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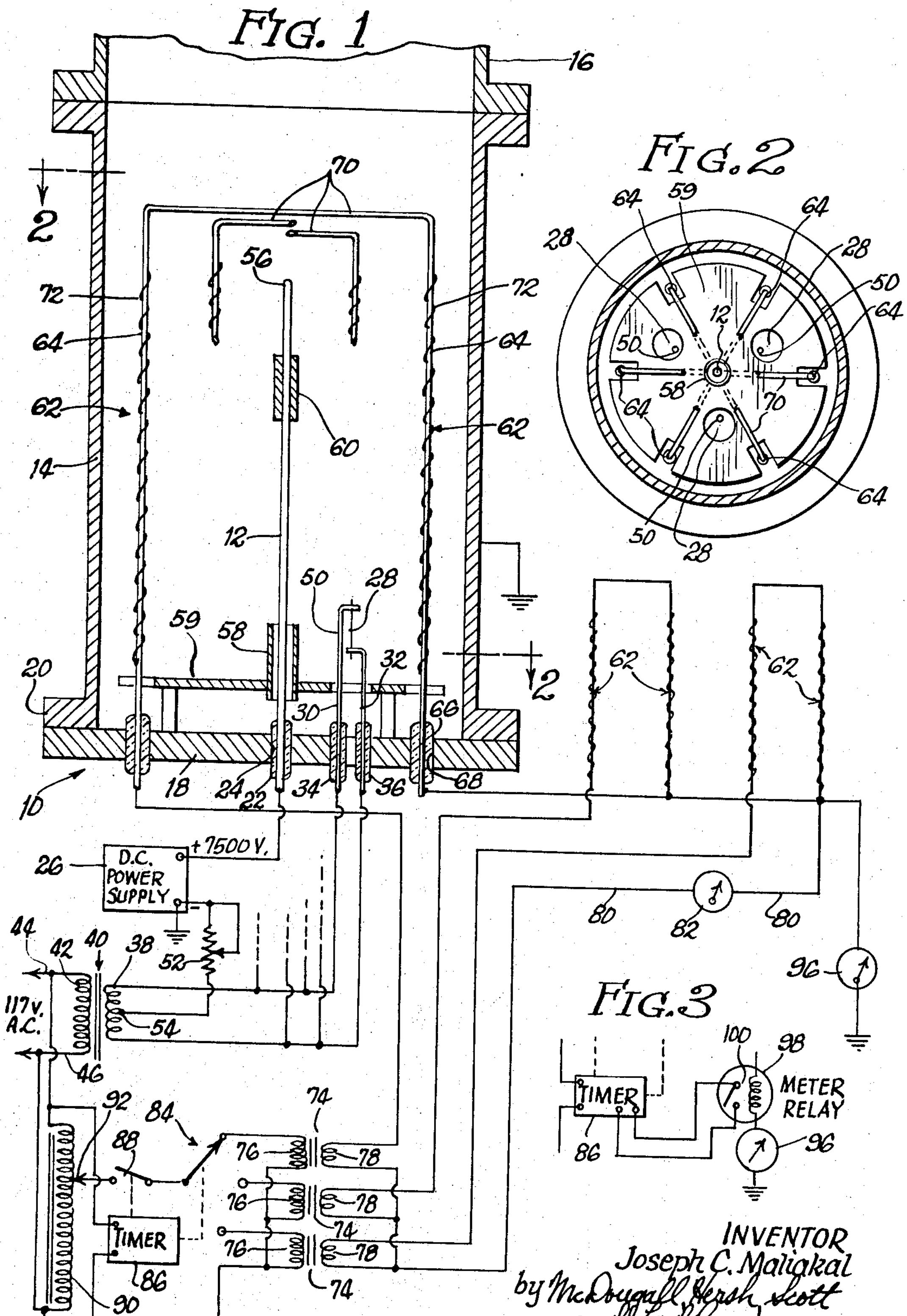

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ORBITRON VACUUM PUMP WITH GETTER VAPORIZATION BY RESISTANCE HEATING

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The invention described herein was made in the course of or under a grant from the National Science Foundation, an agency of the United States Government.

