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# A 250 keV AND 2.5 mA PARTICLE ACCELERATOR*

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This paper describes a low energy particle accelerator (250 keV, 2.5 mA) which so far has been a routine operation for several years. The accelerator is specially designed for neutron production and studies of nuclear reactions induced by low energy charged particles.

## УСКОРИТЕЛЬ С ЭНЕРГИЕЙ 250 КЭВ И ТОКОМ 2,5 мА

В работе описан низкоенергетический ускоритель частиц (250 кэв, 2,5 мА), который использовался для обычных операций на протяжении нескольких лет вплоть до настоящего времени. Ускоритель сконструирован с целью получения нейтронов и изучения ядерных реакций, вызванных низкоэнергетическими заряженными частицами.

## I. INTRODUCTION

The main advantage of the accelerator is the possibility of an easy change of the accelerated particle $h^+$, $D^+$ or $He^+$ and its energy from 10 keV to 280 keV, a high intensity of the accelerated ion beam with a good geometrical parameter; the beam spot size at 250 keV is about 2 mm at a 1 mA current and about 5 mm at a 2.5 mA current at a distance of 2 meters from the end of the acceleration tube.

The accelerator is being mainly used for basic research in nuclear physics and solid state physics and for applications of nuclear methods in other fields of physics, chemistry and technology, among them the most important being:

— reaction cross section measurements and the study of nuclear reactions induced by fast neutrons,
— the study of nuclear reactions induced by low energy charge particles,
— study of the radiation effect in a solid state material.

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## II. ACCELERATOR DESCRIPTION

The accelerator consists of the following major components: — high voltage power supply; — accelerator unit; — control unit, which contains all normal operating controls and meters.

II.1. The high voltage power supply — is an air insulated voltage multiplier using selenium rectifiers and is designed for 250 kV at 10 mA. The generator voltage can be easily varied (by means of an autotransformer) from 0 to 250 kV. The diagram of the voltage power unit is shown in Fig. 1. The unit consists of a 220 V/110 kV ACHT transformer, two 9000 pF/300 kV capacitors and two selenium rectifier type 20 mA/360 kV. The high voltage is measured by means of an oil insulated resistor.

The high voltage power supply is connected to the accelerator terminal through a 100 kΩ damping resistor to decrease the sparkdown current.

II.2. The accelerator unit — is mounted on a chassis and insulating column which supports the high voltage terminal. The accelerating tube with ion source and focusing lens has not a mechanical connection with the high voltage terminal in order to prevent vibration to be passed from the generator driving system.

II.2.1. A high voltage aluminium terminal enclosing the high frequency Rf ion source, the oscillator with its power supply, the gas reservoir ($D_2$ or $H_2$) palladium leak valve or needle valve, the voltage extraction power supply, the high voltage focusing power supply of 40 kV [1]. Some additional space is also provided for auxiliary equipment. Power is supplied to all the components by a motor generator system (alternator 600 HZ, 0.9 kVA), which is driven by a motor through an insulated shaft.

The source and the beam focusing system are remote-controlled by 4 controls.

II.2.2. Accelerating tube. The deuterium or helium ions are produced in a Rf source [2] which has been designed for low power and low gas consumption. The deuterium gas flow rate is typically about 10 $cm^3/h$ at NTP. The ion beam is formed and focused by means of an einzel lens.

The ion beam is accelerated to its final energy of 250 keV through a uniform gradient acceleration tube operating at a gradient below 300 kV/m. The acceleration tube consists of 12 aluminium electrodes with a 86 mm diameter beam aperture. The electrodes are separated by porcelain insulating rings, which have a 200 mm inside diameter and are 66 mm thick. The whole system is glued together with polyvinyl acetate. A lead seal is fitted between the glue layer and the inner part of the tube to prevent any glue outgassing. The insulators are shielded from the beam by a conically shaped metal electrode. A shielded design is very important for a high power beam because it stabilizes the position of the beam on the target and it prolongs the useful life of the tube.



The potential is equally distributed along the whole tube by means of a chain of 28 MΩ/40 W resistors which are enclosed in epoxy resin.

An electrostatic beam steering system for correction of the ion beam position on the target is located inside the beam line at a distance of 1.5 m from the target. The beam steering system consists of a pair of horizontal and vertical deflection plates.

The bean line consists of a sluice gate valve for a rapid target exchange, an automatic beam stopper and two beam viewers.

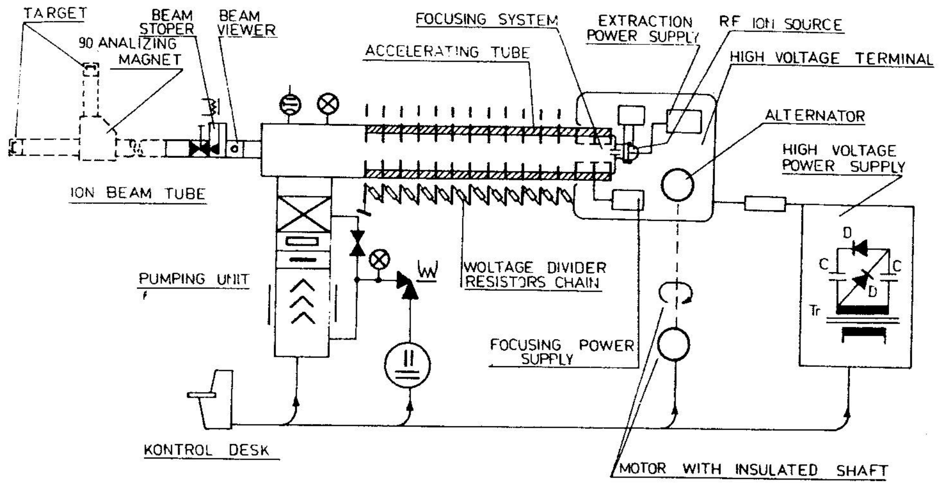


Fig. 1. A schematic drawing of the accelerator units.

II.2.3. A vacuum system — the high vacuum in the acceleration tube is maintainded by a large oil diffusion pump of a speed of 2000 l/s and a freon cooled trap. The base pressure with the accelerator voltage off and with the deuterium gas flowing through the ion source is about $7 \times 10^{-4}$ Pa. During beam acceleration there is an additional pressure rise to about $9 \times 10^{-4}$ Pa due to the outgassing of the target and other components truck by high energy particles.

The vacuum system is equipped with vacuum indicators and safety devices which shut off the heater supply of the oil diffusion pump if the water supply fails.

## III. CONCLUSION

The accelerator has been in a routine operation for several years in our laboratory. The life time of the Rf source is about 100 h at 2 mA of the extracted ion beam, the bottle is then cleaned and the aluminium extracting electrode must be replaced.

Table 1
Main data of the accelerator

| | | | |
|---|---|---|---|
| Characteristics of power supply | Voltage | kV | 0—250 |
| ion current | current | mA | 10 |
| | continuous operation | mA | 2.5 |
| Percentage of monoatomic ions | | % | 80 |
| beam diameter | | mm | 2—5 |
| vacuum | | Pa | $7 \times 10^{-4}$ |
| mains supply | voltage | V, 50 Hz | The phase 220/380 |
| | power consumption | kVA | 12 kW |

Now the new ion beam distribution system is equipped with a 90° bending magnet and an auxiliary vacuum unit.

The main parameters of the accelerator are given in Table 1.

## REFERENCES

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[2] Valyi, L. et al.: Nucl. Instr. and Meth. *49* (1967), 316.

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