March 5, 1963 T. A. VANDERSLICE 3,080,104

IONIC PUMP

Filed Sept. 25, 1958

Fig. 1.

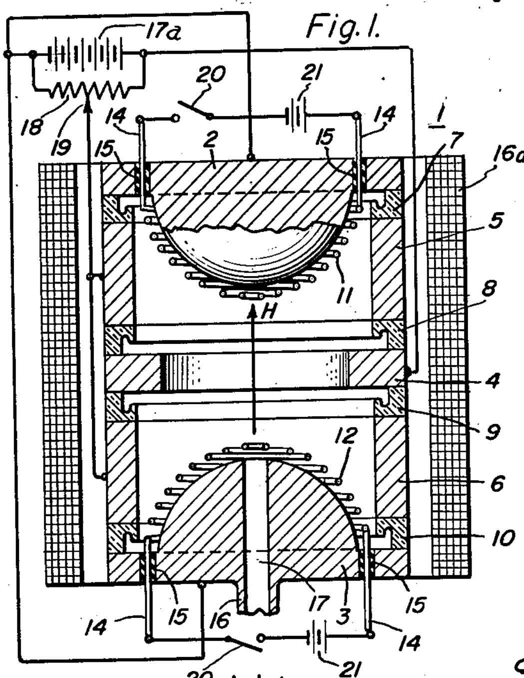


Fig. 2.

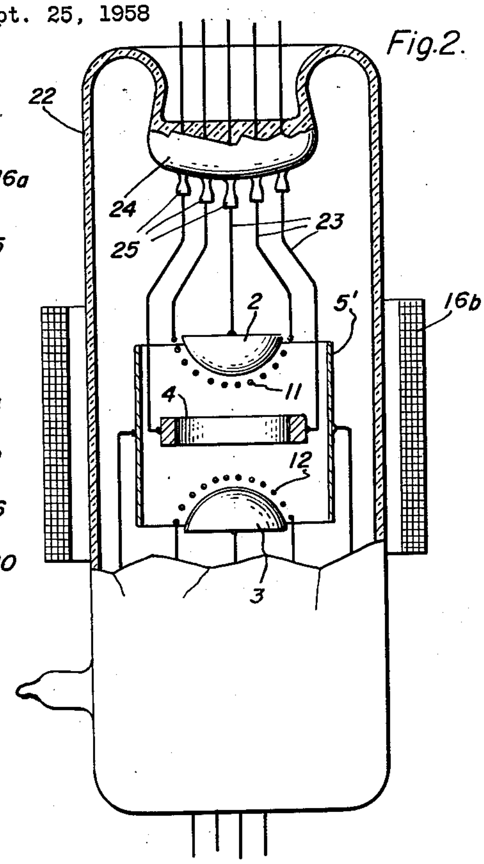


Fig. 4

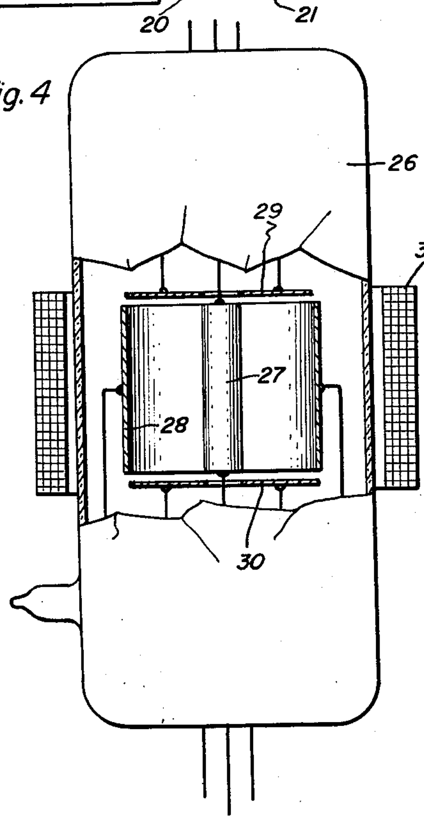
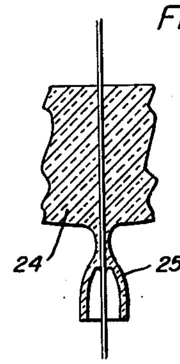


Fig. 3



Inventor:
Thomas A. Vanderslice,
by John F. Ahern
His Attorney.

