SMALL SIZE ION PUMPS

R.Cyranski, Cz.R.Kiliszek, J.Marks, A.Sobolewski, H.Magiełko
Institute of Vacuum Technology, Długa 44/50, 00-241 Warszawa, Poland,
e-mail: jmarks@warman.com.pl

This paper describes some designs of the two versions ion pumps and their range operation for various magnetic fields. The first version is made with different cell size in the anode element and titanium cathode operating in magnetic field from 600 to 650 Gs and the second version with the same anode element but differential Ti/Ta cathode working in magnetic field above 1200 Gs.

Introduction

The small size ion pumps are used in the evacuation systems mainly for electron device and detector applications.

The simplest configuration of ion pump is the Penning cell, with the cylindrical anode made of stainless steel placed between two flat cathode plates made of titanium or with one Ti cathode and one Ta cathode. In almost ion pump such system work with magnetic fields of 1 – 2 kGs and voltages of 3 – 7 kV. In actual ion pumps the pumping units consists of many cells connected in parallel to the same anode potential. At the pressure of 10^{-3} hPa or below, takes place the Penning discharge, in which under the influence of the magnetic field, the electrons are constrained and they follow a cycloid path around the axis of the cell. In the cell cloud of high energy electrons, during the striking with gas molecules, creation of positive ions occurs. These ions are accelerated under the influence of electric field from the positive anode voltage and strike into the titanium cathode plates. The cathode material is sputtered and deposited on the surface of anode, forming a reactive surface layer for pumping active gases. The noble gases are pumped less stable by implantation process in the cathode and more stable pumped by burial in the sputtered and deposited titanium film on the anode. In order to improve the stability of pumping speed of noble gases some pumps have been developed with differential Ti –Ta cathode and made also in various profiles [1,2,3]. An important parameter for estimation of pumping speed is discharge intensity I/P (I is the pump current, P the pressure) as a function of anode voltage, magnetic field, and dimension of anode cells. It has been reported in the literature [4,5,6] that at low magnetic field the ignition discharge depends on the radius r_a of the anode cell and is given by the empirical equation:

$$B_i = 300/ r_a, \qquad (1)$$

where r_a equals cell radius in cm and B_i is the magnetic field at the ignition point in Gs. This empirical equation is valid mainly for working voltages U_a>3kV. For the low potential ignition the dimensions of the electrode structure should be taken according to the relation:

$$0{,}65 < L_a / 2r_a < 1{,}1 \text{ and } 0{,}4 < L_a / 2L < 0{,}7 \qquad (2)$$

where L_a anode height, r_a cell radius, 2L distance between cathodes. The discharge intensity at the constant pressure increases linearly with magnetic field increase from B_i to $2B_i$ according to relation

$$B\,r = \text{const.} \qquad (3).$$

At the magnetic field above $2B_i$ the discharge intensity increases but in a slowly way. Some of the described information was taken under consideration during the designing of the small size ion pumps.

II. Characteristics of new type small ion pumps

One version of the ion pump type PJ-2N is designed to work at the low magnetic field in the range of 600-650Gs and anode voltages of 3-5kV. Such ion pump may be connected to envelope of electron device working in central space of own magnet. Some of lowered magnetic field in the gap of the magnet near the electron device envelope may be used also to work the small ion pump. At the magnetic field of 600Gs according to the empirical equation (1) and (3) the ignition of the discharge process and its intensity may be obtained by increasing the cell diameter above 1cm.

In the ion pump PJ-2N the anode structure con

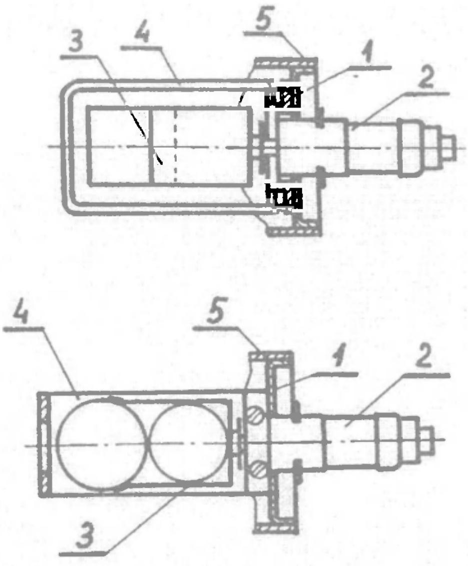

Fig.1. Nude head of PJ-2N ion pump containing: 1-deck ring-shaped, 2-high voltage feedthrough ,3 – anode element, 4 – cathode element, 5 – fragment housing.)

