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R. G. HERB

2,913,167

VACUUM PUMP

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Fig. 1.

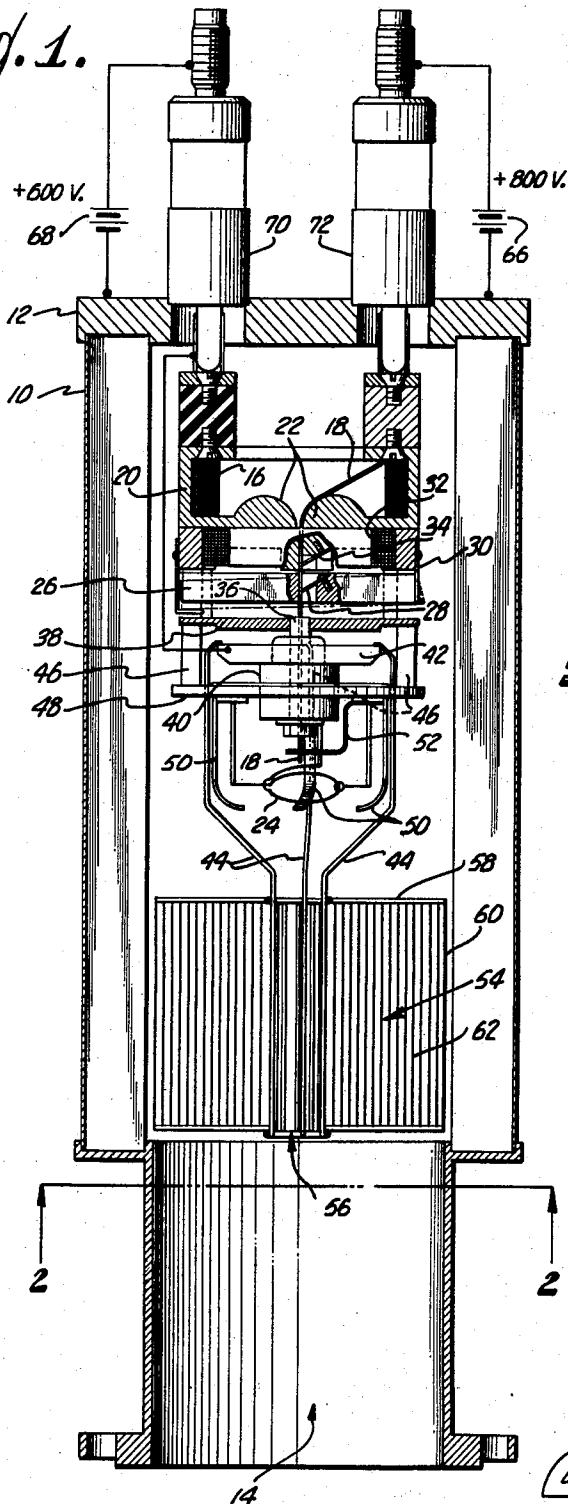


Fig. 2.

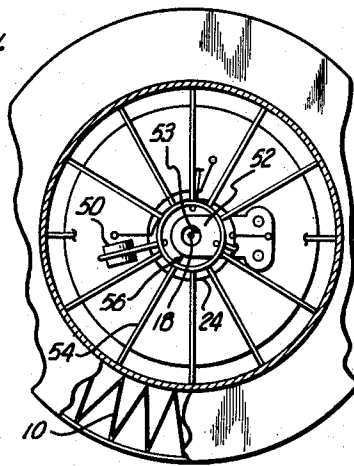
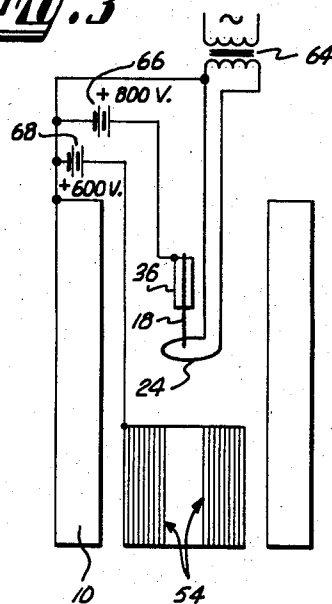


Fig. 3.



