United States Patent

Von Rauch

[15] 3,668,393

[45] June 6, 1972

[54] APPARATUS HAVING EVACUATION SPACES AND A PUMPING ASSEMBLY

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[22] Filed: Sept. 28, 1970

[21] Appl. No.: 75,883

[30] Foreign Application Priority Data

Sept. 30, 1969 Germany ..... P 19 50 328.7

[52] U.S. Cl. ..... 250/49.5 A, 415/90, 415/100, 417/201

[51] Int. Cl. H01j 37/26, F03b 5/00, F01d 3/02

[58] Field of Search ..... 417/199, 201, 205, 423, 49; 415/90, 100; 250/49.5 A, 49.5 B

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[57] ABSTRACT

An apparatus has a high vacuum seal and at least one additional evacuative space as well as a pumping assembly for evacuating the vessel and space. The pumping assembly has a backing pump and a turbomolecular pump having a main section communicating with the vessel and with the backing pump. The turbomolecular pump has an auxiliary section communicating with the additional evacuative space and has a housing enclosing the main and auxiliary sections. The turbomolecular pump has first and second pump members disposed in the main and auxiliary sections respectively. The housing includes a wall intermediate the main and auxiliary sections for separating the sections in vacuum tight relation to each other. The turbomolecular pump has a rotor shaft which passes through the wall and connects the first pump member with the second pump member.

