ISBN: 978-3-95450-197-7 doi:10.18429/JACoW-RUPAC2018-TUPSA56

A COMPACT HIGH-VOLTAGE SOURCE ON THE BASIS OF ELV ACCELERATOR

V.G. Cherepkov, J.I. Golubenko, S.N. Fadeev, D.A. Kogut, A.I. Korchagin, N.K. Kuksanov, R.A. Salimov, A.V. Semenov, A.B. Sorokin, D.S. Vorobyev,.Budker Institute of Nuclear Physics SB RAS, 11, Academic Lavrentiev ave., Novosibirsk, 630090, Russia.

Abstract

Electron accelerators of ELV type are widely used in industrial and research organizations. The high-voltage rectifier of ELV accelerator is used as a high-voltage source of the tandem accelerator for boron neutron capture therapy (BNCT) at the Institute of Nuclear Physics SB RAS. As a source of high voltage, a more adequate source has been developed for subsequent ELV-based machines. Its parameters are: voltage - 1200 kV, load current - 20 mA, voltage polarity - positive. New specific requirements are put forward for this rectifier; therefore, its design has a number of differences in comparison to the ELV design. In particular, high voltage is transmitted to the accelerator-tandem over a sectioned feeder that lies within the rectifier column of the source. In order to reduce the overall dimensions of the source in its rectifier sections, a rectification circuit with four times voltage magnification is used. The operating frequency of the primary supply voltage is 1400 Hz. At present, the source has been manufactured, undergoes bench tests and is being prepared for use in the BNCT complex.

PROBLEM

Accelerators of ELVs have found wide application both in industry and for scientific research. One of the latest applications is the use of ELV as a source of accelerating voltage U_0 tandem for boron-neutron capture therapy [1]. In an installation operating for more than 10 years, the standard rectifier of ELV accelerator is connected to the sectioned high-voltage feeder of the tandem accelerator [2]. The potential distribution over the electrodes of the feeder and the tandem accelerator is provided by a special high-resistance divider Rd. However, when the beam current of accelerated ions is spilled onto the tandem electrodes, the uniformity of the voltage distribution across the electrodes is violated, which leads to breakdowns of the vacuum isolation of the tandem.

Since maintaining the uniformity of the voltage between the electrodes by reducing the resistance Rd became impossible, it was decided to connect the tandem electrodes directly to the rectifier sections of ELV type, as shown in Fig. 1.

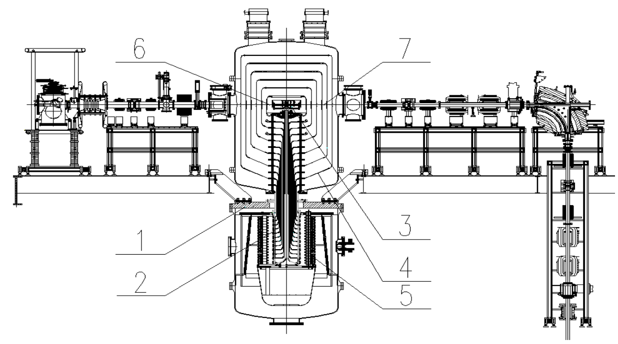

Figure 1: Tandem accelerator circuit: (*1*) high-voltage source; (*2*) sectional high-voltage feeder; (*3*) gas charge – exchange; (*4*) target electrode of the tandem; (*5*) rectifier sections; (*6*) beam H(-); (*7*) beam H(+).

THE DESIGN OF THE RECTIFIER

To solve this problem, a new source of accelerating voltage was developed, manufactured and tested without load at INP SB RAS (see Fig. 2).

In comparison with ELV, the following changes were made to its construction:

1. The rectifier is rotated by 180^0 vertically ("upside down").
2. The primary winding (item 3) has an enlarged diameter. It is fixed in the shell of the vessel (item 1) on three supports (item 4).
3. The primary voltage is supplied to the primary winding by special terminals (item 19). The frequency of the supply voltage of the primary winding f = 1400 Hz.
4. A column of 18 rectifying sections (item. 9) is mounted on a textolite base (item 10).
5. The base and the column with three rods (item 13) are fastened to the single block of the rectifying column with nuts (item 8).
6. The rectifier column unit is located inside the primary winding (see Fig. 2).
7. The photo of the rectifier section (item 9) is shown on (Fig. 3).
8. The diagram of the rectifier section with quadruple alternating voltage is shown in Fig. 4. Maximum rectified section voltage Us = + 80 kV, load current I0 = 20 mA.
9. The coil of the rectifying section has 2000 turns.

Content from this work may be used under the terms of the CC BY 3.0 licence (© 2018). Any distribution of this work must maintain attribution to the author(s), title of the work, publisher, and DOI.