tains two cylindrical cells (one cell with 2cm inner diameter and second cell with 2,3cm inner diameter and both cells are 2cm in height). Figure 1 shows the integrated configuration of the anode and titanium

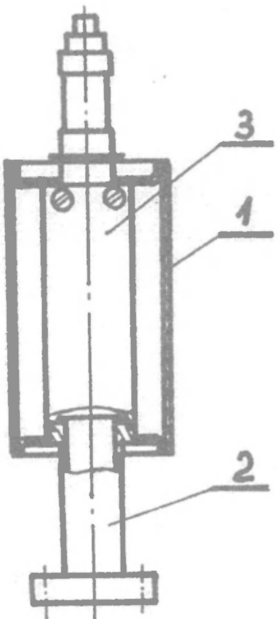

Fig. 2. Schematic configuration of PJ-2N with: 1- cylindrical envelope, 2 – inlet pipe flange NW-16 CF, 3 – nude head.

cathode like to nude gauge and fig 2 this configuration in cylindrical envelope made of copper with 40mm inner diameter and 77mm length [7]. This ion pump by NW-16CF con-flat flange was connected to chamber of about 1dm^3 volume equipped with B-A gauge and valve to operate with experimental vacuum system. The pump was situated in a gap of magnet with magnetic field from 600 to 650Gs. The pumping characteristics presented in fig.3 were carried out by the measurement ion pump current vs. pressure. From the pressure 7.10^{-4} hPa to 2.10^{-6} hPa the pump current was measured without baking of experimental systems and below 1.10^{-6} hPa after baking the system at the temperature about 250°C, during 10h, at the pressure p< 10^{-5} hPa. For estimation the pumping speed which is almost proportional to the discharge intensity (I / P) the obtained results

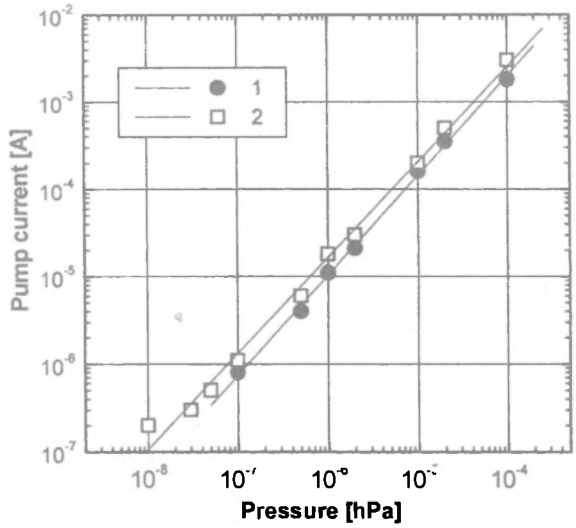

Fig.3 Pump current characteristics for PJ-2N vs. pressure: 1 – at 3 kV and 2 – at 5 kV anode voltage.

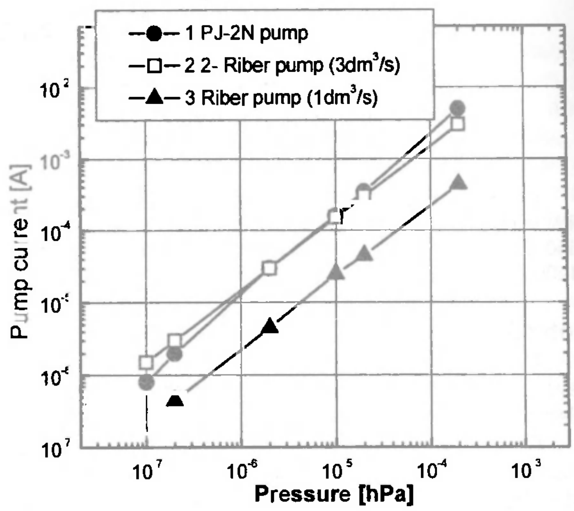

Fig.4. Pump current characteristics of Riber ion pumps and PJ-2-N vs. pressure at the 3 kV anode voltage.

has been compared with pumping characteristics of the Riber ion small pumps for 1dm^3/s and 3 dm^3/s pumping speed. These characteristics are presented in fig 4 and show that the PJ-2N ion pump can obtain about 2 dm^3/s of pumping speed for active gases.