5 Claims, 2 Drawing Figures

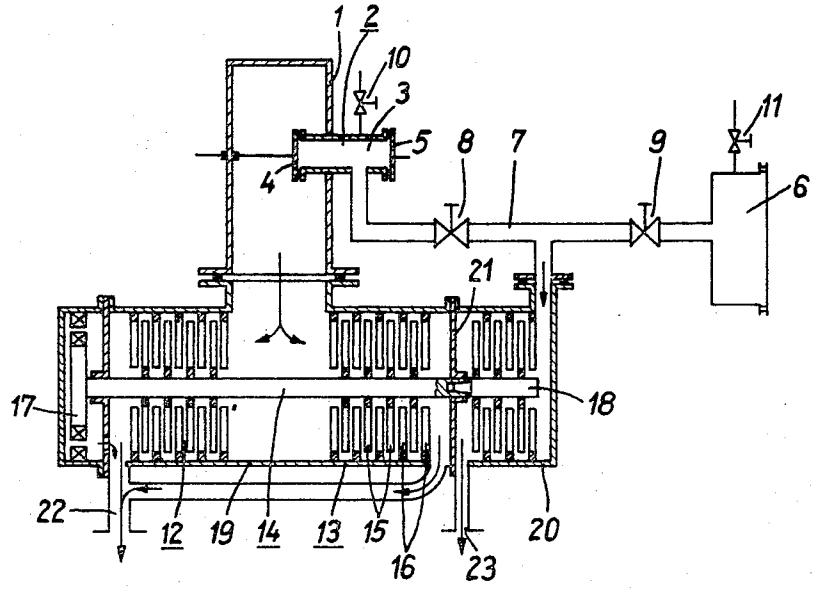

Fig. 1

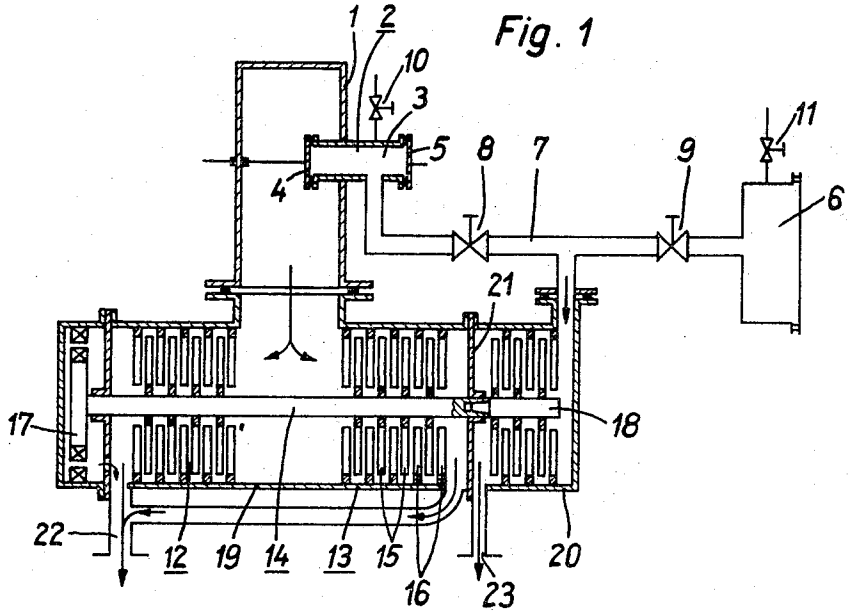
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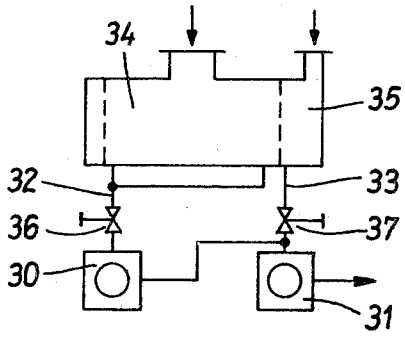
Fig. 2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APPARATUS HAVING EVACUATION SPACES AND A PUMPING ASSEMBLY

My invention relates to apparatus having evacuative spaces and equipped with a pumping assembly comprising a backing pump and a high vacuum pump for evacuating high vacuum vessels and other spaces or compartments in the apparatus. Although the invention is discussed herein relative to an electron microscope, it can be applied advantageously to other apparatus such as ion microscopes, deflection apparatus, vacuum attenuation apparatus or also charge carrier beam handling apparatus. The invention will always find application, if the operation of an apparatus require a hydrocarbon free high vacuum.

For example, with electron microscopes pump stands are used which include high vacuum pumps, mercury vapor beam pumps or oil diffusion pumps. With this type of pump stands, a vacuum in the region of 10^{-5} Torr is obtained.

In recent times, the form and construction of turbo-molecular pumps has become known which permit, producing, without a cooling trap, a hydrocarbon free high vacuum having a residual pressure in the region of 10^{-7} to 10^{-10} Torr. These pumps include, in a housing, a rotor shaft having a slotted disc; this rotor disc cooperates with correspondingly formed stator discs in such a manner that they form discharge channels for the gases evacuated from the high vacuum vessel.

Initially, it would appear practical, to apply this type of pump as a high vacuum pump also for electron microscopes and other apparatus with several evacuated compartments. However, an electron microscope does not only have a space to be evacuated which is in the form of a space for receiving the beam, rather, there are additional compartments such as the locking chamber or a desciccator which must be evacuated during specific operating steps of the microscope, so that several turbomolecular pumps would be required, and the total cost would be very high.

It is an object of my invention to provide an apparatus having evacuative spaces with a good high vacuum in a short time. Subsidiary to this object, it is another object of the invention to provide such an apparatus with a vacuum pumping assembly capable of developing a high suction power.

It is still another object of my invention to provide a vacuum pump assembly adaptable to an apparatus having a plurality of spaces wherein a good high vacuum is to be achieved. Subsidiary to this object, it is an object of the invention to provide such a pump assembly having only one turbomolecular pump.

It is still another object of my invention to equip an apparatus having evacuative spaces with a vacuum pumping assembly at lower cost.

According to the invention the need for several pumps of the turbomolecular type to develop a good high vacuum in an apparatus having a high vacuum vessel and at least one additional evacuative space or compartment is avoided by providing a turbomolecular pump arrangement having a main section that is connected between the high vacuum vessel and a backing pump arrangement. The turbomolecular pump arrangement also has an auxiliary section whose input side is hermetically sealed from that of the main section and connected to the additional compartment. The turbomolecular pump has first and second pump means that are included in the main and auxiliary sections respectively. The housing encloses the main and auxiliary sections and includes a wall intermediate the two sections for separating the sections in vacuum tight relation to each other. The turbomolecular pump arrangement has a rotor shaft which passes through the wall and connects the first pump means with the second pump means.

