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W. KNAUER  
IONIC VACUUM PUMP

3,216,652

Filed Sept. 10, 1962

3 Sheets-Sheet 1

FIG. 1.

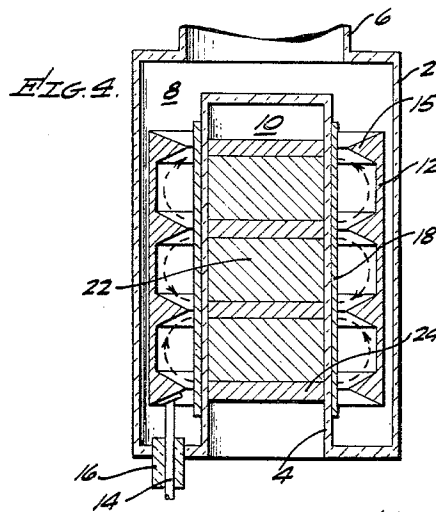
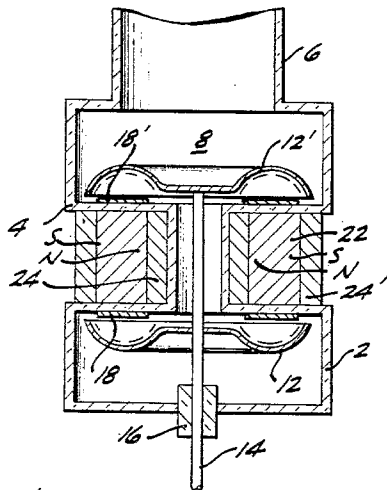
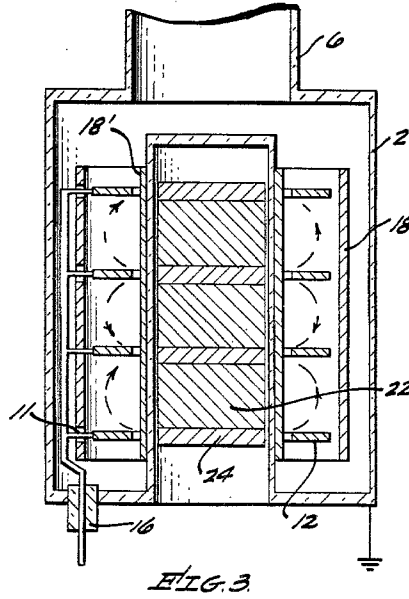
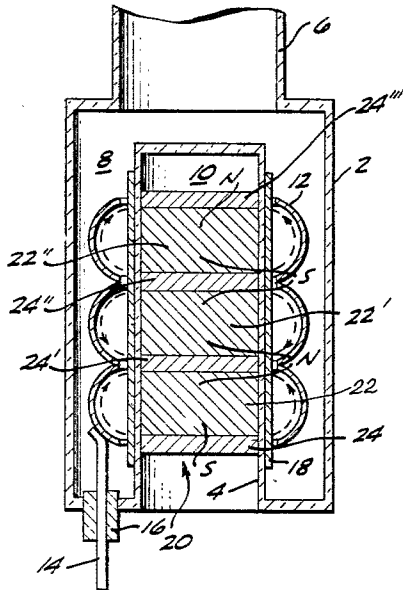


FIG. 2.

FIG. 4.

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FIG. 5.

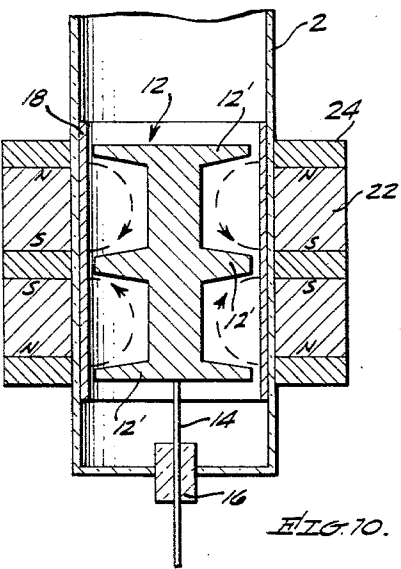
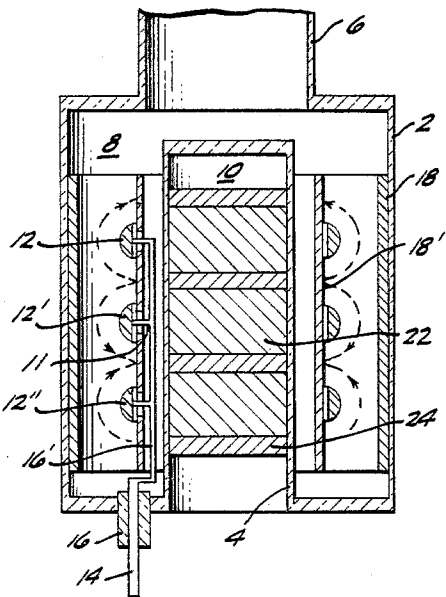


