SPIRAL INFLECTOR EXCHANGE SYSTEM OF THE VINCY CYCLOTRON

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Abstract

The VINCY Cyclotron, the main part of the TESLA Accelerator Installation, has four spiral inflectors, corresponding to the four test ion beams of the machine. They should provide the proper bending of all the ion beams from the operating range of the machine in its median plane. The spiral inflector exchange system of the machine ensures the precise axial and azimuthal positioning of the inflectors as well as their exchange without disturbing the vacuum in the main chamber of the machine. The axial positioning of the inflector is within ±5 mm relative to the median plane with the accuracy of 0.1 mm, and its azimuthal positioning is within ±15 deg relative to the specified direction in the median plane with the accuracy of 0.1 deg. We shall present the elements of the engineering design of the system.

INTRODUCTION

The spiral inflector exchange system of the VINCY Cyclotron should enable quick exchange of the spiral inflectors without disturbing the vacuum in the main chamber of the machine. Exchange of the inflectors will be performed through the upper axial channel of the machine. There will be four inflectors, and they should enable us to cover the whole operating range of the machine [1, 2]. In addition, the system should provide the precise axial and azimuthal positioning of the inflector in its operating position, in order to optimize the ion beam bending in the central region of the machine. The beam is injected in the machine through its lower axial channel.

Designing the spiral inflector exchange system was a complex job with several constraints. The main constraint was that the whole procedure of exchange of the inflectors had to be performed in the limited space between the upper part of the yoke of the machine's magnet and the roof of its shielding vault, without removing any part of the roof. Also, the exchange procedure should be sufficiently quick to enable us to change the operating regime of the machine in a few hours. Finally, it should be performed almost completely automatically, including only a minimal time for the operator to access the system and deal with the radiation activated inflector.

DESIGN OF THE SPIRAL INFLECTOR EXCHANGE SYSTEM

The main requirements for designing the spiral inflector exchange system were the following:

- The system has to enable lifting the inflector and the movable part of the upper plug of the machine's magnet, having the mass of about 10 kg, through the upper axial channel, whose length is 1,735 mm, into the exchange chamber of the inflector.
- Exchange of the inflector has to be performed without disturbing the vacuum in the main chamber.
- As it has been said above, exchange of the inflector has to be performed without removing any part of the roof of the shielding vault. The distance between the upper part of the yoke of the machine's magnet and the roof is 2,397 mm.
- The axial positioning of the inflector in its operating position is within ±5 mm relative to the median plane of the machine with the accuracy of 0.1 mm, and its azimuthal positioning within ±15 deg relative to the specified direction in the median plane with the accuracy of 0.1 deg.
- The maximal voltages of the inflector electrodes have to be ±12 kV. These electrodes have to be insulated from the rest of the system.

Figure 1 gives the spiral inflector exchange system when the inflector is in its operating position, in the median plane, and when it is in the exchange chamber, ready to be exchanged.

In order to place the spiral inflector exchange system in the space below the roof of the shielding vault, we had to introduce a telescopic system for withdrawing the inflector from the median plane to the exchange chamber (EXC). It operates in two phases. In the first phase, servomotor M3, which is a 200 W OMRON AC servomotor with absolute encoder, lifts the inflector through the upper axial channel for 1,100 mm, by a guiding mechanism with threaded spindle. In the second phase, servomotor M4, which is a 1,300 W OMRON AC servomotor with absolute encoder, lifts the inflector for additional 928 mm, by extending bellows BL along a vertical motion stage. Once the inflector is inside the exchange chamber, gate valve GV1 closes the upper axial channel, preserving the vacuum inside the main chamber. When gate valve GV2 is closed, the turbomolecular pump (TP) is turned off and the venting valve of the exchange chamber is opened. The whole of this procedure is performed automatically. Upon its completion, the inflector is ready to be exchanged. The operator should climb to the top platform of the machine, open the front window and lateral door of the exchange chamber, and, wearing the protective gloves, remove manually the old inflector and exchange it with the new one. The inflector is fastened to its supporting structure by a bayonet connection, to make its exchange quick and easy.