This invention relates to improvements in orbitron vacuum pumps of the general type disclosed and claimed in the Herb and Pauly U.S. Patent No. 3,244,969, patented Apr. 5, 1966. The invention also is applicable to orbitron pumps of the type disclosed and claimed in the copending application of Raymond G. Herb and Theodore E. Pauly, Ser. No. 447,678, filed Apr. 13, 1965.

In the orbitron vacuum pumps of the prior Herb and Pauly disclosures, electrons are caused to travel in spiral orbits between a central electrode, normally in the form of a cylindrical wire or rod, and an outer or boundary electrode, generally in the form of a cylindrical wall or cage. A positive voltage is employed between the central electrode and the boundary electrode to produce an electric field therebetween which normally has cylindrical symmetry. The electrons are introduced into the space between the central and boundary electrodes in such a manner that the electrons are given an initial angular momentum about the central electrode. Preferably, the electrons are introduced by means of thermionic filament structures of the types disclosed and claimed in the abovementioned Herb and Pauly patent and copending application.

In such orbitron pumps, the space within the boundary electrode is part of or connected to a vacuum system. A roughing pump or forepump is employed to bring about a partial evacuation of the vacuum system. The orbitron pump is then employed to improve the vacuum so as to reduce the pressure in the vacuum system to an extremely low level.

In the orbitron pump, some of the orbiting electrons collide with gas molecules so as to produce positively charged gas ions. These ions are propelled outwardly to the negatively charged boundary electrode, where they tend to stick and, thus, are effectively removed from the vacuum system. The orbiting of the electrons greatly increases the mean free path of the electrons, so as to increase very greatly the probability that any particular electron will collide with a gas molecule. Thus, a high degree of ionization is produced with a low electron current.

In the orbitron pump, it is preferred to provide a getter material, such as titanium, for example, on the boundary electrode, to provide greatly improved sticking of the ions and gas molecules to the boundary electrode. Furthermore, it is preferred to provide a source within the pump from which the getter material is continuously vaporized, so that the vaporized getter material will continuously condense on the boundary electrode. The freshly condensed getter material is especially receptive to the ions and gas molecules. Moreover, the continuous condensation of the getter material buries the gas ions and molecules so that they will be permanently retained on the boundary electrode. The continuous vaporization and condensation of the getter material greatly increases the getter efficiency of the orbitron pump. The getter material is preferably vaporized by sublimation rather than evaporated from the liquid phase.

Various arrangements are provided in the prior Herb and Pauly disclosures for vaporizing the getter material. Thus, a quantity of the getter material may be placed on the central electrode, and the getter material may be heated by electron bombardment so as to produce sublimation of the getter material. To provide an ample supply of the getter material, the central electrode may be fitted with one or more slugs, washers, or the like, made of the getter material and arranged so as to be heated by electron bombardment. Another arrangement is to provide a cage or screen of getter material between the central electrode and the main boundary electrode. Some of the positively charged gas ions strike the cage and cause sputtering of the getter material therefrom. The vapor of the getter material thus evolved is condensed on the outer boundary electrode.

The principal object of the present invention is to provide a new and improved orbitron pump in which the getter material is vaporized by resistance heating.

A further object is to provide a new and improved orbitron pump of the foregoing character which is arranged so that the vaporization of the getter material may be closely controlled and regulated, independently of regulation of the ionization process.

Another object is to provide a new and improved orbitron pump in which the getter material is vaporized by resistance heating, without interfering in any way with the orbiting of the electrons around the central electrode.

A further object is to provide a getter evaporation arrangement of the foregoing character which is constructed so that it also provides a measurement of ion current, and thus affords an accurate and convenient indication of the pressure in the vacuum space.

Further objects and advantages of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. 1 is a diagrammatic longitudinal section of an improved orbitron pump to be described as an illustrative embodiment of the present invention.

FIG. 2 is a diagrammatic cross-sectional view taken generally as indicated by the broken line 2—2 in FIG. 1.

