, reactive cathode means disposed in said envelope at an angle with respect to said major surfaces, connection means for said anode member secured to said anode member at one of said major surfaces, and a shield for said connection means adapted to be maintained at the potential of said cathode means.

2. An ionic pump comprising an envelope adapted to be connected to apparatus to be evacuated, means for establishing a magnetic field within said envelope, a cylindrical anode member having inner and outer major surfaces parallel to said magnetic field, reactive cathode means disposed in said envelope at an angle with respect to said major surfaces, connection means for said anode member secured to one of said major surfaces, and a shield for said connection means adapted to be maintained at the potential of said cathode means.

3. The invention according to claim 2 wherein said reactive cathode means are disposed adjacent and across end portions of said cylindrical anode member.

4. The invention according to claim 2 wherein said connection means is secured to an outer major surface of said cylindrical anode member.

5. An ionic pump comprising an envelope adapted to be connected to apparatus to be evacuated, means for establishing a magnetic field within said envelope, an open-ended cylindrical anode member having inner and outer major surfaces parallel to said magnetic field, reactive cathode means disposed adjacent the ends of said cylindrical anode member and at an angle with respect to said major surfaces, connection means for said member secured to one of said major surfaces and extending through said envelope, and a shield for said connecting means adapted to be maintained at the potential of said reactive cathode means and being electrically isolated from said connecting means.

6. An ionic pump comprising an envelope adapted to be connected to apparatus to be evacuated, means for establishing a magnetic field within said envelope, an anode member within said envelope and having a plurality of major surfaces parallel to said magnetic field, reactive cathode means disposed in said envelope at an angle with respect to said major surfaces, connection means for said anode member secured to one of said major surfaces, and a shield for said connecting means adapted to be maintained at the potential of said cathode means.

7. The invention according to claim 6 wherein said anode member contains a plurality of folds extending parallel to said magnetic field thereby providing said plurality of major surfaces.

8. An ionic pump comprising a corrugated envelope adapted to be connected to apparatus to be evacuated, the inner surface of said envelope constituting a reactive cathode member, means for establishing a magnetic field within said envelope, an anode member within said envelope having at least two major surfaces parallel to said magnetic field, connection means for said anode member secured to one of said major faces, and a shield for said connection means adapted to be maintained at the potential of said cathode member.

9. The invention according to claim 8 wherein said anode member contains a plurality of folds extending parallel to said magnetic field thereby providing said plurality of major surfaces.

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