Nov. 5, 1968 W. BACHLER 3,409,211

HIGH VACUUM PUMPS

Filed May 2, 1967 2 Sheets-Sheet 1

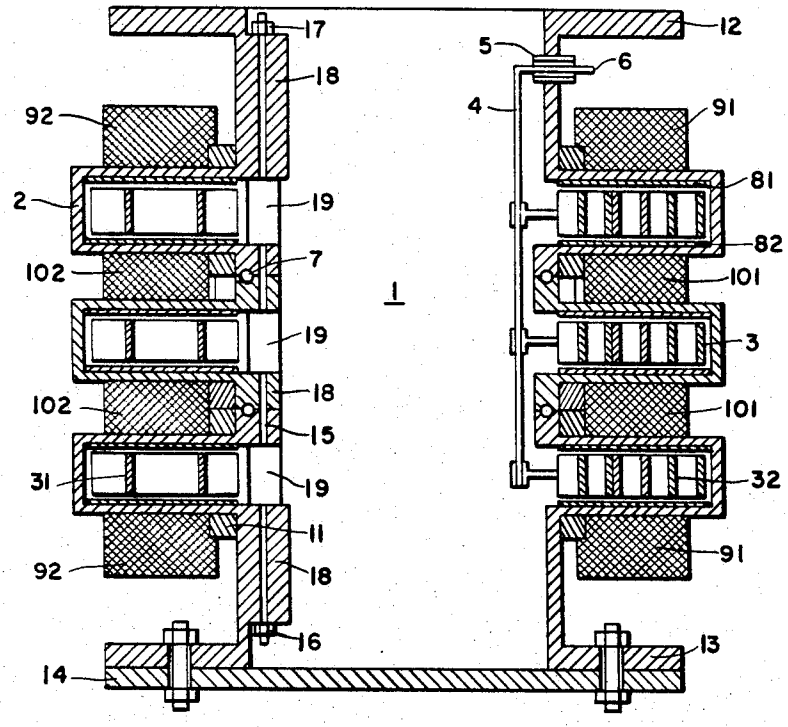


FIG. 1.

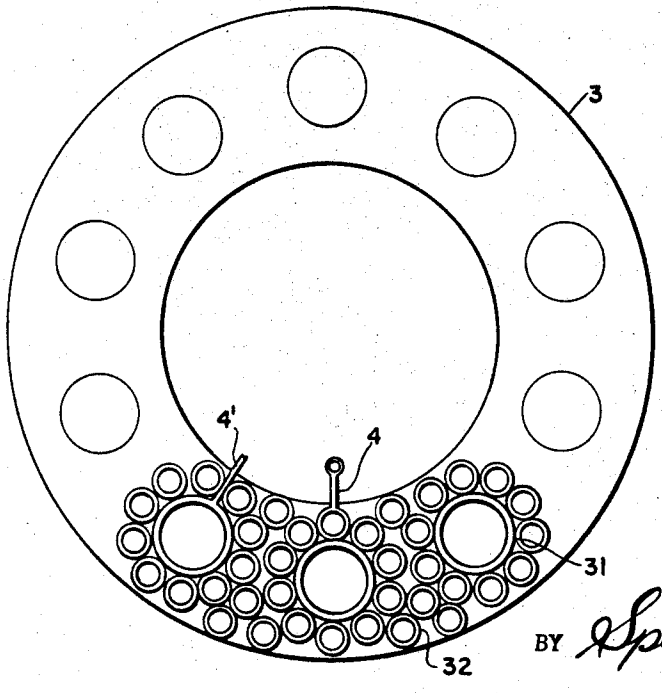


FIG. 2.

