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VACUUM ION PUMP

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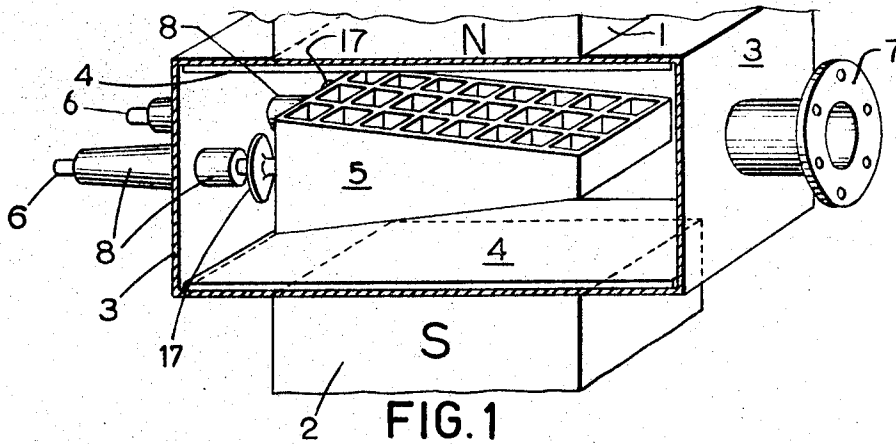


FIG. 1

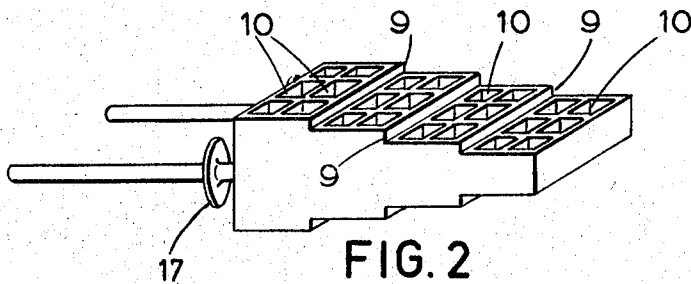


FIG. 2

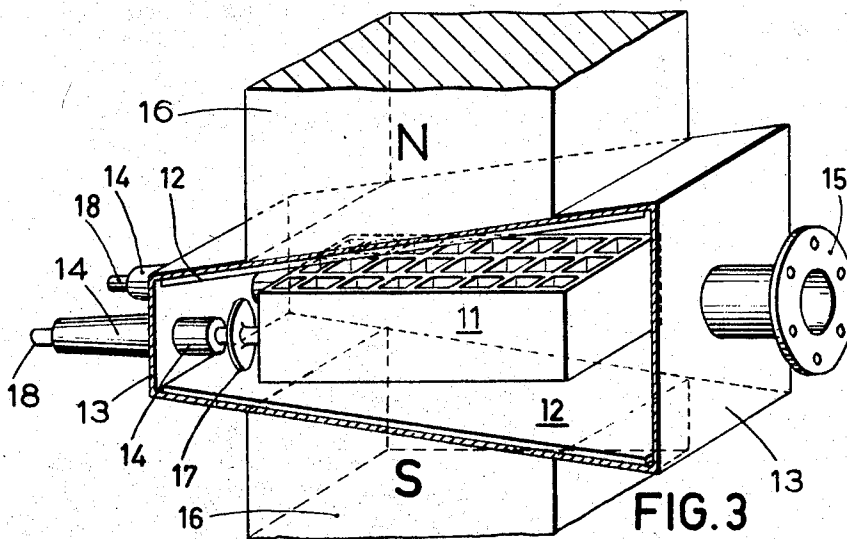


FIG. 3

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1

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## VACUUM ION PUMP

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4 Claims. (Cl. 230—69)

The present invention is directed to an improved construction of vacuum pump of the type operating on the well known Penning principle. Such pumps are now commonly known as vacuum ion or electrical pumps and depend for their operation on the ionization of residual gas molecules by the establishment of an electrical discharge between an anode surface and a cathode surface. A magnetic field is provided to impart an oscillatory motion to the electrons thereby increasing the probability of collision with gas particles and consequential ionization. Ionized gas particles are accelerated by the applied electrostatic field towards the cathode surface, which is usually made of a reactive metal such as titanium. The resultant impact of the gas particles causes sputtering of the cathode surface which tends to trap the gas particles.

