NEW GENERATION OF COMPACT ELECTRON ACCELERATORS FOR RADIATION TECHNOLOGIES

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ABSTRACT

Compact electron accelerators with energy range 0.25-1.0 MeV and beam power up to 32 kW are described. The /feeding high voltage is formed by converter (working frequency 20 kHz), coreless step-up transformer and a set of rectifying sections. The rectifying multiplier circuit used in rectifying sections permits to reach voltage gradient along accelerator's axis up to 14 kV/cm. The accelerators with vertical and horizontal position are described.

The accelerators can be produced together with local radiation shielding and various underbeam transportation systems for irradiation of different products. Such version can be installed in any room facing general requirements for electric equipment.

INTRODUCTION

The design of main accelerator's components was chosen like that of known ELV type accelerators [1]. It consists of coreless step-up transformer, high voltage rectifier, accelerating tube, extraction device, power converter and other auxiliary equipment. The coreless transformer and high voltage rectifier are placed inside the high pressure tank filled with compressed nitrogen with insufficient addition of SF6.

The secondary winding of transformer is divided into separate windings. The high voltage rectifier is performed as a set of rectifying sections containing the winding and rectifying multiplier circuit. Resulting rectified voltage of section is in 2 or 4 times greater than the amplitude of alternative voltage on winding (Fig.1). The sections are connected with each other in series.

The transferred electric power is proportional to the energy stored in the transformer and to the working frequency. The increase of working frequency permits to increase transferred power at fixed outer dimensions. And the quality of primary winding is also growing with the frequency increase so the efficiency became better.

Accelerators in run are pumped by magneto-discharge titanium vacuum pumps. The forvacuum mechanic pump is used only after opening of accelerator for preliminary pumping out of air.

The design and fabrication technology of accelerating tube are the same as that of ELV accelerators. Design of extraction device is practically similar to that of ELV accelerators but its effectiveness and reliability are improved due to additional bending magnets and second protecting foil.

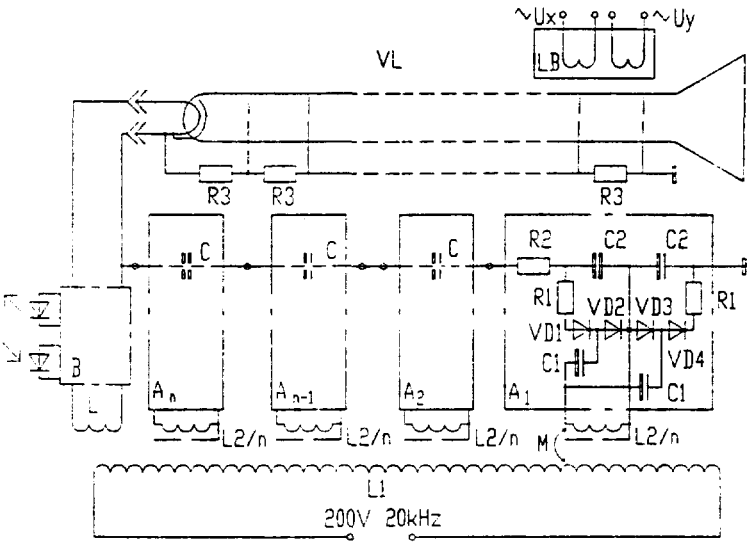

Fig.1. Electrical circuit of the HFELV accelerators.