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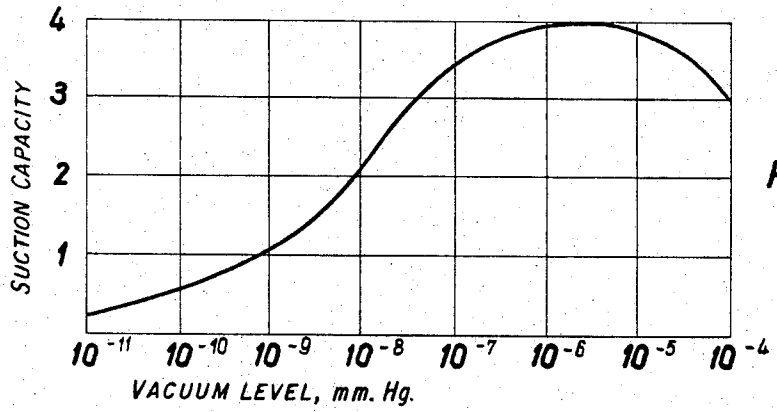


Fig. 3

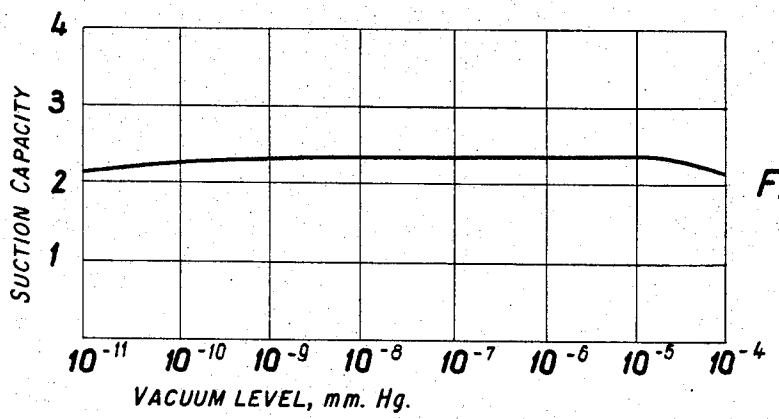


Fig. 4

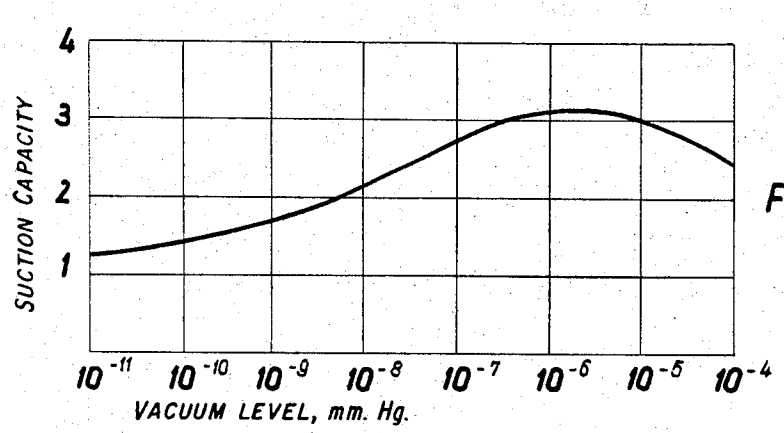


Fig. 5

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HIGH VACUUM PUMPS

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Continuation-in-part of application Ser. No. 573,057, Aug. 17, 1966. This application May 2, 1967, Ser. No. 641,100

Claims priority, application Germany, Aug. 17, 1965, L 51,403

7 Claims. (Cl. 230—69)

ABSTRACT OF THE DISCLOSURE

An all-dry high-vacuum pump having at least one electrode system consisting of a cold cathode and an anode for producing an electric field which ionizes atoms and molecules of the gas to be pumped, the electrode system being composed of a plurality of cells of at least two different types, each type having a different suction characteristic and the combined effect of the two types of cells resulting in optimized pumping action.

Cross reference to related application

This is a continuation-in-part of my application Ser. No. 573,057, filed Aug. 17, 1966 and now abandoned.

Background of the invention

The present invention relates to vacuum pumps, and particularly to improvements in pumps of the all-dry, high-vacuum type.

It is known that pumps of this type rely, at least in part, on the gettering or absorptive power of a vaporized reactive metal for producing a high vacuum. The metal is sputtered to form a vapor of metallic ions which combine with atoms and molecules of the gas being pumped, the resulting compounds then condensing as solid layers on the walls of the pump housing.