FIG. 8.

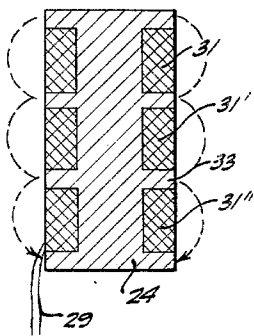


FIG. 7.

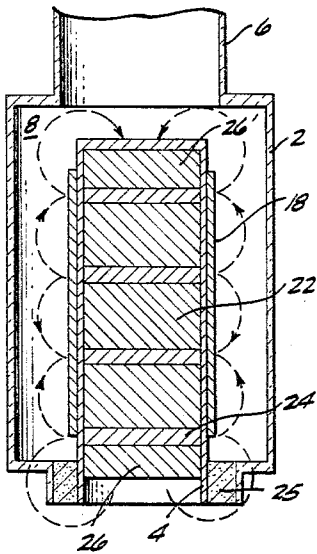
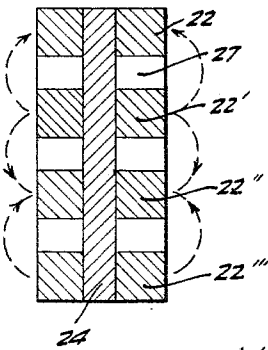


FIG. 6.

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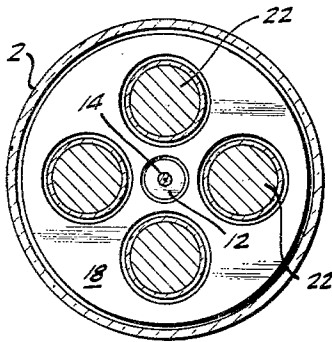


FIG. 12.

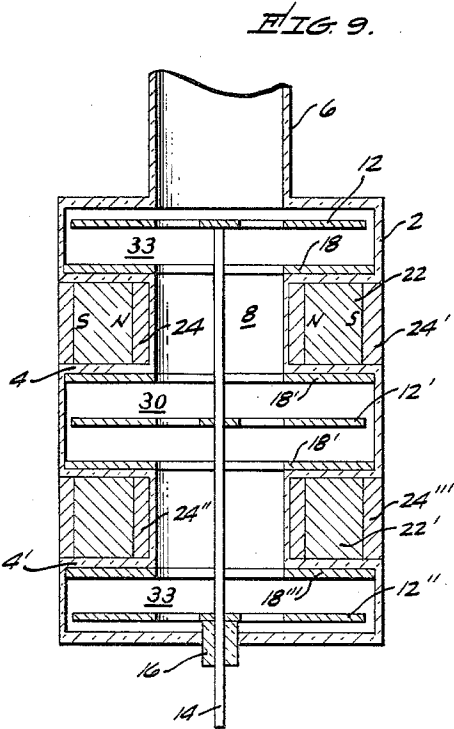


FIG. 9.

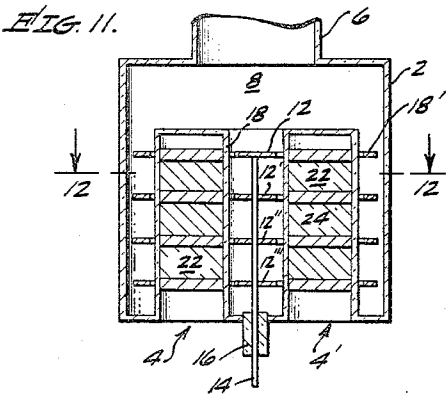


FIG. 11.