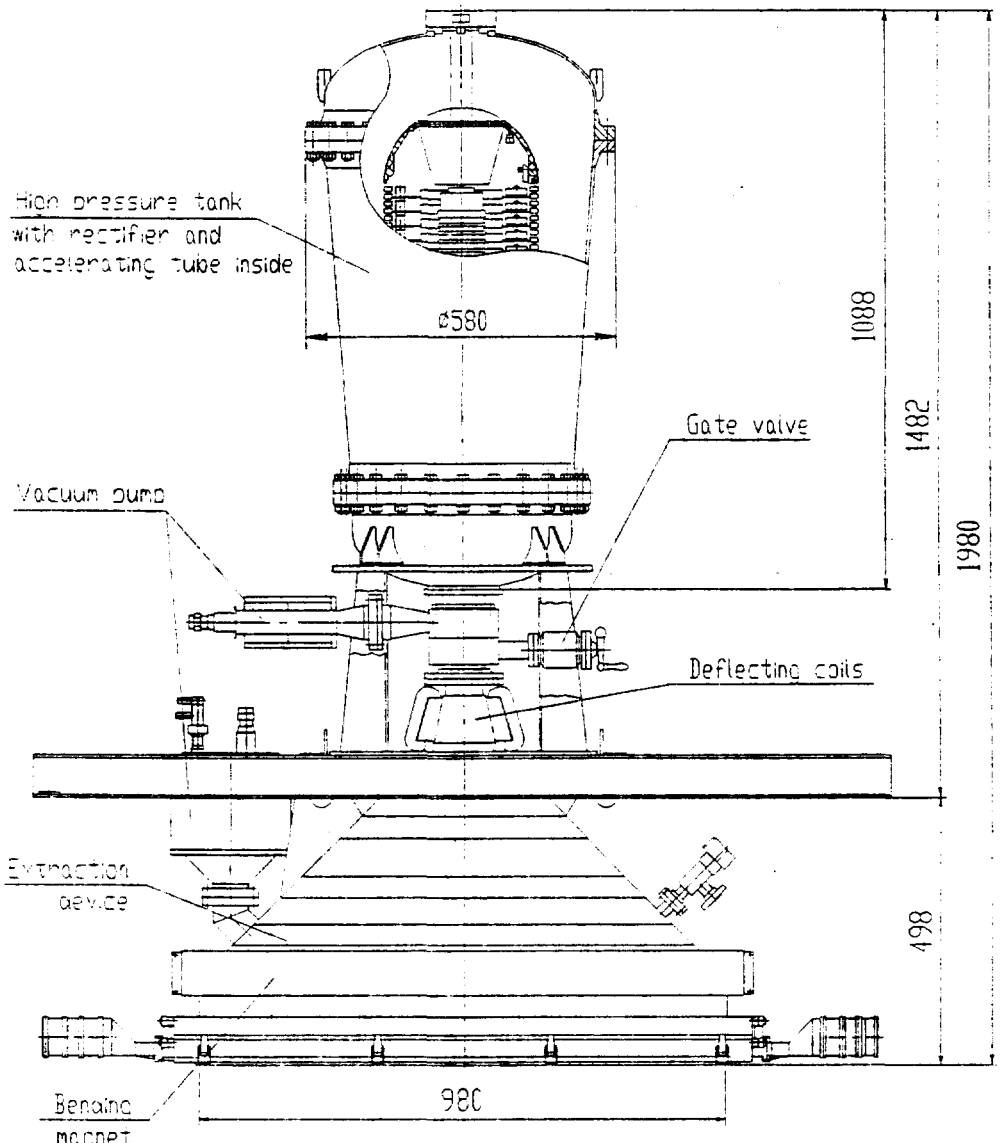

Fig.2. General view of the HFELV-3.