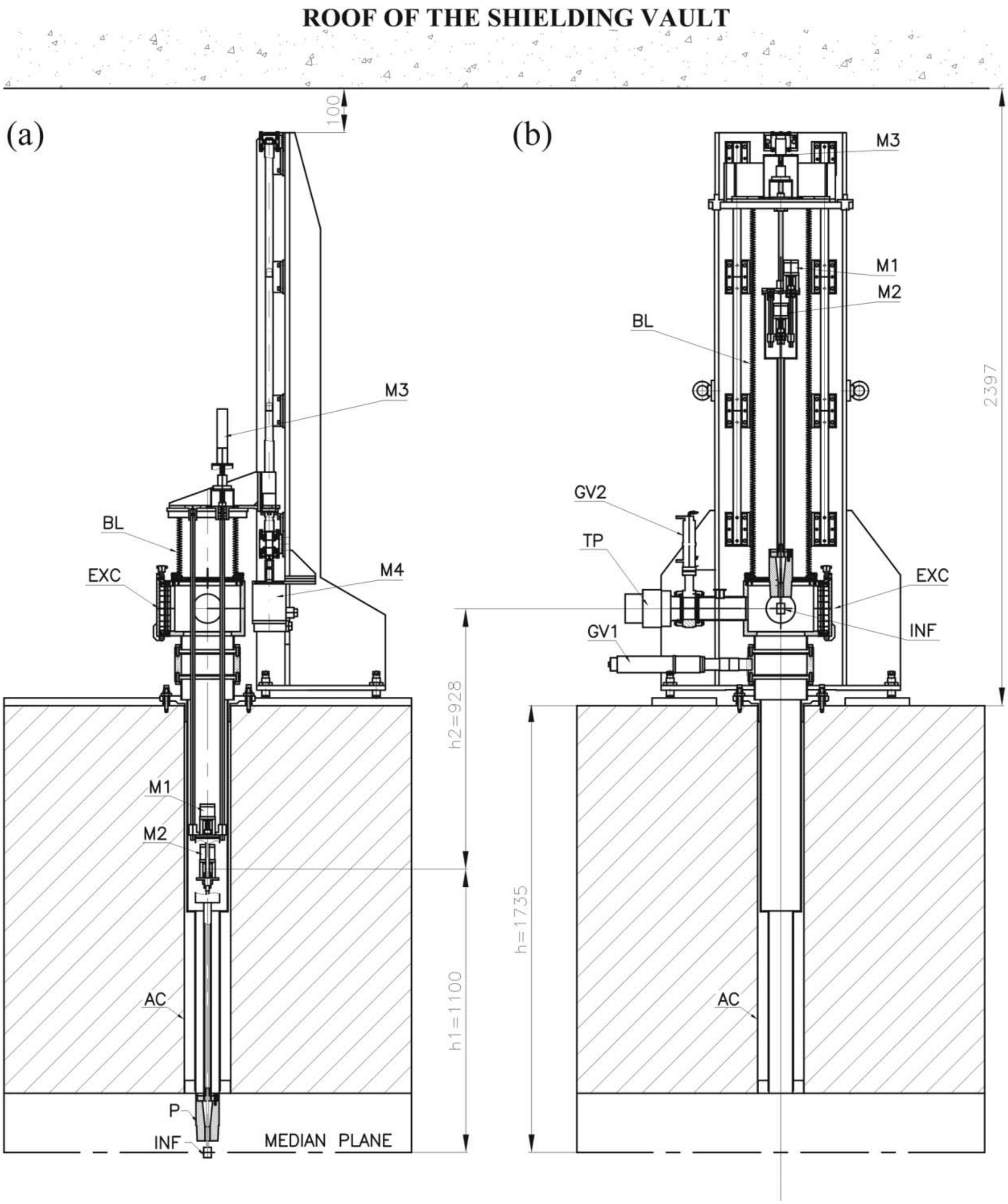

Figure 1: Two characteristic arrangements of the spiral inflector exchange system – (a) with the spiral inflector in the operating position, and (b) with the inflector in the exchange chamber, ready to be exchanged: INF – spiral inflector, P – movable part of the plug of the machine's magnet, AC – upper axial channel, M1 – in-vacuum step motor for the axial positioning of the inflector, M2 – in-vacuum step motor for the azimuthal positioning of the inflector, M3 – servomotor for the first phase of lifting the inflector with the movable part of the plug (for 1,100 mm), M4 – servomotor for the second phase of lifting the inflector with the movable part of the plug (for additional 928 mm) and its positioning in the exchange chamber, EXC – exchange chamber, BL – bellows extendable to 1,200 mm, GV1 and GV2 – gate valves, and TP – turbomolecular pump with the pumping speed of 210 l/s.

Figure 2 shows the exchange chamber and Fig. 3 the inflector.

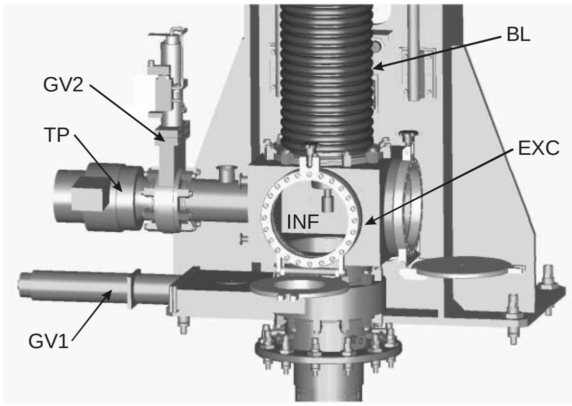

Figure 2: The exchange chamber (EXC) with the front window and lateral door opened, ready for exchange of the spiral inflector (INF); GV1 and GV2 – gate valves, TP – turbomolecular pump, and BL – bellows.

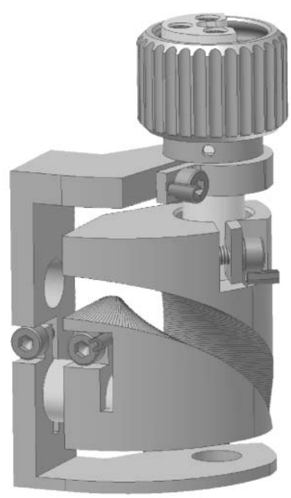

Figure 3: The spiral inflector, with the bayonet type connection.

When the inflector is brought down to the median plane, it can be positioned precisely by two in-vacuum step motors (M1 and M2), which are the CABURN UHV step motors, in order to optimize the beam bending into the central region (see Fig. 1). Motor M1 is used for the axial positioning of the inflector within ±5 mm relative to the median plane, with the accuracy of 0.1 mm. Motor M2 is used for the azimuthal positioning of the inflector within ±15 deg relative to the specified direction in the median plane, with the accuracy of 0.1 deg. The power and control cables of these motors, the cables of the limiting switches, and the high voltage cables of the inflector electrodes are led to a set of 34 circumference contacts and further along the inner wall of the vacuum tube of the spiral inflector exchange system. The two parts of all these cables are connected only when the inflector is in its operating position.

CONCLUSIONS

We have successfully finished engineering designing the spiral inflector exchange system. That was a complex job with a serious constraint regarding the space available for placing the system. An additional problem was to distribute the power and control cables within the system, and connect and disconnect their parts after bringing the inflector down in the median plane and withdrawing it from the median plane, respectively.

REFERENCES

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[2] P. Beličev et al., this proceedings.