FIG. 3 is a fragmentary diagrammatic view showing a modified control arrangement for the pump of FIG. 1.

It will be recognized by those familiar with the prior Herb and Pauly disclosures that the drawings illustrate an orbitron vacuum pump **10** which is basically of the type disclosed and claimed in the Herb and Pauly Patent 3,244,-969, patented Apr. 5, 1966. The orbitron pump **10** of the present invention may also be of the basic type disclosed and claimed in the copending Herb and Pauly application, Ser. No. 447,678, filed Apr. 13, 1965.

As shown, the pump **10** comprises a central or inner electrode **12**, which is illustrated as a cylindrical rod or wire, but may assume various other forms. The central electrode **12** is disposed axially within an outer or boundary electrode **14**, which is illustrated as a hollow cylindrical casing. The electrodes **12** and **14** are made of metal or other conductive material.

The space within the casing **14** is connected with the interior of a vacuum system **16** which is to be evacuated. Such system normally includes a mechanical roughing or forepump which is employed to produce an initial vacuum in the system. The orbitron pump **10** is then employed to improve the vacuum, so that the pressure in the system will be reduced to an extremely low level.

As shown, the end of the casing **14** is closed by an end plate **18** which is bolted, welded or otherwise secured to a flange **20** on the casing **14**. The central electrode **12** is supported by a feed-through insulator **22**, which is sealed into an opening **24** formed in the plate **18**. The central electrode **12** is brought out through the insulator **22** so that an electrical connection may be made at the central electrode.

During normal operation, a high positive voltage is impressed between the central electrode 12 and the casing 14. Thus, a direct current power supply 26 is connected between the central electrode 12 and ground. The casing 14 is also connected to ground. Any desired voltage may be employed on the central electrode, but a typical voltage would be 7500 volts.

The high positive voltage between the central electrode 12 and the boundary electrode 14 produces an electrical field therebetween which is cylindrically symmetrical. Electrons are introduced into this field with initial angular momentum about the central electrode 12, in such a manner that the electrons will travel in spiral orbits around the central electrode. Eventually virtually all of the electrons will be captured by the central electrode 12, but many of the electrons will travel around and along the central electrode through many orbits before being captured. Thus, the mean free path of the electrons may be many times the size of the pump.

Various arrangements may be employed to introduce the electrons into the pump. The illustrated pump employs one of the arrangements disclosed and claimed in the Herb and Pauly patent, mentioned above. If desired, electrons may be introduced in the manner disclosed and claimed in the copending Herb and Pauly application referred to above.

To introduce the electrons, the illustrated pump 10 comprises a cathode in the form of a thermionic filament 28 which is positioned between the central electrode 12 and the boundary electrode 14. The filament 28 is substantially parallel to the central electrode and is disposed toward one end thereof. The filament 28 is adapted to be heated so that it will emit electrons. Thus, the opposite ends of the filament 28 are connected to and supported by wires or leads 30 and 32 which are brought out of the casing 14 through insulators 34 and 36 sealed into openings in the end plate 18. The leads 34 and 36 are connected to a source of electrical power, which is illustrated as the secondary winding 38 of a power transformer 40. The primary winding 42 of the transformer 40 may be connected to power lines 44 and 46, adapted to supply alternating current at 117 volts, or some other suitable voltage.

To improve the efficiency with which electrons are introduced into orbits around the central electrode 12, the wire 30, constituting one of the supports for the filament 28, is arranged to act as a shield or field-modifying electrode. Thus, the wire 30 has a shield electrode-portion 50 which is parallel to the filament 28 and is interposed between the filament and the central electrode 12. Preferably, filament 28 and the shield electrode 50 are in the same radial plane, which also includes the axis of the central electrode 12. However, the position of the filament 28 may depart to a considerable extent from the radial plane of the shield electrode 50, while still providing highly efficient orbiting of the electrons. The shield electrode 50 substantially prevents direct radial movement of the electrons between the filament 28 and the central electrode 12. In addition, the shield electrode 50 modifies the electric field around the central electrode 12 so as to increase the initial angular momentum of the electrons emitted from the filament.

