Sept. 26, 1967 W. H. HAYWARD 3,343,780

VACUUM PUMP APPARATUS

Filed March 5, 1965

FIG. 1

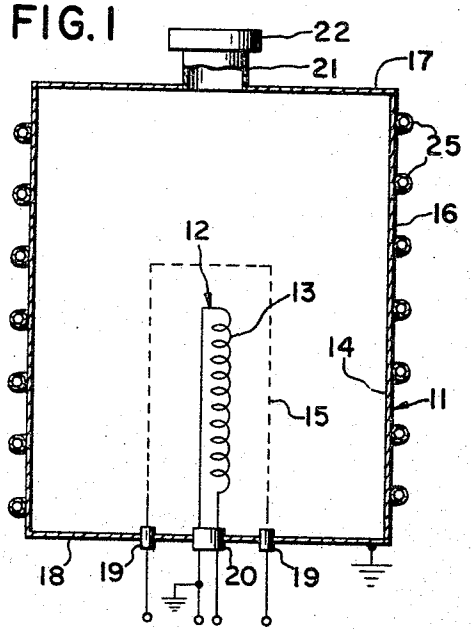


FIG. 3

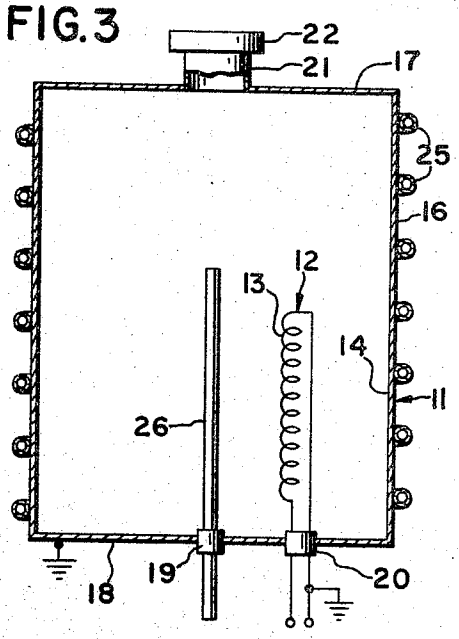


FIG. 2

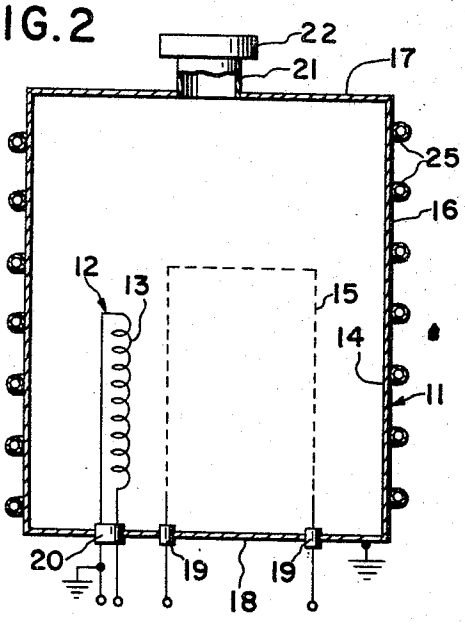
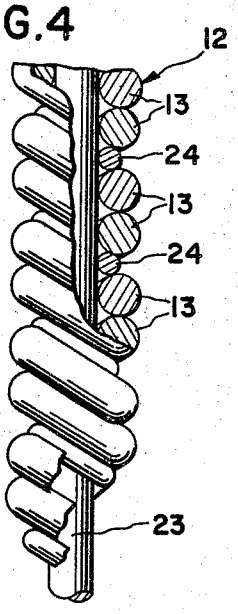


FIG. 4



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VACUUM PUMP APPARATUS

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ABSTRACT OF THE DISCLOSURE

An ion-getter vacuum pump. A titanium-wrapped filament electrode in the pump envelope is electrically heated causing both thermionic emission of electrons and sublimation of the titanium. A second electrode is used to cause the emitted electrons to travel long paths within the envelope to increase the probability of collision with gas molecules and the production of ions of gas. The ions deposited on the walls of the envelope where they are gettered or buried by condensing titanium.

The present invention relates to vacuum pump apparatus and particularly to such apparatus employing sublimation and ionization techniques.

Pumping by thermally evaporating or subliming getter materials onto the internal walls of a housing, suitably forepumped, has been well known for many years. Gas molecules coming into contact therewith combine chemically or physically with the condensed material and are removed from the gaseous state so as to reduce the pressure. Using pumping apparatus of this type, extremely high pumping speeds have been achieved, in excess of 3500 liters/sec., for the active gases such as O_2, N_2, CO, and CO_2, which can be scaled up as the need arises.