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3,216,652

## IONIC VACUUM PUMP

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12 Claims. (Cl. 230-69)

This invention relates to vacuum pumps and more particularly to ionic vacuum pumps wherever high vacuums are provided by removing gases by means of the phenomenon of ionization.

Ionic vacuum pumps are well known for the purpose of establishing high vacuums of the order of  $10^9$  mm. of Hg for example. Such pumps take advantage of the discharge action in a Penning-type discharge cell which results in the removal of gas by absorption in freshly deposited reactive sputter material and also by ion burial. In general such pumps have heretofore comprised a cellular anode structure with straight passageways, mounted between two spaced parallel reactive cathode elements submerged in a substantially linear magnetic field in parallel with the anode passageways. A gas discharge is produced by maintaining the anode structure at a high, positive potential with respect to the cathode. Electrons are then continuously emitted from both cathodes as a result of ion bombardment and the magnetic field confines these electrons to helical paths. The electrons remain trapped in the anode passageways between the cathodes and ionize the gas effectively by collisions therewith. The positive ions which are thus created are accelerated into the cathodes and sputter off some of the reactive material thereon. The sputtered material is then deposited on other surfaces, particularly those of the anode structure. Pump action results from a continuous gettering effect of the continuously deposited reactive material. In some gases such as the noble gases and hydrogen pumping is due also to direct ion burial in both cathodes.

Ionic pumps are desirable inasmuch as they provide vacua entirely free of contaminants such as oil and mercury vapors. A major disadvantage of prior art ionic pumps, however, is their large weight. While modern oil and mercury diffusion pumps weigh as little as 5-10 pounds per 100 L./sec. pump speed, ionic pumps of comparable speed weigh in the order of 100 pounds. Much of this weight is located in the permanent magnets which supply the magnetic fields across the discharge cells. This large magnet weight in prior art ionic pumps is a consequence of the requirement for linear magnetic fields cooperatively associated with straight anode passageways. Magnet configurations which provide such linear fields also generate curved magnetic fields outside of the linear field region and the total magnetic flux contained in the curved field regions is usually a multiple of the flux in the linear region. In a typical magnet configuration for a prior art ionic pump (see U.S. Patent No. 2,993,638 to L. D. Hall et al.), the "leakage" flux, that is, the curved field or outside flux, is approximately 8 times the magnetic flux in the linear field region. Consequently, the magnet weight is approximately 8 times as high as it needs be providing the available flux were fully utilized.

It is therefore an object of the present invention to provide an improved ionic vacuum pump of the Penning-discharge type.

Another object of the invention is to provide an improved light-weight ionic vacuum pump of the Penning-discharge type.

Still another object of the invention is to provide an improved ionic vacuum pump of the Penning-discharge type having a more efficient pumping speed-to-pump weight ratio.

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It is another object of this invention to provide an improved ionic pump of higher electrical efficiency.

It is another object of this invention to provide an ionic pump of less mechanical complexity and smaller size and lighter weight.

These and other objects and advantages of the invention are realized by providing an ionic pump in which the discharge passageways are cooperatively associated with a substantially curved magnetic field, such that a considerable part of the total magnetic flux is located within said passageways.

The invention is based upon the discovery that the Penning discharge is actually a hollow discharge whereby the active discharge region is a plasma sheath which lines the inner surface of the anode passageways, and that this sheath is attached to and follows the anode surface regardless of shape as long as the latter remains parallel to the magnetic fields. Thus the discharge sheath according to the invention is confined within substantially curved magnetic fields by curving the anodes correspondingly. By the invention it is possible to produce a variety of novel and useful discharge configurations with Penning discharge-like behaviour.