The creation of a high vacuum in such pumps is also effectuated by means of a cold cathode discharge resulting from the creation, between a cold cathode and an anode, of an electric field which acts to ionize the gas being pumped and to attract the resulting ions to the cathode, where they are retained.

The basic principle of ion getter pumps with self-sustained or non-sustained discharge is a principle which is used and which can be detected even in the known type of Penning pressure measuring instrument, such as the type disclosed in a catalog published by Leybold's Nachfolger entitled "High Vacuum Engineering," Catalog No. HV 106, page 60. This principle is operative whether or not a magnetic field is employed. When a magnetic field is used, the transit time of the electrons between the electrodes is greatly increased because the electron paths are increased.

The gas consumption of ionization manometers with cold cathode discharge in a magnetic field, such as the Penning type, has been determined by examining their behavior during operation. This has led to certain rules for arranging and constructing vacuum measuring devices of this type. It is known that special systems using cold cathodes of titanium have a high pumping capacity.

Ion getter pumps having a plurality of similar ionization chambers have been constructed by using a parallel arrangement of Penning systems. Research and development efforts in this field have been directed toward multiplying the suction power of the system by employing suitable design and arrangement of the electrodes and the getter surfaces.

In vacuum pumps of this type a container communicating with the interior of the pump is evacuated by

causing molecules of the gas in the pump to be ionized by bombardment with electrons produced in the pump and to be accelerated by a suitably arranged electric field so that the ions are discharged into the cathode and absorbed and/or they are gettered on metal layers produced by cathode sputtering. The low pressure developed in the pump produces a corresponding low pressure in the communicating container.

It has been found that the degree of vacuum obtainable in such a pump is determined, among other things, by the pumping time and the absorptive power of the cathode and/or gettering surface, by the pumping or suction power, and by the glow discharge current, as well as by the surface available for collecting the sputtered cathode material.

Experiments have shown that an optimum suction power can be obtained if, in a vacuum pump of the type described above, the anode is subdivided with respect to its surface and/or volume, so as to create a number of partial discharges which increase the pumping speed. This subdivision of the anodes may be effected in such a way as to produce a plurality of parrallel anode cells which, depending on the required optimum capacity range, have a relatively high suction power over a limited pressure range or a low suction power over a wide pressure range.

Summary of the invention

It is a primary object of the present invention to improve the performance of such pumps.

Another object of the present invention is to permit the suction curve of such pumps to be readily varied.

Yet another object of the present invention is to improve the operating time of such pumps.

A still further object of the present invention is to provide a pump having an improved suction capacity over a wide range.

These and other objects according to the present invention are achieved by the provision, in a vacuum pump employing cathode sputtering and comprising at least one electrode system composed of a cathode and an anode, of the improvement wherein the electrode system is composed of a plurality of cells of at least two different types, each type having a different suction power-vs.-vacuum pressure characteristic, whereby the combined pumping effect of the at least two types of cells results in an improved suction capacity over a wide vacuum pressure range.

Specifically, each electrode cell type is arranged to have an optimum suction capacity which extends over a respectively different pressure range.

It has been found that such an arrangement makes it possible for the first time to provide a pumping system which, although it has a reduced peak suction capacity which is immaterial for many purposes, possesses a hitherto unobtainable suction capacity over a wide pressure range.

Brief description of the drawings

FIGURE 1 is a simplified, longitudinal, cross-sectional view of an ion getter pump employing an electrode system according to the present invention.

FIGURE 2 is a plan view of one embodiment of the present invention.

FIGURE 3 is a chart presenting the suction capacity curve of one prior art type pump.

FIGURE 4 is a view similar to that of FIGURE 3 showing the suction capacity curve of another type of prior art pump.

FIGURE 5 is a view similar to that of FIGURE 3 showing the suction capacity curve of a pump according to the present invention.