In order to enhance the pumping action of a vacuum pump operating on the Penning principle, it is known to construct the anode surface in the form of a plurality of cells the open edges of which face the cathode surface with the magnetic field arranged co-axially with said cells. Such known arrangements provide a plurality of discharge paths each of which contributes to the ionization and the consequential increase in pumping action.

Further, it has been shown that optimum pumping conditions can be related to cell dimensions and the relative spacing between anode and cathode. Furthermore, under operating conditions the applied electrostatic and magnetic field strengths have a significant influence on the pumping action. All these parameters are more or less interdependent and alter with pressure. Physical dimensions are generally chosen as a compromise between economic considerations and the desired range of pumping pressures.

In known types of ion pump constructions it has been noted from detailed examination that where the anode to cathode spacing has been chosen as optimum for a given range of pressures that there is a tendency for arcing to occur during the initial application of the high electro-static field. This arcing between the electrodes causes oxidation of the surrounding surfaces including the cathode surface. Close inspection of such affected cathode surfaces show that the all-important sputtering action has been hindered by the oxidation and that as a consequence to this the useful cathode area has not been fully utilized and the life of the cathode has been shortened.

Furthermore, known pumping structures exhibit the disadvantage that the anode to cathode distance presents a relatively high impedance to incoming gas particles which have to reach the discharge area before ionization can take place. This disadvantage increases with decrease in pressure in that there is a lengthening of the mean free path of the residual gas particles.

In a practical example of this effect an ion pump of the known type comprising a plurality of cells each having a cross-sectional area of 12×12 mm. in which the anode depth facing the exhaust port was 6 cells deep and having a constant anode to cathode spacing of 2.5 mm., was shown to have a calculated unit cell pumping speed of approximately 0.5 litre/sec. However, under operating conditions, the cells farthest from the exhaust port

2

contributed only 0.3 litre/sec. due to the impedance between the port and the remote cell discharge area. This means that the cells farthest away operated at only 60% of their optimum pumping speed.

A further disadvantage noted in known vacuum ion pump constructions is the difficulty in re-establishing a discharge at low pressures. For example, if an initial pumping operation is taken down to 10<sup>-6</sup> torr. and then temporarily switched off, difficulty will be experienced in re-establishing the discharge for continuing the pumping operation because pressure X discharge distance is a constant (Paschen's Law).

It is an object of the present invention to provide an improved ion pump structure which mitigates the above disadvantages and at the same time provides an enhanced pumping speed over a greater range of pressures when compared to known structures.

According to the present invention there is provided a vacuum ion pump of the type hereinbefore described wherein the spacing between at least one anode and an associated cathode is tapered in a direction which provides spacing which increases towards an exhaust port.

According to one embodiment of the present invention there is provided a vacuum ion pump of the type described wherein a wedge-shaped anode section is secured between parallel cathode surfaces and the thin edge of the said wedge-shaped anode is positioned towards an exhaust port.

According to a further embodiment of the present invention an ion pump of the type described is provided with a substantially parallel anode structure arranged in spaced relationship between two cathode surfaces which converge but do not contact the anode part remote from an exhaust port.

Yet a further modification of the present invention resides in a construction in which the anode structure is stepped to provide an increased anode to cathode spacing in a direction towards an exhaust port.

Ion pumps constructed in the manner described according to the present invention have advantages in that arcing between electrodes is substantially restricted to that part where the electrode spacing is closest and the increased spacing towards the incoming gas particles allows such particles a freer access to the discharge areas. Furthermore, the increased electrode spacing allows an easier re-establishment of a discharge at low pressures.