The second version of ion pump type PJ-2 has got the same anode element as in PJ-2N but the cathode element is made of titanium and tantalum plates. The tantalum plate contains some cones situated in the axis of the anode cells. Such system is designed to increase pumping stability of noble gases mainly of argon [8,9,10]. Schematic construction of the second version ion pump is shown in fig 5.

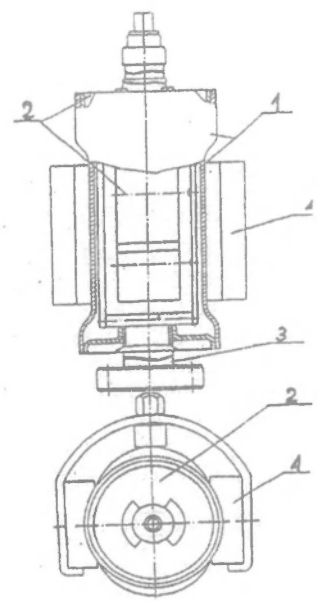

Fig.5. Schematic construction of PJ-2 ion pump containing: 1 – envelope, 2 – nude head, 3 – pipe inlet flange NW-16CF, 4 – magnets

In this version the nude head of anode and cathode system is connected with stainless steel body. The central part of the body wall is profiled for adaptation of Sm-Co alloy magnets. The magnets create magnetic field of about 1500 Gs in the central part of the pump. Fig 6 shows the pumping characteristics of

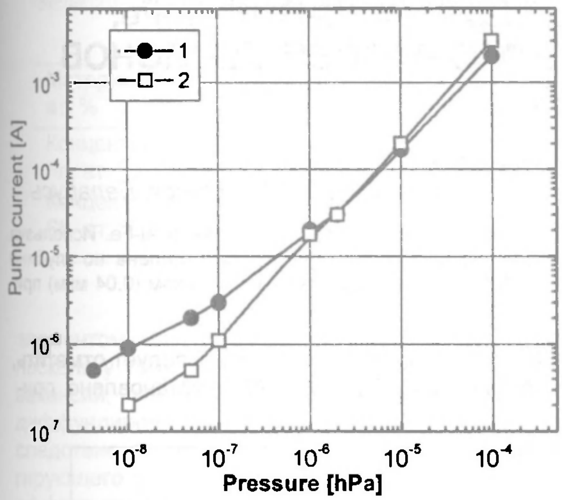

Fig.6 Pump current characteristics for: 1 - PJ-2 and 2 - PJ-2N vs. pressure at 5 kV anode voltage.

PJ-2 connected to the chamber of $2dm^3$ volume with the measurement of pump current for PJ-2 vs. pressure and also comparable measurements for PJ-2N at anode voltage 5kV. For the PJ-2 ion pump the process of pumping was curried out to pressure below 5.10^{-9} hPa. The I/P characteristics show that PJ-2 pump can achieve the pumping speed of about 2 dm^3/s. In this pump the tantalum plate has lowered sputtering in compare with titanium plate, but high magnetic field influences on effective work of such size cell at the pressure below 10^{-6} hPa and in UHV range. In the next step of the investigation the pumping speed of these pump for nitrogen will be carried out on the research apparatus to measurement parameters of ion pumps according to recommendation ISO/DIS 3561.2.

During the measurement some parameters may be corrected.

Conclusion

Two versions of small size ion pump have been designed. The first version PI-2N is made in the form of a nude head with titanium cathode is designated to connect with the body of electron device and a possibility of working in the low magnetic field up to 600Gs. The second version PJ-2 with differential Ti -Ta cathode is equipped in its own magnet (samarium–cobalt type) with magnetic field above 1200Gs. This pump is designated to pump and control the pressure in vacuum devices. From the obtained I/P characteristics these pumps have got the parameters: pumping speed of active gases S = about 2 dm^3/s, ultimate pressure $p < 10^{-9}$ hPa, start pressure $p < 10^{-4}$ hPa , anode voltage $U_a = 3 - 5$kV. The external view of these ion pumps is shown in fig.7

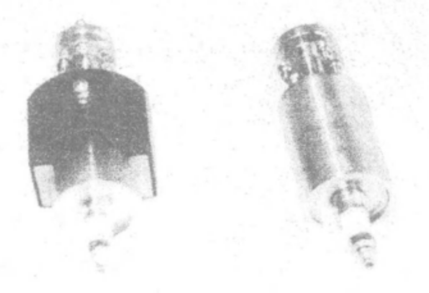

Fig.7. External view of PJ-2 and PJ-2N ion pumps.

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