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2,913,167

VACUUM PUMP

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10 Claims. (Cl. 230—69)

This invention relates to improvements in vacuum pumps which are capable of producing and maintaining a high vacuum, and particularly to improvements useful in pumps of small physical size.

My co-pending application Serial No. 546,025 which was filed on November 10, 1955, now Patent No. 2,850,225, discloses methods and apparatus for producing and maintaining a high vacuum by employing ionization and gettering techniques. Pumps of this type can pump at exceptional speeds while maintaining a high vacuum entirely free of organic or mercurial vapors.

In accordance with the disclosure of the aforesaid patent application, gas molecules are ionized by electron bombardment and they are driven to a collector surface. Gettering material is evaporated and deposited on the collector surface, and the deposition of the gettering material is continued so that the getter traps the gas and secures it to the collector surface and so that the getter buries the gas which has been previously deposited on the collector surface.

My co-pending application Serial No. 573,522 which was filed on March 23, 1956, discloses a geometry for pumps of this general type which provides increased pumping speeds, particularly with respect to the inert gases.

The apparatus which is disclosed in the above two patent applications is primarily suitable for pumps of large physical size designed for pumping large volumes of gas. However, in many instances it is desirable to employ a small pump, and the present invention is directed to improvements which provide effective pumping action in pumps of relatively small physical size employing the ionization and gettering actions which are disclosed in the aforesaid patent applications.

In order to provide effective pumping action in pumps of small size, it is necessary to provide an evaporator for the getter which is compact, yet of large capacity, and it is necessary to provide an effective arrangement for ionizing the gas molecules. These features are achieved in the present invention by feeding the getter material with an electromagnetic device of compact form, and by evaporating the getter by bombardment with electrons from a thermionic filament without requiring the use of a heated post for providing an evaporating surface. Preferably the getter material is composed of stranded wires of a good getter and a material having a higher melting point than that of the getter, all wound in a roll. The wire having the higher melting point serves as an evaporating surface for the getter before it evaporates also. The collector surface for the evaporated getter is corrugated so as to provide a large surface area in a minimum of space. This increases the collector surface area and it also increases the heat radiating area, making it easier to cool the pump. A grid in volume is employed both to direct electrons from the thermionic filament into the ionization space and to drive the ionized and dissociated gas into the collector surface. The grid in volume employs conductors which extend throughout a large

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portion of the ionization space and thereby prevent space charges from building up and interfering with the ionization action.

One embodiment of the invention employing these features has been constructed having a two inch inlet, an outer diameter of three and one-quarter inches, and a height of ten and one-half inches. This pump has provided pumping speeds of 30 liters per second for air and 1 liter per second for argon, one of the inert gases.

Although the various features of the present invention are primarily suitable for use in pumps of small size, it will be apparent that these features may be employed in pumps of large size if desired.

The invention is explained in more detail with reference to the drawings, in which:

Fig. 1 is an elevation view, partially in section, of a preferred embodiment of the invention;

Fig. 2 is a sectional view along line 2—2 of Fig. 1; and

Fig. 3 is a circuit diagram illustrating how suitable

operating potentials may be applied to the pump.

In the arrangement illustrated in the drawings, the pumping apparatus is located in a housing comprising a body member 10 of generally cylindrical shape provided with an enclosure 12 at its upper end and an inlet 14 at its lower end. Preferably the body portion 10 of the housing is corrugated, as illustrated in Fig. 2, so as to provide a large inner surface for collecting the gas molecules and so as to provide a large outer surface for dissipating the heat developed in the pump. It is preferable that the housing be composed of stainless steel, but other metals may be employed in some instances.

A roll 16 of getter material 18 is located in a container 20 which is provided with a guide means 22 for guiding the getter material from the inner periphery of the roll to the center of the roll. The roll is maintained stationary so that very little mass is moved when the getter is fed.

In order to eliminate the space required for an evaporating post or the like, the getter material is evaporated by electron bombardment from a thermionic filament 24. Preferably the getter material is stranded in the form of a plurality of wires with at least one of the wires being composed of a good getter and at least one other wire being composed of a material having a higher melting point than that of the getter. With such an arrangement, the wire having the higher melting point serves as an evaporating surface for the getter before it also evaporates. This reduces the tendency of the getter material to form in droplets and fall through the pump chamber rather than evaporating. The wire strands should be tightly twisted in order to feed properly. Good results have been obtained with the wires disposed to form a 45° angle with respect to the axis of the stranded cable.