The invention will be described in greater detail by reference to the drawings wherein:

FIGURE 1 is an elevational view in section of an ion pump embodying the invention;

FIGURE 2 is an elevational view in section of an ion pump in accordance with the invention illustrating an alternate arrangement of the anode, cathode, and magnetic members thereof;

FIGURE 3 is an elevational view in section of an ion pump in accordance with the invention illustrating still another arrangement of the anode, cathode, and magnetic members thereof;

FIGURE 4 is an elevational view in section of an ion pump in accordance with the invention illustrating a different arrangement of the anode member thereof, in particular;

FIGURE 5 is an elevational view in section of an ion pump in accordance with the invention illustrating still another embodiment of the anode member thereof in combination with a double cathode arrangement;

FIGURE 6 is an elevational view in section of an ion pump in accordance with the invention illustrating an embodiment wherein the pump envelope also constitutes an anode member and means are provided for avoiding stray magnetic field effects;

FIGURE 7 is an elevational view in section of an alternate embodiment of the magnetic field producing means for an ion pump according to the invention;

FIGURE 8 is an elevational view in section of another embodiment of the magnetic field producing means for an ion pump according to the invention;

FIGURE 9 is an elevational view in section of another embodiment of the invention wherein an ionic vacuum pump is provided with a centrally disposed chamber having radially-extending pumping sections connected therewith;

FIGURE 10 is an elevational view in section of another embodiment of an ion pump in accordance with the invention;

FIGURE 11 is an elevational view in section of an embodiment of an ion pump in accordance with the invention having a tapered, centrally-disposed chamber and radially-extending pumping sections communicating therewith; and

FIGURE 12 is a plan view of a section of the pump shown in FIGURE 11 taken along the line 12-12 thereof.

Referring now to FIGURE 1, an ion vacuum pumping apparatus according to the invention is shown as

comprising an outer envelope member 2 having a re-entrant portion 4 at one end thereof and an opening at the opposite end in the form of a coupling tube 6 adapted to be hermetically connected to apparatus from which a gas is to be evacuated. The envelope member 2 may be fabricated from any material capable of providing an airtight enclosure such as glass or steel. For convenience the portion or space 8 within the envelope and surrounding the re-entrant portion 4 will hereinafter be referred to as the pumping chamber and the space 10 within the re-entrant portion 4 communicating to the atmosphere as the magnet chamber. Disposed within the pumping chamber 8 and adapted to surround the re-entrant portion 4 is an anode member 12 illustrated in FIGURE 1 as a corrugated-like cylinder with the concave portions thereof facing and surrounding the re-entrant portion 4. As will be demonstrated hereinafter the anode member may be provided in a variety of shapes and arrangements, the choice thereof being determined by ease and economy of fabrication and the refinement or efficiency of pump operation desired. The anode member 12 may be fabricated of stainless steel, for example. Support for the anode cylinder 12 may be provided by a relatively heavy support rod 14 welded thereto and hermetically secured to and through the outer envelope 2. The support rod 14 may also serve as an electrical connection to the anode member 12. If an electrically conductive material is selected for the envelope member 2, and if the support rod 14 is also utilized as an electrical connection to the anode member 12, means should be provided for electrically insulating the rod 14 from the envelope 2 which means should also be capable of being hermetically sealed both to the envelope 2 and the support rod 14. Such a mounting may be realized by utilizing a header-like member or plug 16 of ceramic material, for example, which is hermetically fused to the envelope 2 and the rod 14 by techniques well known in the art of ceramic-to-metal sealing. Other means may be provided for supporting the anode member 12 such as by rods radially extending from the outer surface of the anode cylinder 12 and received thereto and to the envelope member 2.

Immediately adjacent and around the re-entrant portion 4 and disposed in the pumping chamber 8 is a cathode member 18 which may be of titanium or other reactive material in the form of a cylinder. Alternatively, the cathode member may be provided by a film of reactive material deposited as by evaporation on the interior wall of the re-entrant portion. Any one of a number of suitable reactive materials may be employed for the cathode 18 such as molybdenum, titanium, tungsten, tantalum, niobium, zirconium, barium, thorium, magnesium, calcium, strontium, and even such more common materials as iron and nickel. These materials all possess the property of being disintegratable or sputterable upon ion bombardment for purposes to be explained more fully hereinafter.