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IONIC PUMP

Thomas A. Vanderslice, Schenectady, N.Y., assignor to General Electric Company, a corporation of New York

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The present invention relates to ionic pumps for lowering the pressure of evacuated systems to extremely low values.

Ionic pumps, such as is described and claimed in Patent 2,755,014, Westendorp et al., are highly useful in removing gases from low pressure vacuum systems particularly those of limited volumes. These pumps are particularly useful for the removal of inert gases from vacuum systems, since these gases cannot be chemically gettered and thereby removed. Such pumps operate by causing ionizing electrons to traverse elongated curvilinear paths through the pump volume to undergo a large number of ionizing collisions with gaseous molecules. The ions so formed, are then attracted to and embedded into one or more cathode electrodes and are thereby removed from the system.

Although ionic pumps, as described above, are of great utility and function quite satisfactorily to obtain extremely low pressures, the pumping action is somewhat limited by the limited area of the cathode utilized.

Accordingly, it is an object of the present invention to provide improved ionic pumps in which the attainment of low pressures is not dependent upon the area of the cathode.

A further object of the invention is to provide ionic pumps in which a collector electrode provides a surface for cleanup of inert gas particles.

In accord with one feature of my invention, I provide an ionic pump including cathode and anode electrodes located in an area adapted to contain gaseous molecules. Electrons are emitted from the cathode and, under the influence of an impressed magnetic field and the coexistant electric field established between cathode and anode electrodes, describe greatly elongated curvilinear paths. This results in a large number of ionizing collisions with inert gas molecules. The inert gas ions so formed, are accelerated toward the cathode, but are collected by a collector electrode in close proximity thereto. Ions collected by the collector electrode are subsequently covered by deposited cathode material which has been sputtered by the cathode, thus continually presenting a clean absorbent surface for the reception of high energy inert gas ions.

The novel features believed characteristic of the present invention are set forth in the appended claims. The invention itself, however, together with further objects and advantages thereof, may best be understood with reference to the following description taken in connection with the drawing in which:

FIG. 1 is a vertical cross-sectional view of an ion pump constructed in accord with one feature of the present invention,

FIG. 2 is a partially-sectioned vertical view of an alternative embodiment of the device of FIG. 1,

FIG. 3 is a cross-sectional view of a detail of the device of FIG. 2 and illustrates a protective means for the metallic leads thereof, and

FIG. 4 is a partially-sectioned vertical view of an ionic pump constructed in accord with another feature of the present invention.

In FIG. 1, an ionic pump of the disc-seal type constructed in accord with the present invention includes substantially hemispherical cathode members 2 and 3, an apertured anode member 4 and cylindrical collector electrodes 5 and 6 juxtaposed closely adjacent to respective cathode members 2 and 3. Each of the cathode and anode members possesses an annular portion at the periphery thereof, which is of substantially the same diameter as the diameter of cylindrical electrodes 5 and 6. Adjacent electrode members are separated by insulating ceramic annular members which are hermetically sealed to the adjacent members to cause the formation of an evacuable envelope. Thus, for example, cathode member 2 is electrically separated from and hermetically sealed to collector electrode 5 by an annular member 7, collector electrode 5 is electrically separated from and hermetically sealed to anode member 4 with annular insulating member 8. Anode member 4 is likewise electrically separated from and hermetically sealed to collector electrode 6 by annular insulating member 9 and collector electrode 6 is electrically separated from and hermetically sealed to cathode member 3 by insulating member 10. Each of insulating members 7, 8, 9 and 10 have cross-sectional areas which define a re-entrant portion having a surface which is not in line-of-sight relationship with any active surface portion of cathodes 2 and 3. This is achieved in the device of FIG. 1 by causing a counterbore to be cut in the annular insulating members and cutting a recessed annulus in the base of each counterbore. Suitable thermionic filaments 11 and 12 may, if desired, be located in close juxtaposition to the hemispherical surfaces of cathodes 2 and 3. If thermionic filaments 11 and 12 are included, the entrance of electrical connections 14 thereto is achieved by passing these leads through suitable insulated, hermetically sealed apertures 15 in the disc-shaped portion of cathode members 2 and 3 respectively. Access to the ion pump, suitable for connecting the device to a vacuum system, the pressure of which is to be lowered to an extremely low value, is achieved by means of tubulation 16 which is connected with an orifice 17 in one of cathode members 3.