The invention permits the introduction of a turbomolecular pump generating a good high vacuum in a short time with high suction power. The turbomolecular pump is useable also when several spaces have to be evacuated without the necessity of using additional pumps of this type. Oil vapors developed during rough pumping by the backing pump arrangement will not precipitate on the inner walls of the spaces being evacuated, even if cooling traps are omitted, because during the rough

pumping of the high vacuum vessel or the other spaces, they are separated from the backing pump arrangement by the action of the turbomolecular pump arrangement.

The apparatus according to the invention uses a turbomolecular pump constructed with a housing which forms separate chambers surrounding respective active pump parts. It is often advantageous to expand a single part pump of the turbomolecular type so that the required number of auxiliary pump sections are added. A corresponding variation of the invention is exemplified by expanding a one part turbomolecular pump so that the rotor shaft is extended on its end away from the drive motor and passes vacuum tight at this end through the end face of the housing of the one part pump and into an auxiliary section or chamber formed by a flange attached ancillary housing portion.

Aside from the special construction of the thermomolecular pump, there are advantages afforded by the incorporation of this type of pump. For example, a special advantage in the area of electron microscopes derives from the fact that turbomolecular pumps begin to develop appreciable suction when the pressure is in the region of 10^{-2} Torr, whereas conventional pumps have only a small suction power at these pressure values. Therefore, by using an auxiliary section of a turbomolecular pump, it is possible to effect a rough pumping of an airlock or other space of electron microscopes to a very low pressure.

A difficulty that arises, when providing for the evacuation of several compartments or spaces in an apparatus is that, in order to effect a rough pumping of any additional compartments, the backing pump must normally be disconnected from the turbomolecular pump and be connected via a by-pass with the additional compartments if the use of additional backing pumps are to be avoided. Such switching of the backing pump requires that there be provided a sufficiently large rough vacuum receiver to which the turbomolecular pump can be connected during the rough pumping of the additional compartments or spaces.

This difficulty is avoided according to another feature of the invention wherein there is provided a two stage backing pump arrangement having a high vacuum stage and a rough vacuum stage. The high vacuum stage is connected with its input to the main section of the turbomolecular pump, while the rough vacuum stage is connected permanently to the output of the high vacuum stage, and is connectable via a valve to the output of the auxiliary section of the turbomolecular pump arrangement. This embodiment affords the advantage that it is sufficient to provide a single backing pump of conventional two stage design, without requiring complex switching means and a rough vacuum receiver in order to maintain the rough vacuum in the high vacuum vessel.

As already mentioned, the invention is applicable to any one of several apparatus, and without any limitations to the invention, the preferred application of the instant invention is to electron microscopes wherein the space containing the electron beam is the high vacuum vessel, while the additional spaces comprise the lock space and/or the desiccator. Thus, the instant invention is appplicable wherever an additional space is provided as well as to apparatus having additional spaces to be evacuated.

The invention will now be described with reference to the accompanying drawing wherein:

FIG. 1 is a schematic diagram of the pertinent portions of an electron microscope equipped with a pumping apparatus according to the invention.

FIG. 2 is a schematic diagram of a vacuum pump arrangement wherein the pumping apparatus of the invention is provided with a two stage rotating fore-vacuum pump.

Of the actual electron microscope, FIG. 1 shows simply the microscope column 1. The microscope column of an electron microscope contains all the electro-optical equipment as well as the specimen in its investigative position. In the description which follows the enclosed evacuative space defined by the microscope column is referred as the high vacuum vessel. The

specimen lock 2 extends into the column. There can also be locks for diaphragms, cathodes or the like. The specimen lock 2 with the lock space or compartment 3 contains an internal airlock gate 4 and an external airlock gate 5 of which at least one airlock gate is always closed.

In addition, a neighboring vessel 6 belongs to the microscope which can, for example, be a desiccator for photographic material. The vacuum line 7 communicates with the lock space 3 and the neighboring compartment or container 6. Lock valves 8 and 9 are arranged on the vacuum line 7. Air inlet valves 10 and 11 are arranged on compartments 3 and 6 respectively.

The turbomolecular pump system of the invention is located at the lower portion of the high-vacuum column 1. The system comprises a main section 12, a housing 13, rotor shaft 14, slitted discs 15 arranged on shaft 14 and the corresponding discs 16 constituting the stator of the pump.