Within the re-entrant portion and chamber 10 thereof is provided magnet field-producing means 20. While a plurality of such means is illustrated, this is by no means necessary for operation of the pump according to the present invention and the simplest form of this means may be a single unit. As shown the magnetic field-producing means 20 comprises a number of permanent magnetic members 22, 22', and 22'' which may be in the form of circular disks and fabricated of any suitable magnet material but preferably those capable of establishing the strongest possible magnetic fields. Disposed on both sides of each magnet disk are magnetic shims 24, 24', and 24'' or pole pieces whose function is to provide a flux path for the magnetic lines of force established by the magnets 22, 22', and 22'' whereby the path of these lines of force may be made to assume any desired shape or direction. By providing curved or concave anode portions the Penning discharge sheath can

thus be confined substantially within the curved magnetic fields established by the magnetic members 22, 22', and 22''.

The magnets 22, 22', and 22'' are arranged so that adjacent poles are "like" in magnetic polarity whereby in cooperation with the pole pieces 24, 24', 24'', and 24''' magnetic flux paths are established in the pumping chamber 8 which curve so as to provide complete or closed magnetic circuits as shown by dotted lines. In a typical arrangement magnets of magnet material capable of establishing a magnetic field of up to 1200 gauss in the vicinity of the anode member 12 were provided by magnet disks about 3/4" thick and about 2" in diameter.

In the case of a pump according to the invention capable of pumping at a rate of 5 liters per second, the leakage flux was found to be approximately 50% of the useful flux, which is about 8 times the useful flux of previously known pumps capable of pumping at the same rate.

It will be understood that the magnetic field-producing means 20 may be provided in the re-entrant portion 4 in any convenient manner. One of the advantages of the construction shown in FIGURE 1 is that the magnets and shims may be inserted in the re-entrant portion 4 and removed or replaced therefrom without breaking the hermeticity of the pumping chamber 8. The magnet-shim assembly may conveniently be bolted together by a bolt (not shown) so as to form a unitary assembly to facilitate handling and loading.

Inasmuch as the magnetic flux paths formed by the magnet-shim assembly are curved, the reason for the anode configuration shown in FIGURE 1 will be appreciated as one which utilizes to advantage a substantial portion of the available magnetic flux which, according to the invention, should be provided only in the discharge passageways. This is in marked contrast to ion pumps of the prior art which necessarily provide substantially more magnetic flux outside of the region of discharge, thus accounting for the rather low magnet-weight efficiency which is characteristic of these prior art pumps.

In operation, the ion pump of FIGURE 1 is hermetically connected to apparatus to be evacuated by means of the coupling tube 6 and an electric potential of about 3,000 volts positive with respect to the cathode 18 is impressed upon the anode 12 by means of the support rod 14, for example. A Penning-type discharge is then established in the form of a plasma sheath conforming substantially to the shape of the anode member 12 and substantially coincident with the magnetic flux adjacent thereto. Due to the presence of the magnetic field, the electrons are trapped in the discharge passageways between the concavities of the anode and the cathode which considerably enhances the probability of collisions between these electrons and molecules of the gas to be pumped. The ions formed by these collisions are positively charged and hence are repelled by the positively charged anode member 12 and attracted to the reactive cathode 18. On impact with the cathode, these ions react with or otherwise cause some of the reactive material to sputter-off to the anode and other surfaces which act as a continuous getter for gas molecules. In some instances it may be that the positive ions merely become embedded or entrapped in the cathode reactive material.

Referring now to FIGURE 2, a modification of the ion pump shown in FIGURE 1 is provided wherein an anode structure 12 is shown which is of somewhat less complicated design. That is, the anode structure in FIGURE 2 may comprise a pair of curved rings 12 and 12' to permit greater ease of manufacture. In this embodiment the envelope member is provided with a circular re-entrant portion 4 in the side wall thereof rather than in the end as in FIGURE 1. Mounted in the pumping chamber 8 and on each of the radially extending sides of the re-entrant portion 4 are washer-like cathode members 18 and 18'. The cathode member 18, 18' may com-

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prise flat rings having centrally disposed apertures therein. Curved magnetic fields may be provided in the pumping chamber 8 between the anode and cathode rings by mounting a ring-like magnetic member 22 between a pair of annular shim members 24 and 24". The anode ring members may be supported at their centers by an anode support rod 14 secured to and through the end of the envelope 2 as before. In this embodiment the Penning discharge sheath and the magnetic fields are in line with the envelope axis rather than radially disposed thereto as in FIGURE 1.