Stranded titanium and tantalum or tantoloy or molybdenum or tungsten wires may be employed. In one embodiment two strands of .007" titanium wire were twisted with two strands of .006" tantoloy wire to form a satisfactory cable.

The getter material is fed to the thermionic filament by a movable armature 26 which is provided with a spring 28 for gripping the getter material. The armature 26 is carried by a leaf spring 30 which tends to urge the armature in a downwardly direction. The armature is actuated by an electromagnet 32 which tends to pull the armature in an upwardly direction each time that the electromagnet is energized. A spring member 34 is provided below the guides 22 for securing the getter material during upward movement of the armature.

The electromagnet may be energized periodically or only occasionally, depending upon the pumping requirements. Leads (not shown) for energizing the electromagnet may be connected to insulated terminals located in the enclosure 12 at the top of the housing.

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A conductive tube 36 is provided for guiding the getter material, and it is rigidly mounted on a conductive plate 38. An insulator 40 is disposed around the guide tube 36, and a conductive plate 42 is mounted on the insulator. Three supports 44 for the grids extend from the conductive plate 42.

Three insulators 46 are mounted on the plate 38, and they serve to carry the support 48 which is divided into three equal segments which are spaced from one another. The thermionic filament is supported from these three segments, and electrical connections (not shown) may be made to the filament through two of the segments. Three shields 50 for the grid supports are also carried by the support member 48. Also, a shield 52 is supported by the member 48, and the shield is provided with an aperture 53 (see Fig. 2) through which the getter material may pass. The shield 52 keeps the electrons from bombarding the getter material as it emerges from the guide member 36 and thereby minimizes the tendency for the getter material to plug the hole in the guide member 36.

The grid means 54 is provided with a plurality of vanes which extend radially from approximately the center of the chamber toward the wall of the chamber. The grid is provided with a central opening 56 through which droplets of the getter material may fall in the event that such droplets form as a result of improper operation of the pump.

The grid is provided with an upper portion 58 located adjacent the thermionic filament for directing electrons from the filament into the grid. The grid is also provided with portions of 60 which are disposed adjacent to and which extend along the inner wall of the pump housing. These portions of the grid structure serve to drive positively ionized gas molecules to the collector surface. Each of the vanes of the grid is composed of a plurality of small conductors 62. These small conductors provide a grid in volume, with the entire grid being at the same potential. This prevents the electrons from the filament from building up large space charges in the grid area and thereby permits more uniform electron bombardment of the gas molecules in this area. Also, it is believed that the electrons tend to move around the grid wires so that most of the ionization takes place adjacent the grid wires. By employing grid wires extending throughout the ionization space, somewhat more effective ionization action is obtained.

The getter material should be maintained at a positive potential with respect to the thermionic filament so that it is bombarded with sufficient electrons to evaporate it. The grids 54 should be maintained at a positive potential with respect to the thermionic filament so that the grids will direct electrons from the filament into the space in which the grids are located. The grids 54 should be at positive potential with respect to the collector surface which is provided by the corrugated wall 10 so as to drive the positively ionized gas molecules into the collector surface. Figs. 1 and 3 illustrate suitable electrical connections for obtaining these potentials. The current for the filament is provided by a transformer 64. One side of the transformer is connected to the pump housing so that the filament is at ground potential. A source of potential 66 provides a suitable potential for the getter material, say 800 volts. A source of potential 68 provides a suitable potential for the grids, say 600 volts. The electrical connections are made through insulated terminals, such as the terminals 70, 72 at the top of the pump.

In one embodiment of the invention, the filament heating power was 55 watts, and the current applied from the sources 66, 68 was about .015 ampere from each, making a total power consumption of about 80 watts.

In order to start the pump, it should be heated to between 200° C. and 500° C. Also, it is desirable to reduce the pressure at the inlet 14 such as by a conventional

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mechanical roughing pump while the pump is being baked out. After the pump has cooled to approximately room temperature and with the initial pressure reduced by the roughing pump, the filament may be energized and then the gettering action initiated. The getter is fed in increments each time that the electromagnet is energized, and this may be done periodically or only occasionally, depending upon the amount of pumping required.