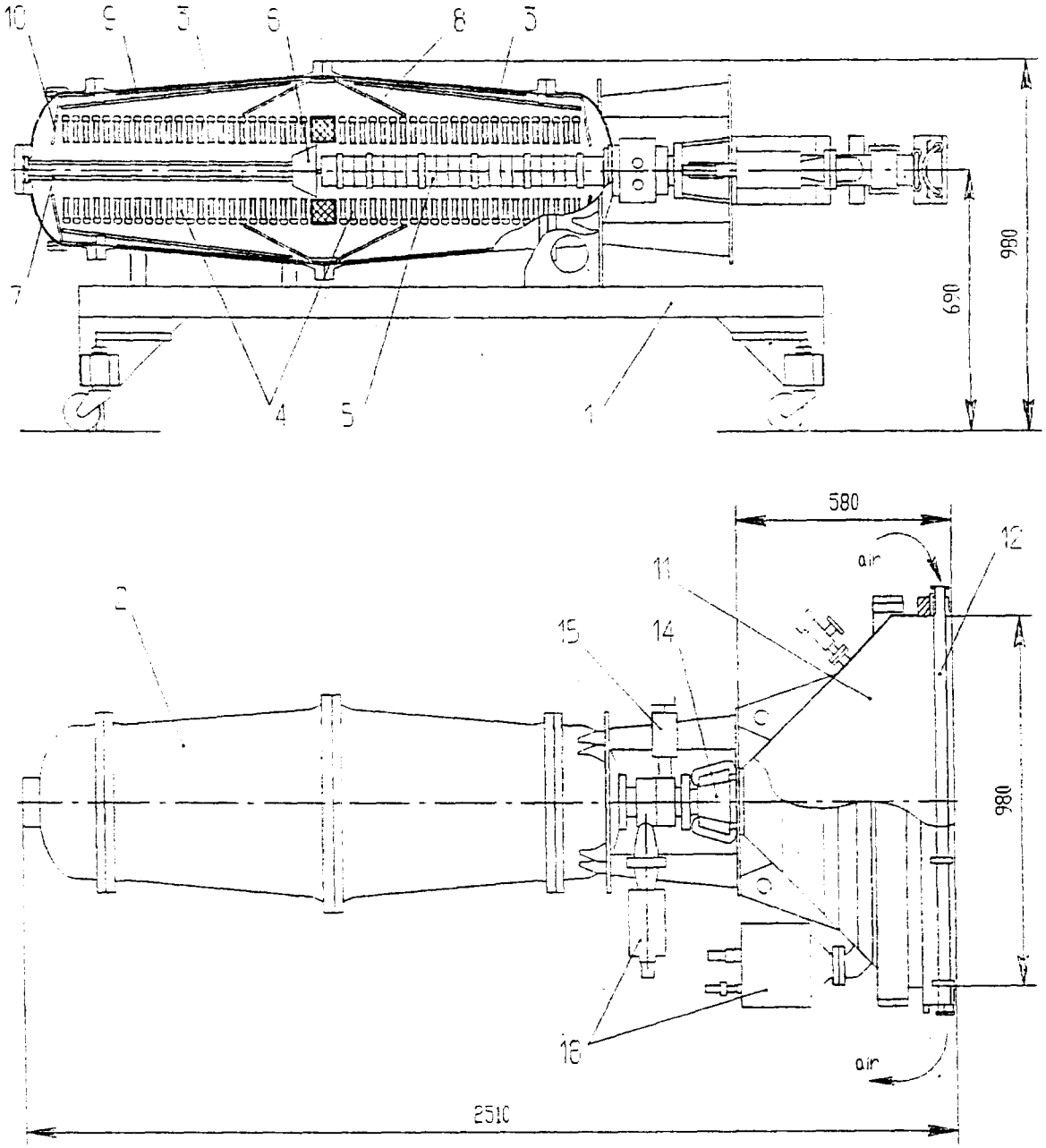

Fig.3 Design of the HFELV-4 accelerator.

1. Bearing Frame.
2. High pressure tank.
3. Primary winding.
4. Rectifying sections.
5. Accelerating tubes.
6. Heating control unit.
7. Optic lines.
8. Bearing insulator.
9,10. Magnetic circuit.
11. Extraction device.
12. Extraction window.
13. Bending magnet.
14. Deflecting coils.
15. High vacuum pumps.
16. Gate valve.

This doubled construction has obvious advantages from high voltage insulation point of view - it is a symmetric coaxial construction, and the point of maximum potential is in the centre of tank. The spheric screen on high voltage end of rectifier is not needed. And the coreless transformer in this design has a symmetric coaxial construction, and its magnetic resistance (for magnetic flux) is lower. So total efficiency of construction is better in comparison with traditional construction in 1.2-1.3 times. The detailed description of these advantages is given in [2].