In FIGURE 3 another modification of the anode structure is shown wherein the anode surface is substantially coincident with the magnetic field lines. The anode structure of FIGURE 3 comprises a number of spaced anode rings 12 disposed between a pair of concentrically arranged cathode cylinders 18 and 18' and perpendicular thereto. The anode rings 12 may be mounted in electrically conductive relationship on support rods 11 which pass through apertures in the outer cathode cylinder 18 and are in turn secured to another support rod 14 which is secured through the wall of the envelope 2 by ceramic-to-metal sealing member 16, as before. While the rings 12 may be mounted by the rods 11, actually the rings may alternatively be constituted by washer-like members secured to the inner surface of a cylinder.

Referring now to FIGURE 4, another embodiment of a suitable anode structure is shown wherein a cylindrical anode member 12 is provided with internally projecting wedge-shaped lips of washer-like members 15. This structure may be formed by machining the inside of a relatively thick-walled cylinder. It will be appreciated that the configuration of the anode surface between the wedge-shaped lips 15 more nearly approximates that of the curved anode surface inasmuch as non-rectilinear geometry is provided by the wedge-shaped members and the cylinder wall.

From the foregoing embodiments of the invention it will be appreciated that the anode surface adjacent or facing the cathode 18 is shaped so as to either conform to the magnetic lines of force or to be substantially coincident therewith. Embodiments have been shown in which conformity between the anode shape of the magnetic lines of force is optimum as well as less than optimum so as to provide simpler structures which may be more economical or less difficult to manufacture.

Referring now to FIGURE 5 another embodiment of the ion pump according to the invention is shown which provides enhanced pumping speed. In this embodiment the anode structure is provided between a pair of cathode members 18 and 18' which may be in the form of a pair of cylinders having different diameters whereby the smaller cylinder 18' is provided around and near the re-entrant portion 4 and the larger cylinder 18' is provided near the inner surface of the external envelope 2 so as to surround and be concentric with the inner cylinder 18' and equidistant therefrom. In this arrangement the anodes 12 may be ring shaped or in the form of semi-toroids. These rings are so mounted as to provide anode surfaces substantially within the magnetic lines of force. The rings may be mounted between the cathode members 18 and 18' by a support rod 16' secured to the rod 14 which penetrates the envelope wall 2. The support rod 16' extends upwardly within the pumping chamber 8 between the re-entrant portion 4 and the inner cathode cylinder 18'. The anode rings or toroids 12, 12' and 12'' are secured to the support rod 16' by means of mounting rods 11 which may be welded to the support rod 16' and to the anode rings. The inner cathode ring 18' may be provided with openings therethrough to permit the mounting rods 11 to extend therethrough to support the anode rings.

In FIGURE 6 another modification of the ion pump according to the invention is shown. In this embodiment the outer envelope wall 2 may be of electrically conduc-

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tive material so as to permit the outer wall to function as an anode as well as a chamber wall. Likewise the re-entrant portion 4 may also be of electrically conductive material with the cathode 18 mounted directly thereon in electrically conducting relationship therewith, the re-entrant portion 4 being hermetically sealed at one end thereof to the end portion of the outer envelope 2 by means of a ceramic insulator member 25. One feature of this construction is the possibility of applying extremely high negative voltage potentials to the cathode while maintaining the anode at ground potential. This is possible inasmuch as no lead need be brought through the anode structure as in other embodiments. In addition, this embodiment illustrates how end-effects from the magnetic stack may be avoided by utilizing extra magnetic members or disks 26 and 26' at the ends of the magnetic disk-shim assembly as shown. It is also possible to eliminate such end effects by utilizing a large pole piece in combination with a magnetic disk which is  $\frac{1}{2}$  the normal magnetic disk width, the combination being disposed at each end of the magnetic stack.

In FIGURE 7 an alternate arrangement of the magnetic stack is shown in which the number of magnetic shims 24 may be reduced, only one common pole piece being required. In this arrangement the magnet disk 22, 22', 22'', and 22''' are provided with a central aperture through which the pole piece 24 is inserted. The magnetic disks may be mounted on the pole piece 24 by a force-fit so as to provide an air space 27 therebetween. Alternatively the air space 27 may be occupied by non-magnetic support rings if desired.