Sublimation pumping apparatus suffer from the drawback that they are ineffective in pumping the inactive gases, such as the noble gases and methane gas. For this reason sublimation pumping apparatus are frequently used in combination with some means which is capable of pumping the inactive gases, such as a diffusion pump or, where extremely low pressures in a contaminant free fashion are desired, a device which employs an ionizing discharge. Typical examples of apparatus which employ both sublimation and ionization techniques (hereinafter referred to as combination vacuum pumps) are described in a note entitled "Evapor-Ion Pump," by R. G. Herb, R. H. Davis, A. S. Divatia and D. Saxon, Physical Review, second series, vol. 89, No. 4, page 897, Feb. 13, 1953 and in an article entitled "Orbitron Vacuum Pump," by R. A. Douglas, J. Zabritski and R. G. Herb, Review of Scientific Instruments, vol. 36, pages 1–6, January 1965.

These prior art combination vacuum pumps are characterized by the provision of a sublimation means including a source of getter material adapted to sublime upon heating, onto the interior walls of the pump, and an ionization means including a source of electrons, which source may also serve to heat the getter material by electron bombardment, and a means for elongating the path of the electrons between the source and electrode serving as a collector to increase the probability of ionizing collisions.

It is the object of the present invention to provide an improved vacuum pump apparatus employing both sublimation and ionization techniques in which the need for a separate source of ionizing electrons is eliminated.

Briefly stated, in accordance with one teaching of the present invention there is disclosed a combination vacuum pump in which the need for a separate electrode which acts as a source of electrons is eliminated comprising a dual functioning sublimation means which acts both as a source of electrons and getter material, in combination with a means for elongating the path of the electrons.

One feature of the present invention is the provision in a combination vacuum pump of a dual functioning sublimation means, which acts both as a source of ionizing electrons and getter material, in combination with a means for elongating the path of the electrons.

Another feature of the present invention is the provision of a combination vacuum pump of the above type wherein the means for elongating the path of the electrons comprises an electrode, for example, an elongated, cylindrical electrode.

These and other objects and features of the present invention and a further understanding may be had by referring to the following description and claims taken in conjunction with the following drawing in which:

FIG. 1 is a diagrammatic view of one embodiment of the present invention;

FIG. 2 is a diagrammatic view of another embodiment of the present invention;

FIG. 3 is a diagrammatic view of still another embodiment of the present invention; and,

FIG. 4 is an enlarged fragmentary view of the sublimation means utilized in the present invention.

Referring now to FIG. 1 there is disclosed a vacuum pump incorporating the novel features of the present invention comprising: an evacuable envelope **11** adapted to contain gas molecules; an electron emissive sublimation means **12**, including a source of getter material **13**, adapted to be heated so as to cause electron emission and sublimation of getter material therefrom; a surface **14** for receiving getter material and collecting positive ions; and, a means **15** for elongating the path traveled by the electrons between emission and collection so as to increase the probability of ionizing collisions between electrons and gas molecules.

Envelope **11** has a cylindrical side wall **16** with a rotationally symmetric interior wall forming a surface **14**, and apertured top **17** and bottom **18** walls, all made of gas impervious material, for example, stainless steel. Bottom wall **18** is apertured for receiving, in vacuum tight manner, high voltage **19** and high current **20** feedthroughs. The envelope **11** is adapted to be connected in vacuum tight manner to a structure to be evacuated (not shown) through the intermediary of a high conductance passage **21** and vacuum flange **22** welded thereto. During operation, the envelope **11** is maintained at a potential equal to or greater than that of the sublimation means **12** so that electrons emitted therefrom will not be attracted to surface **14**.

Axially positioned within envelope **11** is the electron emissive sublimation means **12** supported on high current feedthrough **20**. The means **12** is electrically isolated from the envelope **11** and is described with more particularity in U.S. Patent No. 3,311,776, issued March 28, 1967 and assigned to the same assignee as the present invention. As best seen in FIG. 4, it includes a core **23** typically tungsten, and an overlay made up of a plurality of getter material wires **13**, typically titanium, and a single wire **24** of a refractory material such as molybdenum, helically twisted tightly about the core **23** so that the overlay is in direct thermal contact with the core **23** throughout its length. Core **23** is preferably located on the axis of symmetry of the surface **14**. It is believed that this overlay constitutes the source of electrons. During operation, the sublimation means **12** is essentially at ground potential. A power supply (not shown) of, for example, 5–6 volts is connected to the sublimation means **12** and current passed therethrough, typically 40–45 amperes, which is high enough to cause sublimation of the getter material. In addition, it has been found that at sublimation temperatures the sublimation means itself is a copious source of electrons enough to support an ionizing discharge in combination with the means **15**.