Description of the preferred embodiments

With more particular reference to the drawings, FIGURE 1 illustrates an arrangement of an ion getter pump having three ionization chambers. A pump casing **1** is provided which is generally in the shape of a hollow cylinder and has disk-shaped ionization chambers **2** attached together to define, in part, this casing. A plurality of ring or annular anodes **3**, structurally interconnected, are disposed in the chambers, i.e., one anode in each chamber. A connection line **4** is provided to which the ring anodes **3** are connected and which passes through to the exterior of the casing by means of a vacuum type bushing **5**, where it defines a common electric connection point **6** exteriorly of the casing. Ground is used as a further electrical connection for the hollow cylindrical casing **1**. Since the casing **1** is comprised of several sections, electrically conductive intermediate packings **7**, for example of gold, copper or aluminum, are used in order to assure the uniform electric distribution of potential.

Ring-shaped or annular metal sheets **81**, **82**, of a material which is particularly suitable for sputtering and preferably titanium, hafnium, aluminum, zirconium, or other known getter materials which are placed into the ionization chambers **2** are provided and serve as cold cathodes. If desired, the inner surfaces of the ionization chambers may be appropriately designed of a getter material, such as titanium, and may be used directly as cold cathodes.

Above the uppermost ionization chamber **2** and below the lowermost ionization chamber, an annular disk type magnet is provided. Both these magnets are constructed of two semi-circular halves **91**, **92**. These magnets are greater in height than the other annular disk type magnets which are disposed between adjacent ionization chambers **2** and which are also constructed of two ring halves **101** and **102**.

The magnets are so constructed in order to provide the most advantageous and uniform design as far as the magnetic field in the ionization chamber is concerned. This is clearly illustrated in FIGURE 1 wherein the disk magnets **91** are of greater height than the magnets **101**. Also, the ring magnets may be provided with a smaller outer diameter and/or a larger inner diameter than that which corresponds to the dimensions of the anodes in the ionization chambers. By this means, maximum utilization of the stray field of the ring magnet edges is provided.

In a preferred embodiment, the outer pump body was formed of non-ferromagnetic high grade steel, and the magnetic field strength within the ionization chambers amounted to about 1,000 oersteds in an approximately uniform distribution.

Flanges **12**, **13**, are provided at the ends of the hollow cylindrical casing **1** for connecting the pump to various other structures. In the embodiment shown, the flange **13** is sealed by means of an end plate **14**. The elements and parts of the hollow cylindrical casing **1** are held together by means of threaded rods **15** which are secured by nuts **16** and **17** in the region of their end portions. One-piece flange portions **18** are provided on the hollow cylindrical casing **1** for guiding the threaded rods **15**. Ionization chambers **2** are longitudinally spaced by spacers **19**.

In order to operate this ion getter pump, a D.C. voltage of several kilovolts is applied between the electrical connection point **6** and a ground point on the mass of the hollow cylindrical casing **1**. Glow discharges are then formed between the ring-shaped metal sheets **81** and **82** which serve as cold cathodes.

Particularly favorable results are obtained if the radial projection or extension of the disk-shaped ionization chambers **2** amounts to a multiple of the height of the chamber.

Each anode **3** is constructed of a plurality of anode cell portions **31** and **32**. One manner in which these cell portions can be arranged is shown most clearly in the plan view of FIGURE 2. According to this arrangement, a plurality of relatively large anode cell portions **31**, which might have diameters of the order of 40–50 millimeters for example, are distributed around the annular anode **3** and around each portion **31** is distributed a plurality of substantially smaller anode cell portions **32** which might have diameters of the order of 10–15 millimeters, for example. Each anode cell portion cooperates with the cathode portion immediately adjacent thereto to form a separate electrode cell.

All of the anode portions **32** are connected together electrically and are connected to the connection line **4**. The larger cell portions **31** might be electrically connected to the portions **32**, and hence be placed at the voltage applied to line **4**, or they may be electrically insulated from the portions **32** and connected together to a separate line **4'** in order to be placed at a different operating potential. In this embodiment, each large diameter cell portion **31** defines an electrode cell of a first type, while each small diameter cell portion **32** forms an electrode cell of a second type.