The filament 28 is preferably biased to a positive voltage or potential which differs substantially from the potential which would exist in the pump at the location of the filament, in the absence of the filament. In this case, the biasing voltage for the filament 28 is developed by providing a variable biasing resistor 52 between the filament circuit and ground. It will be seen that the resistor 52 is connected to a center tap 54 on the secondary winding 38 which supplies power to the filament 28. The current due to the emission of electrons by the filament 28 produces a voltage drop across the resistor 52, so that the filament is biased to a positive potential above ground.

One end of the central electrode 12 is supported by the feed-through insulator 22, while the other is free and unsupported, as indicated at 56. The free end 56 provides efficient reflection of the spiralling electrons so that the upwardly spiralling electrons are reflected back along the central electrode 12, without substantial loss of angular momentum. At the end of the central electrode 12 adjacent the insulator 22, the reflection of the electrons is improved by providing a terminating electrode 58. As disclosed in the previously mentioned Herb and Pauly patent, the terminating electrode 58 is preferably in the form of a cylindrical metal sleeve spaced outwardly from the central electrode 12 and concentric therewith. The terminating sleeve 58 may be mounted on and supported by a flange or plate 59 having cutouts for the various leads and supports. The flange 59 protects the feed-through insulators from being coated with vaporized titanium. The terminating electrode 58 is at a low potential, and in this case is grounded to the end plate 18, as also is the flange 59. A relatively intense electric field is produced between the central electrode 12 and the terminating sleeve 58, due to the relatively close spacing therebetween. Moreover, the field lines are curved in such a way as to produce efficient reflection of the spiralling electrons. The sleeve 58 also plays an important part in the efficient introduction of the electrons into orbits around the central electrode 12. It will be noted that the position of the filament 28 is approximately opposite the free end of the terminating sleeve 58.

While a single filament is sufficient for the efficient operation of the pump, it is often preferred to employ a plurality of angularly spaced filaments, for the sake of increased emission of electrons. Thus, the illustrated pump 10 is provided with three filaments which are spaced at equal angular intervals around the central electrode 12. Each filament 28 is provided with its own shield wire 50. All of the filaments 28 may be connected in parallel, across the transformer winding 38. If desired, the filaments may be operated individually, or in any desired combination.

In acordance with the previously mentioned Herb and Pauly patent, getter material may be vaporized from the central electrode 12 by electron bombardment. In the illustrated pump 10, a slug or mass 60 of getter material is mounted on the central electrode 12. The illustrated slug 60 is cylindrical in shape and is positioned toward the free end 56 of the central electrode 12. The slug 60 is preferably made of titanium, but may be made of any other suitable getter material. Many such materials will be known to those skilled in the art.

Some of the orbiting electrons impinge upon the slug 60 and cause heating of the slug. Due to the high voltage on the central electrode 12, the bombarding electrons achieve high energies and are capable of heating the slug to incandescence. Preferably, the titanium slug 60 is heated to a temperature close to but definitely below the melting point of titanium. At such temperatures, the titanium is vaporized freely by sublimation, directly from the solid state to the vapor state. Thus, there is no problem with liquid titanium, which would tend to run down the central electrode 12.

The titanium vapor travels outwardly in all directions from the slug 60 and is condensed on the cylindrical inner surface of the outer electrode or casing 14. The freshly condensed titanium has a high affinity for gas molecules and is capable of absorbing large quantities of gas.

The spiralling electrons cause ionization of gas molecules in the space around the central electrode 12. The positively charged gas molecules are propelled outwardly by the electric field so that they impinge against the outer casing 14. At this point, the ions are absorbed by the getter material and are buried by the subsequent condensation of additional getter material. This process is particularly valuable for removing molecules of the noble gases (helium, argon, neon, etc.) from the vacuum system.