According to the invention, this pump is arranged as a multipart pump in such a manner that an auxiliary section is provided by providing the rotor shaft 14 with an extension on the side away from its drive motor 17, that is, the rotor is extended toward the right in FIG. 1 as illustrated therein by the ancillary part 18. The housing 13 is put together from two housing parts 19 and 20. The main section of the pump system is included in housing part 19, the latter having an opening in the end face 21 for the rotor shaft 14. Housing part 20 includes the auxiliary section of the pump arrangement and is flange connected to part 19 in the region of end face 21. The two housing parts 19 and 20 form chambers vacuum separated from each other of which the larger chamber communicates with the high vacuum vessel 1 and the smaller chamber to the right communicates with the compartments 3 and 6 to be evacuated. The paths of flow during pump operation are indicated by arrows in FIG. 1. Output ports 22 and 23 serve for connection to a backing pump arrangement which is provided but not shown in FIG. 1.

FIG. 2 illustrates the two-stage backing pump arrangement used in a preferred embodiment. This pump arrangement has a high vacuum stage 30 and a rough vacuum stage 31. These two pump stages are connectable with the two sections 34 and 35 of a turbomolecular pump arrangement such as that shown in FIG. 1 via lines 32 and 33 respectively; these lines corresponding to the output ports 22 and 23 in FIG. 1. To permit the two-stage backing pump to be operated without a rough vacuum receiver, valves 36 and 37 are provided in the connecting lines 32 and 33 respectively, and the output of the high vacuum stage 30 is permanently connected to the input of the rough vacuum stage 31. Thus the input of the rough vacuum stage 31 is connectable at the input side either exclusively to the output of the high vacuum stage 30, or both to this output and to the auxiliary section 35 of the turbomolecular pump. This ensures that even during the rough pumping of airlocks and other auxiliary compartments, the main section 34 remains connected via the high vacuum stage 30 with the rough vacuum stage 31 of the backing pump arrangement.

Other designs of multistage turbomolecular pump arrangements may be used with such a backing pump arrangement, and additional connecting lines may be provided for other facilities. Additional compartments or spaces may be formed by sectionalizing of the column of an electron microscope, for example.

To those skilled in the art it will be obvious upon a study of this disclosure that the invention permits of other configurations of the turbomolecular pump having a main section and at least one auxiliary section and, likewise, other applications requiring other interconnecting lines. The additional evacuative spaces can also arise, for example, by the subdivision of the column of an electron microscope.

I claim:

1. Apparatus having a high vacuum vessel and at least one additional evacuative space and equipped with a pumping assembly for evacuating said vessel and said space, said pumping assembly comprising a backing pump, and a turbomolecular pump having a main section communicating with said vessel and with said backing pump, said turbomolecular pump having an auxiliary section communicating with said additional evacuative space, said turbomolecular pump having housing means enclosing said main section and said auxiliary section, said turbomolecular pump having first and second pump means disposed in said main section and said auxiliary section respectively, said housing means including separation means intermediate said main section and said auxiliary section for separating said sections in vacuum tight relation to each other, said turbomolecular pump having a rotor shaft passing through said separation means and connecting said first pump means with said second pump means.

2. In an apparatus according to claim 1, said turbomolecular pump comprising a drive motor attached to one end of said rotor shaft, said housing means comprising first and second housing parts surrounding said main section and said auxiliary section respectively, said second housing part being flange connected to said first housing part, and the other end of said rotor shaft extending vacuum tight through said separation means into said second housing part.

3. In an apparatus according to claim 1, said backing pump being a two stage backing pump, one of said stages being a high vacuum stage, the input of said high vacuum stage being connected with said main section of said turbomolecular pump, the other one of said stages being a rough vacuum stage, the input of said rough vacuum stage being connected to the output of said high vacuum stage, and means connected between said input of said rough vacuum stage and the output of said auxiliary section of said turbomolecular pump for selectively connecting said rough vacuum stage to said auxiliary section.

4. In an apparatus according to claim 1, said apparatus being an electron microscope, said vessel defining the space through which the electron beam passes and said one space being a lock space.

5. In an apparatus according to claim 4, wherein said apparatus has at least two additional evacuative spaces, one of said spaces being a lock space and the other of said spaces being a desciccator.

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