In FIGURE 8 another magnetic arrangement is shown whereby the magnetic lines of force are provided by electro-magnetic means. This is accomplished by providing a pole piece 24 having radially extending lips 33 integral with the pole piece 24. Electro-magnetic coils 31, 31' and 32'' are then disposed around the pole piece 24 and between the radially extending portions 33 so as to provide a plurality of magnetic fields as shown. It will be appreciated that this arrangement permits a readily controllable variation of the intensity of the magnetic lines of force which may be desirable in some applications.

Except for the embodiment of the invention described in connection with FIGURE 2, the re-entrant portions have been disposed in the envelope 2 so that the major axis of each portion has been parallel to the major axis of the envelope. For convenience such disposition may be referred to as "in-line." Likewise in most of the previous "in-line" configurations, the anode and cathode members have also been "in-line." Referring now to FIGURE 9 an arrangement is shown wherein the "in-line" configuration is not followed and the anode and cathode members and re-entrant portions are "tilted" or at right angles to the major axis of the pump envelope. In this embodiment circular re-entrant portions 4 and 4' are provided in the wall of the envelope 2 and coaxially therewith. Disposed in the re-entrant portion 4 and around the inner wall thereof is an annular shim member 24'. Likewise positioned in the re-entrant portion 4' are inner and outer annular shim members 24'' and 24''' and an annular magnet member 22'. By this arrangement the magnetic paths established are principally in the spaces 30 and 33 between the annular re-entrant portions 4 and 4' and between each of these portions and the ends of the envelope 2 respectively.

Cathode members are provided in the form of circular plates 18, 18', 18'' and 18''' in the pump spaces 30 and 33 within the envelope and coaxial therewith. These cathode plates may be mounted on the walls of the re-entrant portions 4 and 4' as shown and are provided with central apertures through which an anode support rod 14 passes. Circular anode plates 12, 12', and 12'' are mounted on the support rod 14 so that the anode plate 12' extends therefrom within the space 30 intermediate

the re-entrant portions themselves, and the anode plates 12 and 12'' extend therefrom within the spaces 33 between each re-entrant portions and the end walls of the container 2. The anode plates 12, 12' and 12'' are provided with a series of apertures disposed around central portions thereof and around the support rod 14 so as to permit the gas to be pumped to flow throughout the pumping spaces in the container 2.

In FIGURE 10 a construction is shown in which the re-entrant portions in the container 2 have been eliminated. In the apparatus of FIGURE 10 the shims 24 and magnet members 22 are mounted or secured around the exterior walls of the container 2. The reactive cathode member 18 is in the form of a cylinder disposed inside and adjacent the interior walls of the container 2. Disposed coaxially within the container 2 is an anode member 12 comprising an electrically conductive support shaft 14 hermetically sealed to and through the end wall of the container 2 as described before. Anode plates or disks 12' are mounted on the support shaft 14 and extend radially therefrom toward the reactive surface of the cathode cylinder 18. The sides of the anode disks which face another may be tapered as shown to approximate curved anode surfaces therebetween and the magnet and shim members are so disposed as to establish substantially curved magnetic fields adjacent the curved anode surfaces thus provided.

In FIGURES 11 and 12 another embodiment of an ion pump is shown in which a plurality of "in-line" re-entrant portions 4 and 4' are provided. In this embodiment the envelope may be metallic and each re-entrant portion is shown as constituting a cylindrical cathode member 18 and 18', respectively. Circular anode plates 12, 12', 12'' and 12''' are mounted on an anode support rod 14 which extends through the container 2 and is coaxial therewith. By this arrangement it will be appreciated that the anode surfaces are at right angles to the cathode surfaces.

The anode plates are provided with apertures whereby they may be mounted in the envelope 2 and adapted to permit the re-entrant portions to extend therethrough at right angles to the plane of the plates. In this manner any number of re-entrant portions may be provided such as four as shown in FIGURE 12.

There thus has been shown and described novel ionic vacuum pumps of the Penning-discharge type which are of light weight and have a more efficient speed-to-pump weight ratio. In addition a number of alternative embodiments of the ionic vacuum pump have been shown and described which permit a marked freedom in design, complexity, size and capacity in the manufacture thereof.