The evaporated getter tends to move toward the cooler outer walls of the housing where it condenses to form an active gettering surface. It traps gas molecules, and it also buries previously trapped gas molecules so as to prevent them from escaping.

The electrons which are directed into the grid structure ionize gas molecules by impact, and the positively ionized molecules are driven from the grid structure to the collector surface by the potential difference between these two parts of the pump.

The corrugated wall 10 of the housing provides a large surface for heat radiation, and in some instances this radiation is sufficient. Further cooling action may be provided by blowing air across the pump wall, or by circulating water through cooling coils disposed around the housing.

The paths of the electrons for ionizing the gas may be increased by using a magnetic field having flux lines extending along the axis of the pump chamber.

I claim:

1. A pumping device comprising a housing defining a chamber from which gas is to be removed, a collector surface disposed inside the housing for receiving deposits of getter material, a source of electrons located in the chamber, a reservoir of getter material, electromagnetic means for feeding getter material from the reservoir toward the source of electrons, means for coupling the getter material and the source of electrons to a source of potential for maintaining the getter material at positive potential with respect to the source of electrons to cause the getter to be evaporated by bombardment by electrons from the source, grid means having a portion located adjacent the source of electrons and having another portion located adjacent and extending along the collector surface, and means for coupling the grid means to a source of potential for maintaining the grid means at positive potential with respect to the source of electrons and with respect to the collector surface to cause the grid means to direct electrons from the source into the grid means and to cause the grid means to drive positively ionized gas to the collector surface.

2. A pumping device comprising a housing defining a chamber from which gas is to be removed, a collector surface disposed inside the housing for receiving deposits of getter material, a source of electrons located in the chamber, a roll of getter material, electromagnetic means for feeding getter material from the roll toward the source of electrons and having guide means for feeding the getter material from the inner periphery of the roll so that the roll remains stationary, means for coupling the getter material and the source of electrons to a source of potential for maintaining the getter material at positive potential with respect to the source of electrons to cause the getter to be evaporated by bombardment by electrons from the source, grid means having a portion located adjacent the source of electrons and having another portion located adjacent and extending along the collector surface, and means for coupling the grid means to a source of potential for maintaining the grid means at positive potential with respect to the source of electrons and with respect to the collector surface to cause the grid means to direct electrons from the source into the grid means and to cause the grid means to drive positively ionized gas to the collector surface.

3. A pumping device comprising a housing defining a chamber from which gas is to be removed, a collector surface disposed inside the housing for receiving deposits

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of getter material, a thermionic filament located in the chamber, stranded getter material in the form of at least two wires tightly twisted about one another and wound in a roll, with one of the wires being composed of a good getter and the other wire being composed of a material having a higher melting point than that of the getter so that the latter wire serves as an evaporating surface for the getter before it evaporates also, electromagnetic means for feeding the getter material toward the thermionic filament, means for coupling the getter material and the filament to a source of potential for maintaining the getter material at positive potential with respect to the filament to cause the getter to be evaporated by bombardment by electrons from the filament, grid means having a portion located adjacent the filament and having another portion located adjacent and extending along the collector surface, and means for coupling the grid means to a source of potential for maintaining the grid means at positive potential with respect to the filament and the collector surface to cause the grid means to direct electrons from the filament into the grid means and to cause the grid means to drive positively ionized gas to the collector surface.

4. A pumping device comprising a housing defining a chamber from which gas is to be removed, a collector surface disposed inside the housing for receiving deposits of getter material, the collector surface being corrugated to provide a large surface area in a small space, a source of electrons located in the chamber, getter material in the form of a plurality of wires tightly twisted about one another and wound in a roll, with at least one of the wires being composed of a good getter and at least one other wire being composed of a material having a higher melting point than that of the getter so that the latter wire serves as an evaporating surface for the getter before it evaporates also, electromagnetic means having a movable armature provided with means for gripping the getter material and for feeding it from the inner periphery of the roll toward the source of electrons, means for coupling the getter material and the source of electrons to a source of potential for maintaining the getter material at positive potential with respect to the source of electrons to cause the getter to be evaporated by bombardment by electrons, grid means having a plurality of vanes which extend radially from the center toward the wall of the chamber to form a portion located adjacent the source of electrons and another portion located adjacent and extending along the collector surface, and means for coupling the grid means to a source of potential for maintaining the grid means at positive potential with respect to the source of electrons and the collector surface to cause the grid means to direct electrons from the source into the grid means and to cause the grid means to drive positively ionized gas to the collector surface, with the vanes providing conductors which extend through a large part of the space in which gas is ionized so as to prevent the electrons from the source from building up large space charges.