In accordance with the present invention, means are provided for vaporizing a large quantity of additional getter material within the pump **10**, so as to cooperate with the ionizing action of the pump, without in any way interfering with the orbiting of the electrons. The illustrated pump **10** is provided with a plurality of additional sources **62** of vaporized getter material. It will be understood that a single source could be provided, but it is preferred to employ several sources so that a greater amount of getter material may be vaporized. The illustrated sources **62** comprise supporting wires or rods **64** which extend longitudinally within the pump casing or outer electrode **14**. The rods **60** are preferably spaced outwardly from the circle of the filaments **28**, but inwardly from the cylindrical inner surface of the outer electrode **14**. Each rod **62** is supported and brought out of the casing **14** by a feed-through insulator **66** sealed into an opening **68** in the end plate **18**.

The rods **64** are adapted to be heated by passing electric currents therealong. In order to withstand such heating, the rods are preferably made of tungsten or some other similar material having a high melting point. As shown, the rods **64** are preferably arranged in pairs, connected together within the casing **14** by means of cross rod portions **70**. The rods of each pair are diametrically opposite each other, so that the corresponding cross rod portion **70** extends along a diametrical line. As shown to best advantage in FIG. 2, the illustrated pump is provided with three pairs of the supporting rods **64**, which are spaced at equal angular intervals around the longitudinal axis of the pump. The rods **64** of each pair and the corresponding cross rod portion **70** are bent from a single piece of material. The cross rod portions **70** are located well above and beyond the free end **56** of the central electrode **12** so that the cross rod portions do not interfere with the orbiting of the electrons around the central electrode.

Each rod **64** is provided with getter material **72** which is adapted to be vaporized by the heat developed in the rod. The getter material is preferably titanium, but may comprise any suitable getter material. The getter material may assume various forms, but, in the preferred construction, as illustrated, the getter material very advantageously assumes the form of wire which is wrapped around each rod **60**. By passing electric currents along the rods **64**, the rods and the wires **72** of getter material are heated to a temperature at which the getter material is vaporized at a substantial rate. For titanium getter material, it is preferred to heat the wires **72** to a temperature just below the melting point of titanium, so that the titanium will be vaporized copiously by sublimation, directly from the solid state to the vapor state, without any troubles which might be caused by the presence of liquid titanium. It will be understood that liquid titanium would tend to flow down the rods **64** so as to cause trouble with short circuiting of the insulators **66**. However, a certain amount of liquid titanium can be tolerated, because it will be retained between the wires **72** and the rods **64** by capillary action.

In the illustrated pump, the electric currents for heating the rods **64** are provided by transformers **74**, each of which has a primary winding **76** and a secondary winding **78**. A separate transformer is provided for each pair of rods **64**. In this way, the pairs of rods may be heated individually or in any desired combination.

As shown in FIG. 1, the pairs of rods **64** are connected across the respective secondary windings **78**. All three secondary windings **78** have one output lead **80** in common. An ammeter **82** is connected into the lead **80** to measure the total current in the rods **64**. If desired, separate ammeters may be provided for each pair of rods.

The illustated circuit is arranged for individual energization of the three pairs of rods **64**. Thus, the three primary windings **76** are connected to a three-position selector switch **84** which could be operated manually, but is shown as being operated by an electrical timer **86**. If desired, three separate switches may be employed instead of the three-position switch. A master On-Off switch **88** is also controlled by the timer. The timer **86** is preferably of the type which may be programmed to provide any desired duty cycle for each of the three pairs of heating rods **64**. Thus, for example, the three pairs of rods may be energized successively for equal intervals of time, to equalize the rates at which the titanium is evaporated from the three pairs of rods. The time intervals may be adjusted in accordance with the amount of getter vaporization which is needed to maintain the desired vacuum in the vacuum system.

Means are preferably provided to regulate the currents in the heating rods **64**. For this purpose, the illustrated pump is provided with a variable transformer **90** which is connected between the master switch **88** and the power lines **44** and **46**. As shown, the master switch **88** is connected to a movable tap **92** on the transformer **90**. One side of the transformer **90** is connected to the power line **44**, while the other side is connected in common to the power line **46** and one side of each primary winding **76**. The variable transformer **90** makes it possible to adjust the voltage to any desired value between zero and its maximum voltage. This voltage is supplied to the primary winding **76** through the master switch **88** and the selector switch 84.