What is claimed is:

1. An ionic pump comprising a first chamber being adapted to be connected to apparatus to be evacuated, and a second chamber extending into said first chamber, an anode member within said first chamber, a reactive cathode member within said first chamber, and magnetic field-generating means disposed in said second chamber and including means providing a substantially curved magnetic field between said anode and cathode members within said first chamber.

2. The invention according to claim 1 wherein said anode member has a curved surface and said magnetic field-generating means is adapted to provide said curved magnetic field substantially parallel to said curved anode surface.

3. An ionic pump comprising a first chamber being adapted to be connected to apparatus to be evacuated and a second chamber extending into said first chamber, a first member providing an anode surface within said first chamber, a second member providing a reactive cathode surface within said first chamber, and magnetic field-generating means disposed in said second chamber and including means providing a substantially curved magnetic

field between said anode and cathode surfaces with said first chamber.

4. An ionic pump comprising a first chamber being adapted to be connected to apparatus to be evacuated and a second chamber extending into said first chamber, a curved anode member within said first chamber, a reactive cathode member within said first chamber, and magnetic field-generating means disposed in said second chamber and including means providing a substantially curved magnetic field between said anode and cathode members and parallel to said curved anode member.

5. An ionic pump comprising an envelope for forming an hermetically sealable chamber having a re-entrant portion therein, said sealable chamber being adapted to be connected to apparatus to be evacuated, a first member having a surface of reactive material disintegrable by ion bombardment disposed within said sealable chamber, a second member disposed within said sealable chamber for collecting disintegrated reactive material from said first member, and magnetic means disposed within said re-entrant portion for establishing a substantially curved magnetic field between said first and second members within said sealable chamber.

6. The invention according to claim 5 wherein said second member has a curved surface and said curved magnetic field is parallel to said curved surface.

7. An ionic pump comprising a container for forming an hermetically sealable chamber having re-entrant portions therein, said sealable chamber being adapted to be connected to apparatus to be evacuated, magnetic means disposed in said re-entrant portions for establishing magnetic lines of force in said container, magnetic flux path means magnetically coupled to said magnetic means for providing within said sealable chamber a plurality of substantially curved magnetic paths for said magnetic lines of force, a plurality of members providing a plurality of surfaces of reactive material disintegrable by ion bombardment disposed in said sealable chamber, and a plurality of members disposed within said sealable chamber with respect to said plurality of surfaces of reactive material for collecting disintegrated reactive material therefrom.

8. An ionic pump comprising a first chamber being adapted to be connected to apparatus to be evacuated and a second chamber extending into said first chamber, internal surface portions of said first chamber providing an anode member within said first chamber, a reactive cathode member within said first chamber, and magnetic field-generating means disposed in said second chamber and including means providing a substantially curved magnetic field between said anode and cathode members within said first chamber.

9. An ionic pump comprising a first chamber being adapted to be connected to apparatus to be evacuated, and a second chamber extending into said first chamber, a first member within said first chamber having a surface of reactive material disintegrable by ion bombardment, a second member within said first chamber for collecting disintegrated reactive material from said first member, and magnetic field-generating means disposed in said second chamber and including means providing a substantially curved magnetic field between said first and second members within said first chamber.

10. An ionic pump comprising a first chamber being adapted to be connected to apparatus to be evacuated, and a second chamber extending into said first chamber, a first member within said first chamber having a surface of reactive material disintegrable by ion bombardment, a second member within said first chamber for collecting disintegrated reactive material from said first member and having a curved surface, and magnetic field-generating means disposed in said second chamber and adapted to provide a substantially curved magnetic field between said first and second members within said first chamber and parallel to said curved surface.

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11. An ionic pump comprising a container for forming an hermetically sealable chamber having re-entrant portions therein, said sealable chamber being adapted to be connected to apparatus to be evacuated, magnetic means disposed in said re-entrant portions for establishing mag- 5 netic lines of force in said sealable chamber, magnetic flux path means magnetically coupled to said magnetic means for providing within said sealable chamber a substantially curved magnetic path for said magnetic lines of force, a first member having a surface of reactive material disintegrable by ion bombardment disposed in said sealable chamber, and a second member for collecting dis- 10 integrated reactive material from said first member within said sealable chamber in said container.

12. The invention according to claim 11 wherein said 15 second member is provided with portions shaped to correspond to said curved magnetic path.

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*Examiners.*