ISBN: 978-3-95450-197-7 doi:10.18429/JACoW-RUPAC2018-TUPSA56

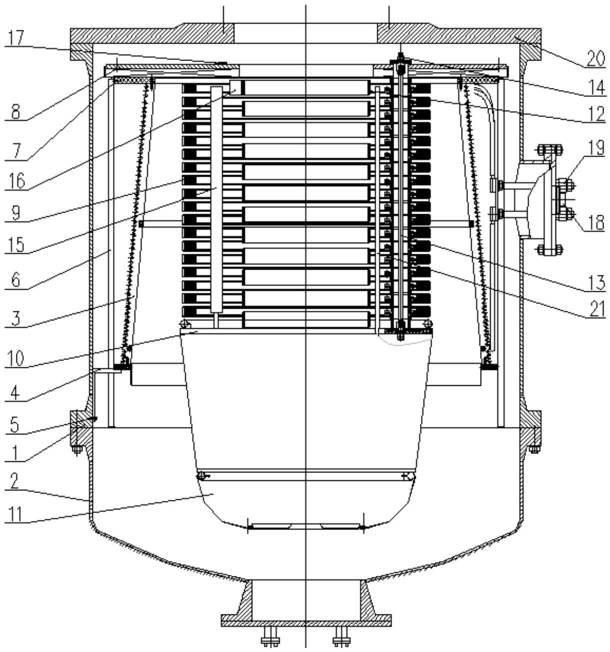

Figure 2: The design of rectifier: (*1*) High pressure vessel; (*2*) Cap of the vessel; (*3*) Primary winding; (*4*) Support of the primary winding; (*5*) Screws to fasten the supports of the primary winding; (*6*) The magnetic guide of the primary winding; (*7*) The fastenings of the magnetic conductor of the primary winding; (*8*) Bottom magnetic guide; (*9*) Rectifier sections; (*10*) Textolite base; (*11*) High-voltage electrode; (*12*) Screening copper short-circuit rings; (*13*) Rods of the high-voltage column; (*14*) Fastening nuts of rods; (*15*) Divider of energy; (*16*) Divider of the first section; (*17*) Current sensor; (*18*) Connector for measuring signals; (*19*) Terminals of the primary winding; (*20*) bottom of the vessel; (*21*) Switch.

Figure 3: Photo of the rectifier section

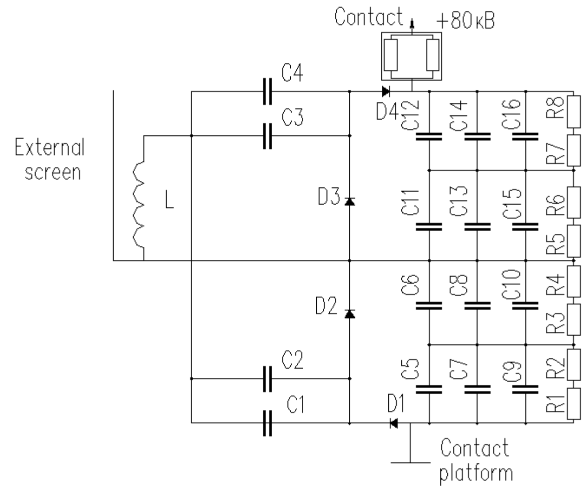

Figure 4: Scheme of rectifier section: (L) coil N = 2000 turns; (D1, ..., D4) diodes of the mark SDL-0,55-130 04; (C1, ..., C16) capacitors of the brand FHV-6AN, 3500 pF; (R1, ..., R8) resistors of the brand C3 - 14M.

Figure 5 shows the mounted rectifier column of the source while transporting it to the shell of the pressure vessel. The height of the rectifier column is determined by the height of the sectioned high-voltage feeder (item 2 in Fig. 1).

Figure 5: Photo of the rectifier column.

The overall dimensions of the rectifier: diameter - 1730 mm, height - 2200 mm.

Content from this work may be used under the terms of the CC BY 3.0 licence (© 2018). Any distribution of this work must maintain attribution to the author(s), title of the work, publisher, and DOI.

ISBN: 978-3-95450-197-7 doi:10.18429/JACoW-RUPAC2018-TUPSA56

TEST RESULTS

The high-voltage source there was manufactured and tested:

1. With a pressure of SF6 in the vessel 8 atm and voltage U0 = 1200 kV, the rectifier operates reliably without breakdowns for 7 hours.
2. The Rods of the high-voltage column (item 13) are tested for tensile load F = 12000 N (1200 kg), which is a sixfold margin of safety.
3. The breaking force of the Rods of the high-voltage column (item 13) was F = 39200 N (3920 kg), which is 19 times more than the possible load.

REFERENCES

[1] I. Sorokin, S. Taskaev. A new concept of a vacuum insulation tandem accelerator. Applied Radiation and Isotopes 106 (2015) 101 – 103.

[2] ISSN0020-4412, Instruments and Experimental Techniques, 2017, Vol. 1, pp.70 – 73. Pleiades Publishing, Ltd, 2017. Original Russian Text E.V. Domarov, A. A. Ivanov, N. K. Kuksanov, R. A. Salimov, I. N. Sorokin, S. Yu. Taskaev, and V. G. Cherepkov. A Sectioned High-Voltage Rectifier for a Compact Tandem Accelerator with Vacuum Insulation.

Content from this work may be used under the terms of the CC BY 3.0 licence (© 2018). Any distribution of this work must maintain attribution to the author(s), title of the work, publisher, and DOI.