A magnetic field, substantially normal to the plane of anode member 4 and indicated schematically by arrow H, is provided by electromagnetic coil 16*a*. Alternatively, a cylindrical permanent magnet, properly demensioned so as to slip over the cylindrical envelope formed by the metallic and ceramic members comprising ion pump 1 and properly insulated therefrom so as not to short circuit the electrodes thereof, may be utilized.

Operating potentials are supplied by a unidirectional voltage source as indicated generally by battery 17*a* and potentiometer 18. Anode member 4 is biased positively with respect to cathode members 2 and 3 to a potential of several thousand volts. Collector electrodes 5 and 6 are biased positively with respect to cathode members 2 and 3 but negative by a value of several hundred volts with respect to anode member 4 by connection to center tap 19 on potentiometer 18.

Alternatively, a suitable alternating current voltage source may be substituted for unidirectional voltage source 17*a*. A suitable value for the magnetic field strength, H, may be from several hundred to several thousand oersteds.

Electrode members 2 and 3 are constructed of an active metal which is a good getter for chemically active gases and which further possesses the characteristic of being readily sputtered under positive ion bombardment. Such materials include titanium, zirconium, hafnium, and like materials. Likewise anode 4 is preferably constructed of such material, although, since no sputtering occurs from the anode the anode may very well be constructed of other materials. Anode electrode 4 may constitute an apertured disc as is illustrated in FIG. 1 or may, alternatively, comprise a honeycomb structure which contains a plurality of apertures. It is only necessary that anode 4 be permeable to the majority of electrons attracted thereto from cathodes 2 and 3. Preferably, anode 4 and collector electrodes 5 and 6, as well as cathodes 2 and 3 are composed of titanium metal so that annular insulating members 7, 8, 9, and 10 may be composed of a suitable titanium-matching ceramic as, for example, a forsterite disclosed and claimed in application S.N. 546,215, Pincus, filed Nov. 10, 1955, now Patent No. 2,912,340, issued November 10, 1959 and assigned to the assignee of the present invention. Assembly may be as described in the copending Lafferty application 690,849, filed October 17, 1957, now Patent Number 2,957,751, issued October 25, 1960 and assigned to the present assignee.

In the operation of the device of FIG. 1, when voltages as indicated hereinbefore are applied and a relatively low pressure as, for example, below 10^{-3} mm. of mercury of gas is obtained within the device, a discharge is initiated between cathodes 2 and 3 on one hand and anode 4 in the other hand. Due to the fact that the electrons emitted by cold emission from the cathodes are subjected to parallel electric and magnetic fields, the electrons approach the anode from the cathode with a helical motion. Since the anode is apertured and preferably comprises a ring, and since most of the electron flux is concentrated at the center of the device away from the periphery of the ring anode by the magnetic field, most of the electrons emitted from cathodes 2 and 3 will pass through the ring anode and will approach the opposite cathode, from which they are repelled. The electrons, therefore, oscillate back and forth between the two cathode electrodes and execute elongated curvilinear paths due to the parallel electric and magnetic fields. In executing such elongated curvilinear paths, each electron has a high probability of undergoing an ionizing collision with a gaseous molecule. Eventually, however, any particular electron is collected at the anode. Ionizing collisions between an electron and a molecule causes the creation of a positive gas ion and a freed electron which is also accelerated in an elongated curvilinear path and may enter into an ionizing collision. The positive ions created by such collisions, while likewise affected by the electric and magnetic fields, because of their great mass, are accelerated directly toward the nearest cathode and strike the cathode with a force of the order of 10^3 electron volts. These collisions of ions with the cathode cause metallic particles of the cathode material to be ejected by cathode sputtering therefrom and to enter the space between the tube walls. Due to the high current density at the point where most positive ions strike the cathode, the positive ions are generally ejected therefrom by further collisions of positive ions with the cathode. The space within the ionic pump of FIG. 1 is, therefore, filled with a large number of positive ions and sputtered metallic particles which originate from the cathode. Both of these materials are eventually attracted to collector electrodes 5 and 6. Positive ions are attracted to electrodes 5 and 6 because these electrodes are negative with respect to the electron-ion plasma and the attraction is that of an electric field. Sputtered metallic particles from the cathode migrate to colector electrodes 5 and 6, not because of any electrical attraction, but because of the proximity of these electrodes to the cathode and the high probability of incidence thereupon because of the substantially hemispherical nature of the cathode surface. This surface, therefore, while preferably hemispherical may be any curved or discontinuous shape which directs sputtered metallic particles to the collector electrodes.