The heating rods **64** for vaporizing the getter material **72** are arranged to form a cage-like structure which is symmetrical about the axis of the central electrode **12**. Moreover, the rods **64** are spaced outwardly of the filament **28** and relatively close to the cylindrical inner surface of the outer electrode **14**. With this construction, any interference with the orbiting of the electrons can be avoided by connecting the rods to ground potential or to a low positive or negative potential relative to the outer electrode **14**. As shown, the common lead **80** of the three pairs of rods **64** is connected to ground through a micro ammeter or other sensitive meter **96** for measuring the total ion current to the rods. Some of the positively charged gas molecules are attracted to the rods **64** rather than passing outwardly to the outer electrode **14**. The resulting ion currents are indicated by the meter **96**. As the pressure drops in the vacuum space due to action of the pump, the number of ions captured by the rods **64** also drops, so that the ion current registered by the meter **96** is decreased. Thus, the current indicated by the meter **96** is a measure of the pressure in the vacuum space. Accordingly, the rods **64**, together with the meter **96** and the cooperating circuits, form an ion-type pressure gauge, which is very advantageous for monitoring the action of the pump. Inasmuch as the rods are mounted on insulating supports, there are no substantial stray or leakage currents to mask the ion currents through the meter **96**.

It may be helpful at this point to review the operation of the pump **10**. Electrons are emitted by the filament **28** with sufficient angular momentum to go into orbits in the cylindrically symmetrical electric field around the central electrode **12**. The orbiting of the electrons is achieved without the use of a magnetic field. The electrons spiral upwardly and downwardly around and along the central electrode **12**. In this way, the mean free path of the electrons greatly exceeds the size of the pump, so that there is a relatively high possibility that any particular electron will cause ionization of a gas molecule in the pump, before the electron is attracted to the central electrode **12**. The positively charged gas molecules produced by the ionizing electrons are propelled outwardly toward the negatively charged outer electrode **14**. When the gas molecules strike the cylindrical surface of the outer electrode **14**, they tend to be retained and absorbed by the previously deposited getter material. A fresh supply of getter material is deposited continuously, or as needed, on the outer electrode **14**, by virtue of the vaporization of getter material from the getter wires 72 on the heating rods 64. The newly deposited getter material buries the gas molecules so that they will be permanently retained on the outer electrode 14. Thus, the gas molecules are effectively removed from the vacuum system.

The rods 64 are heated by passing electrical currents therealong from the secondary windings 78 of the transformers 74. The rods 64 may be energized individually or in any desired combination. The getter material 72 is prefereably titanium wire, while the rods 64 are preferably made of tungsten so that the titanium may be heated to a temperature just below its melting point. At such temperatures, the titanium is copiously vaporized by sublimation directly from the solid state to the vapor state. The presence of troublesome liquid titanium in the pump is thus avoided. The variable transformer 90 makes it possible to control and adjust the amount of heating current which is passed along the rods 64.

Some of the positive ions are captured by the heating rods 64 and produce ion currents which are measured by the meter 96. These ion currents are a measure of the pressure in the vacuum space.

Some sputtering of the getter material is produced by the impact of positive ions upon the getter wire 72. However, the vapor evolved by sputtering is a small factor when compared with the large quantity of vapor which may be evolved by the heating of the wires 64.

If desired, the getter material 60 on the central electrode 12 may be dispensed with, in view of the high rate at which getter material may be vaporized by heating the rods 64. The removal of the getter material from the central electrode 12 improves the orbiting of the electrons around the central electrode and increases the mean free path of the electrons so that electrons will produce greater ionization of the gas molecules within the pump. Thus, the pumping speed of the pump will be increased, particularly for noble gases.

A large quantity of titanium wire 72 may be wound on each of the heating rods 64. Thus, the pump may be operated for a very long time before all of the titanium getter material is vaporized from the rods 64. This feature is highly advantageous, because the vacuum in the vacuum system may be lost when it is necessary to open the pump to replenish the supply of getter material.