The resultant slight loss in pumping speed due to the cells positioned nearest the exhaust port having an increased electrode spacing is more than offset by the improved pumping speed contributed by the cells farthest from the cathode and which now offer freer access to incoming gases.

The present invention will now be described with reference to FIGURES 1, 2 and 3 of the diagrammatic drawings accompanying the provisional specification.

FIGURE 1 illustrates an ion pump comprising a box like housing 3 which is constructed of stainless steel and in which is supported a wedge-shaped cellular anode structure 5 of titanium. The anode structure 5 comprises three columns of cells each column 8 cells deep. The anode structure 5 is held by rods 6 which also serve as terminals for the application of an electro-static potential. The rods 6 are insulated from the housing 3 in a gas tight manner by feed-through insulators 8. Sputter guards 17 surround the internal rod parts to prevent the deposition of sputtered material around the insulators 8. The housing 3 is provided with cathode surfaces 4 which may be of titanium or other reactive metal and are positioned adjacent the open ends of the wedge-shaped cellular anode structure 5. An exhaust port 7 is provided in the housing 3 in a position adjacent the thin end of the

3

wedge-shaped anode 5 and magnetic pole pieces 1 and 2 are shown as part of a permanent magnet system which provides a magnetic field substantially parallel with the walls of the cells of the anode 5.

FIGURE 2 shows a modified anode structure comprising a number of cells 10, the lengths of the walls of which are reduced by steps 9. Again, as in FIGURE 2, this anode structure is intended to be mounted in a pump housing (not shown) in which the cathode surfaces are parallel and in which an exhaust port is positioned in the vicinity of the shortest cell length and the longest discharge path.

The construction shown in FIGURES 1 and 2 afford a further advantage in that the anode structure is secured to the pump housing at a point where the anode weight is greatest and this gives for better rigidity and ruggedness and allows such pump structures to be incorporated in equipment which may be in motion or vibrated.

FIGURE 3 illustrates a modified ion pump structure according to the present invention in which a multi-cellular anode 11 is provided with substantially constant cell lengths and the varying electrode spacing is effected by converging cathode surfaces 12 contained within a pump housing 13. Permanent magnet pole pieces 16 are included for providing the magnetic field substantially parallel with walls of the anode cells. The anode structure 11 is held in position by rods 18 which together with feed-through insulators 14 serve as terminals for the application of an electro-static potential. An exhaust port 15 is provided opposite the anode 11 where the anode to cathode spacing is greatest.

As a comparison with the known pumping structure previously herein described, a pump having substantially the same dimensions previously given but having a construction similar to FIGURE 1 of the accompanying drawings and in which the anode to cathode spacing in the vicinity of the exhaust port was increased to 4.5 mm. and tapered to 2.5 mm. showed an increase from the

4

previous 0.3 litre/sec. to 0.48 litre/sec. in the cells positioned furthest from the port. The loss due to the increased electrode spacing in the vicinity of the port was shown to have dropped from the previous 0.5 litre/sec. to only 0.41 litre/sec. Thus, the total pumping speed for the pumping structure in accordance with the present invention results in an increase from the previous 0.08 litre/sec. to 0.89 litre/sec., i.e. an increase of 12% in the overall pumping speed.

What is claimed is:

1. In a vacuum ion pump at least one anode and an associated cathode spaced from said anode, the spacing between the anode and cathode being tapered in a longitudinal direction which provides spacing which increases towards an exhaust port spaced from said anode and said cathode for communication to an atmosphere to be pumped.

2. A vacuum ion pump as claimed in claim 1 in which the anode has a wedge-shaped section and is secured between parallel cathode surfaces, the thin edge of said wedge-shaped anode being positioned towards an exhaust port.

3. A vacuum ion pump as claimed in claim 1 in which the anode comprises a substantially parallel structure arranged in spaced relationship between two cathode surfaces which converge but do not contact the anode part remote from an exhaust port.

4. A vacuum ion pump as claimed in claim 1 in which the anode is provided with stepped section which increases the anode to cathode spacing in a direction towards an exhaust port.

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LAURENCE V. EFNER, *Primary Examiner.*