The accelerator HFELV-4 has the same accelerating tube as HFELV-3 (insulator length 660 mm). It has heated lanthanum hexaboride cathode with diameter 6 mm and beam current control is the same as in HFELV-2. It is built in right rectifier (see Fig.3). The horizontal position of HFELV-4 required the special construction elements for support of rectifier sections. It is done by special bearing insulator (8) and three insulating bars penetrating through rectifiers. Each section is attached to these bars.

Right high voltage rectifier with accelerating tube inside, right half of tank, extraction device and vacuum pumps are fastened on the bearing frame supplied with rollers. The left high voltage rectifier and left half of tank are fastened on the movable supporting frame which can be moved along bearing frame during the mounting and service works.

EXTRACTION DEVICE

From the accelerating tube the beam of accelerated electrons goes into extraction device where it is extracted into atmosphere through window covered with foil. Design of the extraction device is practically similar to ELV accelerators but its effectiveness and reliability are improved due to additional bending magnets and second protecting foil. This more thin foil is preventing the main titanium foil from contact with air in irradiation zone. The foils are cooled by air flux in the gap between them created by high pressure blowers. The electron beam is scanned over the surface of foil by deflecting coils in two directions. The main coil is deflecting beam along extraction window at an angle +/- 45 degrees with frequency 50 Hz. The additional coil is deflecting beam across the extraction window at an angle +/- 3.5 degrees with frequency 1075 Hz. A additional bending magnets permit to deflect the beam at an angle more than 60 degrees without increase of losses on the foil. Dimensions of extraction window for all modifications are 75*980 mm. The width of irradiation zone with high dose homogeneity is up to 900 mm.

CONTROL AND POWER SUPPLY SYSTEM

The accelerators are fully automated and controlled by IBM PC compatible computer. Manual operation mode is also envisaged. Energy and beam current are controlled and monitored. The underbeam transportation system can be synchronized with accelerator to organize industrial irradiation process.

The accelerator has control rack with dimensions 570*570*1600 mm. It comprises all control and monitoring circuits and most part of power supply system. The computer is installed in the same room and connected with control rack through cable. The accelerator is fed from standard three phase 220/380 V 50 Hz mains.

The development of technique of thyristor converters and industrial production of high-frequency rectifying units permit us to design new generation of compact electron accelerators. We have designed compact powerful controlled thyristor converter with working frequency 20 kHz and power up to 20 kW. It is built in the control rack, and its weight is only 10 kg. It also can be realized as a separate block and can be located near the accelerator or in other place because the length of output connecting cable can be up to 25 m. It has remote control and its output voltage is computer or manually controlled from 100 to 200 V. Its efficiency is high so air cooling is sufficient. Power supply blocks for magneto-discharge vacuum pumps are also air-cooled and very compact.

As all power supply system is very effective the need in cooling is very little. Nevertheless accelerator itself requires little water cooling. The primary winding of the step-up coreless transformer requires 1 l of water per minute. and magneto-discharge vacuum pumps consume 2 l per minute. The cooling water should be pure and have input temperature no more than 30 centigrades.

Gas filling post is used for filling of tank with gas mixture (nitrogen with 8-10% addition of SF6) up to working pressure about 12 at. It comprises two standard gas balloons with volume 40 litres each (one with compressed SF6, and other with compressed nitrogen), connecting pipes, valves (including protecting valve) and measuring devices. Its dimensions are 290*500*1800 mm and weight is 220 kg. The insulating gas mixture is not used again and after every opening the tank is filled by fresh gas mixture from these balloons. For HFELV-4 one balloon with SF6 can provide about 18 fillings of tank, and one balloon with nitrogen can provide about 2 fillings of tank. As HFELV-3 and HFELV-2 have lower volume of tank, the number of fillings for them is correspondingly higher.

CONCLUSION

The set of compact electron accelerators with energy range 0.25-1.0 MeV, beam power up to 32 kW and specific power up to 130 kW per cubic meter of high voltage generator are designed. Supplied with local radiation shielding they can be installed in any room like any other technological electric equipment.

REFERENCES

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2. R.Salimov et al. "Sdvoyennyye uskoriteli tipa ELV", preprint N 79-54, Budker Institute of Nuclear Physics, Novosibirsk, 1979.