It will be recognized that the present invention provides an orbitron-type vacuum pump in which titanium or other getter material may be vaporized at a very high rate. Moreover, the pump may be operated for an unusually long time without replenishing the getter material. The arrangement for vaporizing the getter material does not interfere with the orbiting of the ionizing electrons, but may actually improve the orbiting of the electrons, so that the degree of ionization will be increased.

FIG. 3 illustrates another modification, in which the meter 96 is replaced or supplemented by a relay 98 having switch contacts 100 which are connected to the timer 86. The relay 98 may be of the meter type and may be adapted to provide a reading of the ion current, as well as operating the contacts 100 at any desired current, so as to initiate or change the operation of the timer 86. Thus, the relay 98 is effective to initiate or regulate the activation cycle of the timer as a function of the gas pressure in the orbitron pump. At higher pressures, for example from 10^{-7} torr to about 10^{-3} torr, a high rate of sublimation of getting material is desirable. At lower pressures for example below 10^{-7} torr, the automatic control afforded by the meter relay 98 can desirably lower the rate of sublimation to conserve the titanium wire 64 on the rods 62 and thereby prolong the useful life of the titanium wire.

Various other modifications, alternative constructions, and equivalents may be employed without departing from the true spirit and scope of the invention, as exemplified

in the foregoing description and defined in the following claims.

I claim:

1. An ion getter vacuum pump,
comprising the combination of a generally cylindrical casing constituting an outer electrode,
means for connecting the interior of said casing to a vacuum system to be evacuated,
a central electrode extending along the axis of said outer electrode,
said central electrode being generally cylindrical and of a small diameter relative to the diameter of said outer electrode,
means for compressing a positive voltage between said inner and outer electrodes to produce a generally cylindrical electric field therebetween,
a thermionic cathode disposed between said inner and outer electrodes and toward one end of said inner electrode for introducing electrons into said electric field with initial angular momentum about said inner electrode,
said electrons traveling in spiral orbits around said inner electrode,
at least one pair of heating rods extending longitudinally in the space between said inner and outer electrodes,
said rods being spaced outwardly of said cathode and inwardly from said outer electrode,
getter material in the form of titanium wire wound around said rods,
said rods of each pair being connected together at one end,
and means for supplying electrical current to the opposite ends of said rods to cause the current to pass along said rods so as to heat said rods and thereby cause vaporization of titanium from said wire,
the evaporated titanium being condensed on the inside of said outer electrode.

2. A pump according to claim 1,
including a meter connected between said rods and said casing for measuring the ion current to said rods so as to afford an indication of the pressure in the vacuum system.

3. In an ion getter pump,
the combination on comprising an inner generally cylindrical electrode of relatively small diameter,
an outer electrode of relatively great diameter spaced outwardly from said inner electrode,
means forming enclosure for connecting the interior of said outer electrode to a vacuum system to be evacuated,
means for impressing a positive voltage between said inner and outer electrodes to produce a generally cylindrical electric field around said inner electrode,
means for introducing electrons into said field around said inner electrode with initial angular momentum so that the electrons will travel in spiral orbits around said inner electrode,
a heating member disposed in the space between said inner and outer electrodes,
a quantity of getter material adjacent said heating member,
and means for passing an electric current along said heating member to heat said member and said getter material so as to cause vaporization of said getter material,
the vapor of the getter material being condensed on said outer electrode to absorb gases and ions.

4. A combination according to claim 3,
in which said heating member extends longitudinally adjacent one side portion of said outer electrode and is slender and elongated in form.

5. A combination according to claim 3,
comprising at least one pair of elongated generally

parallel members extending longitudinally adjacent said outer electrode,

and electrically conductive means disposed within said enclosure and connected between the heating members of each pair at one end thereof.

6. A combination according to claim **5**,

in which said electrically conductive means comprises a cross rod portion extending between the members of each pair.

7. A combination according to claim **3**,

in which said heating member is rod-like in form and extends longitudinally adjacent one side portion of said outer electrode,

said getter material being in the form of wire wrapped around said heating member.