Since the collector electrodes 5 and 6 are only several hundred volts, or thereabout, negative with respect to the electron-ion plasma, the positive ions attracted thereto do not impinge thereupon with extremely high energy so as to cause the material thereof to be sputtered. The potential of the collector electrodes is deliberately chosen to be sufficiently negative with respect to the plasma to attract positive ions, but insufficiently negative to cause these ions to impinge upon the collector with sufficient force to cause any substantial sputtering thereform. Thus, postive ions attracted to collector electrodes 5 and 6 remain at the surface thereof until they are covered by sputtered cathode material. Once this occurs, the positive ions are completely removed from the pump volume, lowering the gas pressure therein. Concurrently, the metal sputtered upon collector electrodes 5 and 6, while covering up positive ions resting upon the surface thereof, presents a clean surface which is ready to receive further attracted positive ions.

In the manner described above, it may readily be seen that devices constructed in accord with the present invention function by the concurrent and continued processes of attraction of positive ions to the collector electrodes and the covering of these collected positive ions by metallic particles sputtered from the cathode. Devices constructed in accord with the present invention are capable, therefore, of removing a large number of positive ions even of inert gases from a vacuum system and for pumping for great lengths of time, since the buildup of sputtered metal upon collector electrodes 5 and 6 is infinitesimal insofar as the dimensions of the device are concerned.

For the operation of devices in accord with the present invention as, for example, the device illustrated in FIG. 1, it is not necessary that filaments 11 and 12 which may, for example, be composed of a highly electron emissive material such as tungsten wire, be utilized. At pressures down to approximately 10^{-8} mm. of mercury, a sufficient number of electrons are created by ionizing collisions of electrons with gas molecules and by the impingement of high energy ions upon the cathodes, causing the emission of secondary electrons, to sustain the discharge between cathodes 2 and 3 on one hand and anode 4 on the other hand. When, however, pressures below 10^{-8} mm. of mercury are reached, under certain circumstances, these processes may not be sufficient to maintain a discharge of sufficient current density to pump at a satisfactory rate. In this instance, it becomes desirable in order to reach lower pressures in a short period of time that an auxiliary source of electrons sufficient to cause ionizing collisions be provided. Such an auxiliary source of electrons may be provided by energizing either thermionic emitting filaments 11 or 12 by closing either of switches 20 to connect a suitable source of potential represented generally by batteries 21 across the energized filament. Either one or both filaments may be energized. Since the area of these filaments is relatively small with respect to the area of cathodes 2 and 3, the filaments have little effect upon the operation of the device other than to provide an auxiliary source of electrons, when neded, to allow the attainment of extremely low pressures as, for example, 10^{-12} mm. of mercury. It will be appreciated, however, that thermionic filaments are not necessary for the operation of the devices.

In FIG. 2 of the drawing there is illustrated an alternative embodiment of the device of FIG. 1 wherein a conventional glass or other vitreous envelope structure is utilized rather than the metal and ceramic disc-seal type construction of the device of FIG. 1. In FIG. 2, cathode electrodes 2 and 3 and anode electrode 4 have the same configuration and spatial arrangement as in the device of FIG. 1. Collector electrode 5, however, comprises a continuous cylindrical member which is in close juxtaposition to both of cathodes 2 and 3, and is substituted for the two collector electrodes 5 and 6 of the device of FIG. 1. Magnet *16b* which may be either an electromagnet or a metallic permanent magnet which slips closely over the glass envelope 22 enclosing the elements, establishes a magnetic field which is substantially normal to the plane of anode 4 and performs the same function as in the device of FIG. 1. Lead and support members 23 pass through the re-entrant portion 24 of envelope 22 as is conventional in glass electron discharge devices.

A breakdown shield 25 is built up upon each of members 23 to prevent electrical breakdown occurring from the point at which these members enter into re-entrant glass portion 24 of envelope 22.

The device of FIG. 2 is connected in circuit identically as the device of FIG. 1 and functions substantially the same, the important difference being that the envelope is a vitreous material such as glass rather than ceramic and metal, and that the collector electrode is single unitary cylindrical member rather than the plurality of electrodes of the device of FIG. 1.

In FIG. 3 of the drawing there is shown in greatly amplified detail the breakdown-preventing members 25 which are mounted upon lead and support members 23. As may be seen from the detail of FIG. 3, breakdown members 25 comprise a re-entrant glass member entirely surrounding the lead wire and connected with the re-entrant portion 24 of envelope 22.