Experiments have revealed that the electrode cells defined by these small diameter cell portions **32** will exhibit a suction capacity-vs.-vacuum pressure level characteristic similar to that shown in FIGURE 3. As is shown in this figure, the ordinate of which is simply in arbitrary terms representing relative suction capacity, these electrode cells possess a relatively high suction capacity over a limited pressure range.

The curve of FIGURE 4 is representative of the type of suction capacity-vs.-vacuum pressure level curve exhibited by the electrode cells defined by the large diameter cell portions **31**. It may be noted that these cells exhibit a moderate suction capacity characteristic over a wide pressure range.

By combining the actions of the two electrode cell types, in accordance with the present invention, it is possible to produce a pump having a suction capacity-vs.-vacuum pressure level characteristic of the type shown in FIGURE 5, which characteristic presents both a high peak suction capacity and a high average suction capacity. It has been found that, for many applications, a pump having a characteristic of this type will produce a pumping action which is markedly superior to that of comparable prior art pumps.

It should be appreciated that the specific embodiment illustrated in FIGURE 2 represents but a single example of the present invention and that there are many other ways for creating two or more types of electrode cells such that the combined effect of the different suction capacity characteristics of the different cell types will result in an improved combined suction capacity characteristic. Thus, for example, the anode cell portions might have different shapes and/or different axial lengths. Alternatively, the various anode cell portions could be disposed at different distances from the cathodes, or the various anode cell portion types could differ from one another in the material from which they are made. Similarly, the different electrode cell types could be created by providing cathodes having individual portions of different materials. The different cell types could also be created by placing each type of anode portion at a different operating voltage or by subjecting each different electorde cell type to a different magnetic field strength. It is only necessary that the differences between the two electrode cell types be such that the combined effect of the suction capacity characteristics of the two or more different electrode cells will combine to give the pump an improved suction capacity characteristic.

If desired, the pump cathodes could be made of high-grade steel. Pumps according to the present invention are capable of producing vacuum levels as low as 10^{-10} millimeters of mercury.

If it is desired to operate the different electrode cell types at different voltages, it is only necessary to apply two different voltage levels to the lines **4** and **4'**, or to discon-

nect one of the lines. This ability to independently control the voltages applied to the two cell types permits the electron emission between the cathode and anode to be continuously adapted to the molecules to be ionized and thereby permits the operating life of the pump to be increased and its operating costs to be substantially decreased.

According to a further feature of the present invention, the various anode cells can be replaced either individually or as a group so as to increase the suction capacity range of the pump, simplify its fabrication, and reduce the stock of spare parts which must be maintained. For example, in an electrode system having three different cell types, one or two of the cell types could be replaced, or the whole system could be replaced.

According to a further feature of the present invention, the pump might be associated with a magazine-type housing which is placed under a vacuum and which houses different types of electrode cells.

In addition, the magnets **91–92** and **101–102** could be replaced by controllable electromagnets for producing a variable magnetic field strength or by a plurality of smaller magnets each associated with a different electrode cell type and each producing a different magnetic field strength.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In a vacuum pump employing cathode sputtering and comprising at least one electrode system composed of a cathode and an anode, the improvement wherein said system is composed of a plurality of anode cells of at least two different types, each said type having a respectively different suction power-vs.-vacuum pressure characteristic, whereby the combined pumping effect of said at least two types of cells results in a suction capacity over a wide vacuum pressure range which is better than that which would otherwise result if only one such type of cell were provided.

2. An arrangement as defined in claim **1** wherein each of said cells of one said type has a diameter of between 10 and 15 mm., and each of said cells of another said type has a diameter of between 40 and 50 mm.

3. An arrangement as defined in claim **1** further comprising means connected to said electrode system for applying a variable amplitude operating voltage thereto.

4. An arrangement as defined in claim **1** further comprising means for applying a magnetic field to said system.

5. An arrangement as defined in claim **3** wherein said means for applying an operating voltage are arranged for applying a separately variable voltage to all of the cells of each said type and for selectively disconnecting all the cells of each said type.

6. An arrangement as defined in claim **1** wherein at least part of said electrode system is readily removable.

7. An arrangement as defined in claim **6** further comprising a magazine associated with such pump for storing removable electrode portions.

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