8. A combination according to claim **3**,

in which said heating member is U-shaped in form and comprises a pair of elongated rod-like legs extending longitudinally adjacent opposite side portions of said outer electrode,

and a cross rod portion extending between said elongated rod-like legs.

9. A combination according to claim **8**,

in which said getter material comprises wire wrapped around said rod-like legs.

10. A combination according to claim **3**,

including meter means connected between said heating member and said outer electrode for measuring the ion current to said heating member so as to afford an indication of the pressure in the vacuum system.

11. A combination according to claim **3**,

including means for varying the heating current along said heating member to regulate the rate of evaporation of said getter material.

12. In an ion getter vacuum pump,

the combination comprising a central generally cylindrical electrode of relatively small diameter,

an outer electrode of relatively larger diameter spaced outward from said central electrode,

means forming an enclosure connecting the interior of said outer electrode to a vacuum system to be evacuated,

means for impressing a positive voltage between said central and outer electrodes,

an electron emitter disposed in the space between said central and outer electrodes for introducing electrons into said space with initial angular momentum around said central electrode so that the electrons will travel in spiral orbits around said central electrode,

said electrons causing ionization of gas molecules in said space,

a heating member disposed in said space outwardly of said electron emitter and inwardly of said outer electrode,

said heating member having a pair of legs extending longitudinally in said space and a cross portion extending between said legs,

a quantity of getter material on said longitudinal legs,

and means for passing an electric current along said heating member to heat said heating member and said getter material so as to cause vaporization of said getter material,

the vapor of said getter material being condensed on said outer electrode.

13. A combination according to claim **12**

in which said getter material is in the form of wire wrapped around said legs.

14. A combination according to claim **12**,

including meter means connected between said heating member and said outer electrode for measuring the the ion current to said heating member and thereby indicating the pressure in the vacuum system.

15. A combination according to claim **3**,

including a current responsive device connected between said heating member and said outer electrode for carrying the ion current to said heating member,

and means operable by said current responsive means for changing the electric current along said heating member as a function of the gas pressure in the vacuum system.

16. A combination according to claim **12** ,

including relay means connected between said heating member and said outer electrode and operable by the ion current to said heating member,

and means operable by said relay means for changing the electric current along said heating member as a function of the gas pressure in said enclosure.

17. In an ion getter pump,

the combination comprising a central generally cylindrical electrode,

a boundary electrode spaced outwardly from said central electrode,

means forming an enclosure for connecting the interior of said boundary electrode to a vacuum system to be evacuated,

means for impressing a positive voltage between said central electrode and said boundary electrode to produce a generally cylindrical electric field therebetween,

means for introducing electrons into said field with initial angular momentum so that the electrons will travel in spiral orbits around said central electrode,

a cage-like member having getter material thereon and disposed between said central electrode and said boundary electrode,

means for evolving the getter material from said cage-like member so that the getter material will condense on said boundary electrode to absorb gases and ions,

and current measuring means connected between said cage-like member and said boundary electrode for indicating the ion current to said cage-like member and thereby providing an indication of the remaining gas pressure in said enclosure.

18. A combination according to claim **17**,

including means operable by said current measuring means for changing the operation of said means for evolving getter material to vary the rate at which the getter material is evolved.

19. In an ion getter pump,

the combination comprising an inner generally cylindrical anode,

an outer electrode received around and spaced outwardly from said anode,

means forming an enclosure for connecting the interior of said outer electrode to a vacuum system to be evacuated,

said anode being adapted to be supplied with a positive voltage relative to said outer electrode to produce a generally cylindrical electric field around said anode,

means for introducing electrons into said field with initial angular momentum so that the electrons will travel in orbits around said anode,

a body of getter material in the space between said anode and said outer electrode,

a heating element adjacent said body of getter material,

and means for causing an electric current to flow along said heating element to heat said element and said getter material so as to cause vaporization of said getter material,

the vapor of said getter material being condensed on said outer electrode to absorb gases and ions.

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