In FIG. 4 of the drawing there is represented, in a partially sectioned vertical view, another alternative embodiment of the invention. The device of FIG. 4 includes an evacuable glass or other vitreous envelope 26, having therein a cathode electrode 27, a cylindrical anode electrode 28, concentric with and surrounding cathode 27, and a pair of disc shaped collector electrodes 29 and 30 positioned at the ends of anode cylinder 28. A cylindrical magnet 31, which may be either a permanent magnet or an electromagnet, is positioned about the central portion of evacuable envelope 26 and is poled so as to produce a magnetic field substantially parallel with the longitudinal axis of cathode electrode 27. Cathode electrode 27 is, in this embodiment, a thermionic cathode and is heated to thermionic emission temperatures, either by the passage of a high current therethrough or by a heater filament enclosed in the center thereof. In any instance, cathode 27 is constructed of a material which is readily sputtered and is conveniently constructed of titanium, zirconium, hafnium and like materials as are the cathodes of the devices of FIGS. 1 and 2. Anode and collector electrodes need not be of any particular material and may conveniently comprise nickel, fernico, iron or any material suitably used for the electrodes of electron discharge devices.

Cathode, anode and collector electrodes of the device of FIG. 4 are biased similarly to the analogous electrodes of the device of FIG. 1, so that the anode is maintained several thousand volts positive with respect to the cathode and the collector electrode is several hundred volts negative with respect to the anode electrode. The strength of the magnetic field maintained within the volume defined by the anode electrode may be several hundred oersteds and is adjusted so that the tube operates as a magnetron, biased to cutoff. That is to say, electrons thermionically emitted from the cathode are subjected to crossed electric and magnetic fields and spiral around the cathode in circular paths so as to just miss impinging upon the anode cylinder. This curvilinear path increases the probability of ionizing collisions of electrons with gas molecules between the time they are ejected from filament 27 and collected by anode 28. Collector electrodes 29 and 30 are positioned in close juxtaposition to the cathode and properly biased to collect positive ions of inert and other gases formed by electron-gas molecules collisions and to collect metal sputered from cathode 27 as are the collector electrodes of the devices of FIGS. 1 and 2. The main difference in the device of FIG. 4 as compared with the devices of FIGS. 1 and 2 is that this device uses crossed electric and magnetic fields and magnetron operation whereas the devices of FIGS. 1 and 2 utilize an oscillating plasma discharge. Although the advantages of the invention are gained in the embodiment of FIG. 4, an arrangement of electrodes as in FIGS. 1 and 2 is preferred because of the longer electron paths, greater cathode area and higher probability of sputtered metal reaching the collector electrode.

It is evident, from the foregoing, that there has been disclosed, in several distinct embodiments, ionic pumps capable of pumping evacuated systems down to extremely low pressures, even as low as 10^{-12} mm. of mercury pressure utilizing the concept of a cathod, an anode and negatively biassed third electrode positioned in close juxtaposition to a cathode which is composed of a readily sputterable material. Electric and magnetic fields are properly impressed thereupon so that electrons passing between cathode and anode electrodes describe greatly elongated curvilinear paths to cause a large number of ionizing collisions. I have found from actual experimental and developmental work that positive ions collected upon surfaces such as the negatively biased (with respect to the electron-ion plasma) collector electrodes of the devices of FIGS. 1, 2 and 4 are rapidly covered by sputtered cathode material which constantly presents a fresh surface for the deposition of newly collected positively charged inert gas molecules. Operating in this fashion, the devices of the present invention make it possible to obtain extremely low pressures heretofore obtainable with ionic vacuum pumps.

While the invention has been set hereinbefore with respect to specific embodiments, many modifications and changes will readily occur to those skilled in the art. Accordingly, by the appended claims, I intend to cover all such modifications and changes as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an apertured cylindrical anode member; a pair of apertured cylindrical collector electrode members disposed on opposite sides of said anode member and coaxial therewith, a pair of cathode members each having a disc-shaped peripheral portion disposed on opposite sides of said collector electrode members and forming end-wall members for said device; a plurality of annular insulating ceramic members interposed between said cathode members and said collector electrode members and between said collector electrode members and said anode member respectively and hermetically sealed thereto to form an hermetically sealed envelope; means for supplying operating potentials to each of said cathode, anode and collector electrode members to cause an oscillating electron discharge to exist between said cathodes and the subsequent creations of positive ions thereby by collision with gas molecules, which ions are attracted to said collector electrode members and covered by metallic particles sputtered from said cathode members; and means connected to said envelope for connecting said pump device to a cavity to be evacuated thereby.

2. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an evacuable envelope having means for connecting said device to a volume to be evacuated; a cathode member having a cylindrical surface of substantial area sufficient to serve as a source from which accelerated positive ions may eject metallic particles by sputtering upon collision therewith and extending along the longitudinal axis of said envelope; an anode member having a cylindrical surface within said envelope coaxial with and external of said cathode member; a pair of ion collector electrode members electrically insulated from said cathode and anode members substantially closing the ends of an annular space defined within said envelope by said cathode and anode member and serving as a repository for positive ions and metallic particles sputtered from said cathode; means for applying a magnetic field within said device longitudinally along said axis so that electrons emitted by said cathode member execute elongated curvilinear paths and enter into ionizing col-

lisions with gas molecules contained within said envelope creating positive ions which are attracted to and retained by said collector electrode member and subsequently covered by metallic particles sputtered from said cathode members to thereby reduce the pressure within said envelope and conductive means for connecting suitable operating potentials to said cathode, anode, and ion collector members.

3. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an evacuable envelope defining a space adapted to contain gas molecules; means for connecting said envelope to an enclosure to be evacuated; means providing ionized gaseous molecules within said space, said means including cathode means adapted to sustain a cold electron discharge and to serve as a continuous source of sputtered particles when bombarded by high velocity positive ions, and anode means, each of said cathode and anode means including active surfaces located within said envelope between which electrons may pass to cause ionization of said gas molecules; means for establishing a magnetic field in said space to cause the path of electrons passing between said cathode means and anode means to be greatly elongated so as to permit a large number of ionizing collisions between electrons and gas molecules; ion collector means electrically insulated from said cathode means and said anode means, located adjacent to said cathode means, providing an electrode-free space therebetween, and including a substantial surface for the deposition of positive ions and metallic particles sputtered from said cathode means, said anode means being located within said envelope at a position outside of said electrode-free space so as to sustain an oscillating discharge without electrically shielding said ion collector means from said discharge and impeding the free flow of positive ions from said discharge to said ion collector means; and means for applying operating potentials to each of said cathode, anode and ion collector means to cause metallic particles to be continuously sputtered from said cathode means and deposited upon said collector means to thereby cover positive gaseous ions which are electrically attracted thereto from said discharge space.

4. The ionic pump device of claim 3 wherein the means for applying operating potentials maintains said ion collector means at a potential which is sufficiently negative with respect to said anode means as to attract positive ions thereto and sufficiently positive with respect to said cathode means as to prevent positive ions being attracted thereto with a velocity sufficient to cause a substantial sputtering of metallic particles therefrom.

5. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an evacuable envelope defining a space adapted to contain gas molecules; means for providing ionized gas molecules within said space, said means including a pair of oppositely disposed cathode members and an anode member located therebetween and apertured to permit electrons to oscillate between said cathode members, each of said cathode members and said anode member having an active surface located within said envelope and defining therein, a discharge space, said cathode members being of substantial area and comprising an easily sputtered metal; means for establishing a magnetic field within said discharge space to cause the path of electrons passing between said cathode and said anode members to be greatly elongated so as to permit a large number of ionizing collisions between electrons and gas molecules; ion collector means located adjacent to said cathode members, providing an electrode-free space between said means and each of said cathode members, and forming a surface for the deposition of positive ions and metallic particles sputtered from said cathode members; means for maintaining said anode member at a potential positive with respect to said cathode members to cause said positive ions to bombard said cathode members and cause the ejection of metallic particles therefrom, said anode member being spaced between said cathode members outside of said electrode-free space so as to sustain an oscillating electron discharge therebetween without electrically shielding said ion collector means from said discharge space; and means for maintaining said ion collector means at a potential positive with respect to said cathode members and negative with respect to said anode member to cause the removal of gases from said space by the unimpeded attraction of positive ions from said discharge space to said collector means from said discharge space and the subsequent covering of said positive ions by said metallic particles sputtered from said cathode members and deposited upon said ion collector means.

6. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an evacuable envelope defining a space adapted to contain gas molecules; means for connecting said envelope to an enclosure to be evacuated; means for ionizing said molecules, said means including a pair of oppositely disposed cathode members both comprising an easily sputtered metal and adapted to sustain a cold electron discharge and to serve as continuous sources of sputtered particles when bombarded by high velocity positive ions, and an anode member located therebetween and apertured to allow electrons to pass therethrough, said cathode members and said anode member each having an active surface within said envelope and defining therewith a discharge space; means for establishing a magnetic field within said discharge space substantially normal to the plane of said apertured anode member to cause electrons passing between anode and cathode members to follow greatly elongated curvilinear paths, thus facilitating a large number of ionizing collisions between electrons and gas molecules; a substantially cylindrical collector electrode electrically insulated from, and juxtaposed adjacent to each of said cathode members and providing an electrode-free space therebetween, said collector electrode being adjacent and contiguous with said discharge space so as to permit free and unimpeded flow of positive ions from said discharge space to said collector electrode; means applying a potential to said anode member positive with respect to said cathode members to cause an oscillating electron discharge to be established between said cathodes and subject said cathodes to continuous positive ion bombardment causing the continuous sputtering of metallic particles therefrom; and means applying a potential to said collector electrode positive with respect to said cathode member and negative with respect to said anode member to cause positive ions to be attracted thereto from said discharge space and subsequently covered over by material sputtered from said cathode members.

7. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an evacuable envelope having means for connecting said device to a volume to be evacuated; a pair of oppositely disposed cathode electrode members within said envelope adapted to sustain a cold electron discharge and serve as a continuous source of sputtered metallic particles when bombarded by positive ions; an apertured anode electrode member spaced intermediate between said cathode electrode members to allow electrons to oscillate therebetween and defining with said cathode electrode members, a discharge space; means for establishing a magnetic field longitudinal of an axis of said device connecting said cathode electrode members to cause electrons oscillating between said cathode electrode members to describe curvilinear paths which favor a high probability of electron-gaseous molecule collisions; a pair of ion collector means electrode members one adjacent to each of said cathode

electrode members providing an electrode-free space between each of said cathode electrode members and the adjacent collector electrode member, and for collecting positive ions created by electron-gaseous molecule collisions to thereby reduce the pressure within said envelope; and means applying operating potentials to said anode and cathode electrode members and to said collector electrode members to cause an oscillating electron discharge to exist between said anode and said cathode electrode members, which discharge results in the bombardment of said cathode electrode members with a continuous stream of positive ions resulting in an ejection of sputtered metallic particles therefrom which particles are deposited upon said ion collector electrode members covering the positive ions which are attracted thereto from said discharge space to reduce the gaseous pressure within said device, said anode member being spaced between said cathode members outside of said electrode-free space so as to sustain an oscillating electron discharge therebetween without electrically shielding said collector electrode members from said discharge space.

8. An ionic pump device adapted to remove gases from an enclosure by the mechanism of entrapment of positive ions by sputtered metallic particles and comprising: an evacuable envelope defining a space adapted to contain gas molecules; means for connecting said envelope to an enclosure to be evacuated; means for ionizing said molecules, said means including a pair of oppositely disposed cathode members comprising an easily sputtered metal and both adapted to sustain a cold electron discharge and to serve as continuous sources of sputtered particles when bombarded by high velocity positive ions, and an anode member located therebetween and apertured to allow electrons to pass therethrough, said cathode and said anode members each having an active surface located within said envelope and defining therein a discharge space; means for establishing a magnetic field in said discharge space substantially normal to the plane of

said apertured anode member to cause electrons passing between anode and cathode members to follow greatly elongated curvilinear paths, thus facilitating a large number of ionizing collisions between electrons and gas molecules; a pair of collector electrodes one of which is electrically insulated from and juxtaposed adjacent to each of said cathode members and providing an electrode-free space therebetween; means for maintaining said anode member positive with respect to said cathode members to cause an electron discharge to be established between said cathodes to subject said cathodes to continuous positive ion bombardment and causing the continuous sputtering of metallic particles therefrom, said anode member being positioned between said cathode members outside of said electrode-free space so as to sustain an oscillating electron discharge therebetween without electrically shielding said collector electrodes from said discharge space; and means for maintaining said collector electrodes sufficiently positive with respect to said cathode members and sufficiently negative with respect to said anode member to cause positive ions to be attracted thereto at a velocity which is insufficient to cause substantial sputtering of particles therefrom from said discharge space and subsequently covered over by material sputtered from said cathode members.

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