5. A pumping device comprising a housing defining a chamber from which gas is to be removed, a portion of the housing being corrugated to provide a collector surface of large area in a small space, a source of electrons located in the chamber, a source of getter material, electromagnetic means having a movable armature for gripping the getter material and for feeding it in increments toward the source of electrons to cause the getter to be evaporated by bombardment by electrons from said source of electrons, and grid means having a portion located adjacent the source of electrons for directing electrons into the grid means and having a portion located adjacent and extending along the collector surface for driving ionized gas to the collector surface upon application of an electric potential between the grid means and the collector surface.

6. A pumping device comprising a housing defining a

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chamber from which gas is to be removed, a roll of getter material disposed adjacent the upper portion of the chamber, an electromagnetic feeder for the getter located below the roll of getter and having guide means for feeding the getter material from the inner periphery of the roll so that the roll remains stationary, a source of electrons located below the feeder for directing electrons toward the getter material as it emerges from the feeder and thereby evaporating the getter material by electron bombardment, and grid means located below the source of electrons for directing electrons into a portion of the chamber to ionize gas molecules and for driving the ionized gas to a wall of the housing where the gas is collected and buried by the evaporated getter material upon application of an electric potential between the grid means and the wall of the housing.

7. A pumping device comprising a housing defining a chamber from which gas is to be removed, a roll of getter material located inside the upper portion of the chamber, an electromagnetic feeder for the getter located below the roll of getter, a source of electrons located below the feeder for evaporating the getter material by electron bombardment by electrons from said source, and grid means located below the source of electrons for directing electrons into a portion of the chamber to ionize gas molecules and having a portion extending along the wall of the housing which defines said chamber for driving the ionized gas to a wall of the housing where the gas is collected and buried by the evaporated getter material upon application of an electric potential between the grid means and the housing.

8. A pumping device comprising a housing defining a chamber from which gas is to be removed, a roll of getter material disposed adjacent the upper portion of the chamber, an electromagnetic feeder for the getter located below the roll of getter, a source of electrons located below the feeder for evaporating the getter material by electron bombardment by electrons from said source, and grid means located below the source of electrons and having a plurality of vanes which extend radially from the center toward the wall of the chamber for directing electrons into a portion of the chamber to ionize gas molecules and for driving the ionized gas to a wall of the housing where the gas is collected and buried by the evaporated getter material upon application of an electric potential between the grid means and the housing.

9. A pumping device comprising a housing defining a chamber from which gas is to be removed, a roll of getter material disposed adjacent the upper portion of the chamber, an electromagnetic feeder for the getter located below the roll of getter, a source of electrons located below the feeder for evaporating the getter material by electron bombardment by electrons from said source, and conductive grid means located below the source of electrons for directing electrons into a portion of the chamber to ionize gas molecules and having a portion which is located adjacent a wall of the housing for driving the ionized gas to the wall of the housing where the gas is collected and buried by the evaporated getter material, with the grid means extending along a plurality of directions through the portion of the chamber in which the gas molecules are to be ionized by electron bombardment to provide a grid in volume to prevent the electrons from creating large space charges in that portion of the chamber upon application of an electric potential between the grid means and the housing.

10. A pumping device comprising a housing defining a chamber from which gas is to be removed, a roll of stranded getter material disposed adjacent the upper portion of the chamber, the getter material being a plurality of tightly twisted wires with one of the wires having a higher melting point than the remainder so that it serves as an evaporating surface before it evaporates also, an electromagnetic feeder for the getter located below the roll of getter, a source of electrons located below the

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feeder for evaporating the getter material by electron bombardment by electrons from said source, and grid means located below the source of electrons for directing electrons into a portion of the chamber to ionize gas molecules and having a portion extending along the wall of the housing which defines said chamber for driving the

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ionized gas to a wall of the housing where the gas is collected and buried by the evaporated getter material upon application of an electric potential between the grid means and the housing.

No references cited.