By way of example, in a typical embodiment at sublimation temperatures of about 1650° C. a temperature limited electron emisison of about 170 milliamps is obtained.

To obtain easy starting and low base pressure one may cool the walls of the envelope **11**, for example, by the provision of a cooling conduit **25** brazed to the wall **16** through which a coolant fluid such as water may be circulated, to dissipate heat from the sublimation means **12**.

Surface **14** acts as a collector for getter material sublimed from the means **12** and for gas atoms or molecules ionized by impact, the ions being impelled by electric fields into contact with the sublimed getter material which removes them by absorption, adsorption, or entrapment.

The means **15** may comprise a grid cage of relatively small surface area spaced from and coaxially surrounding the sublimation means **12**, supported on high voltage feedthroughs **19** and insulated from the envelope **11**. During operation, the grid cage is maintained positive with respect to sublimation means **12** and envelope **11** high enough to draw saturation electron emisison from the means **12**, but low enough that ionization probability remains high, typically 500–1000 volts. The electrons emitted by the sublimation means **12** are caused to oscillate back and forth within envelope **11** greatly lengthening the path traveled by the electrons emitted by the means **12**. In their flight back and forth, the electrons will gain kinetic energy and may collide with a neutral gas molecule. If the electron has gained sufficient energy it will ionize the neutral molecule and produce a free electron. Positive ions formed between the grid **15** and surface **14** will be driven toward the surface **14**, where they may be absorbed by getter material deposited thereon, as well as covered over by subsequently sublimed titanium. The embodiment of FIG. 1 is particularly advantageous for ion pumping, since the region of maximum ion bombardment coincides with the region of maximum deposition of getter material. Some ions created between the grid **15** and means **12** may be driven back towards the means **12** and therefore may not be pumped. This loss is minimized by making the radius of the grid a small fraction of the radius of the chamber, for example, a grid of one inch radius in an envelope with an inside radius of three inches.

FIG. 2 discloses still another embodiment of the present invention similar to the embodiment of FIG. 1 but modified in that the sublimation means **12** and grid cage **15** now enlarged, are disposed in side-by-side rather than coaxial relationship with each other. In this embodiment it is believed that there is a higher probability that ions formed within the grid cage will reach the collector surface **14**. The apparatus as thus far disclosed is claimed in copending application Serial No. 437,537 of John C. Helmer, filed March 5, 1965 and assigned to the same assignee as the present invention.

FIG. 3 discloses an alternate embodiment of the present invention in which a large portion of the electrons emitted by the sublimation means **12** are orbited about an axial rod **26** of small surface area in a symmetric electrostatic field between surface **14** and axial rod **26**. The potential of surface **14** may be equal to or greater than

the potential of the grounded sublimation means **12** while the axial rod **26** is held at a high positive potential by a power supply means (not shown), typically 5–10 kv. The sublimation means **12** is disposed parallel to the axis of surface **14**, being spaced between the rod **26** and surface **14** so that adequate electron emission and long electron paths may be achieved. The electrons so orbited serve to ionize gas molecules which are driven to the collector surface **14** where they may be absorbed and subsequently covered over by the sublimed getter material. This embodiment has the advantage that extremely long electron paths between emission and collection may be obtained if the diameter of the rod **26** is sufficiently small and voltage is sufficiently high.

Since many changes can 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 vacuum pump apparatus comprising:
   (a) an evacuable envelope adapted to contain gas molecules;
   (b) electron emissive sublimation means disposed within said envelope and including a source of getter material, said means adapted to be heated so as to cause electron emission and sublimation of getter material therefrom;
   (c) a surface disposed within said envelope for receiving getter material and collecting positive ions; and
   (d) means for elongating the path of said electrons between emission and collection so as to increase the probability of ionizing collisions between said electrons and said gas molecules, said means comprising an elongated, straight cylindrical electrode disposed within said envelope, spaced from said sublimation means and adapted to be maintained at a potential positive with respect to said surface.

2. The apparatus according to claim **1** wherein said envelope has a rotational symmetric interior wall defining said surface, and said elongated electrode lies on the axis of symmetry of said wall.

3. The means according to claim **1** wherein said electron emissive sublimation means is disposed parallel to said elongated electrode, more closely spaced to said surface than to said elongated electrode.

4. The apparatus according to claim **1** including means for cooling said envelope in intimate contact therewith.

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