ELECTRON BEAM WITH AN ENERGY 1 MEV IN THE RECUPERATION REGIME

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The power achieved value for industrial accelerator is about hundreds kilowatts [1]. Typically an energy of such machines is in the range of 0.5 - 2.5 MeV, and current 100 mA. Further development is limited by the possibilities both of the accelerating system and beam extraction device. Simultaneously the charged heavy particles beams development and their application has shown to be promising in using [2,3] electron cooling in energy region a few GeV/nucleon. An electron beam with an energy $\simeq$ 1 MeV and current 1 ÷ 10A is needed for this purpose. Therefore the device at energy of 1 MeV and 1 A continuous electron beam recuperation was built for studying the power accelerating system and testing possibility of forming electron beam for high-voltage cooling. We supposed that specific problems of electron cooling device as: high vacuum, long size of electron tract, low transverse velocities of electrons, longitudinal magnetic field high uniformity could be solved. The main problem for such a device is to achieve a continuous high-power electron beam, its transportations in the relatively low (1 kG) magnetic field, the placed in to magnetic field accelerating tube behaviour, a possibility of 1 MeV beam recuperation. Such an approach enabled simplifying and speeching up the device development. Besides that the design was performed in such a way, that the main elements of device could used in future machine: device for beam extraction.

The schematic diagram of the device is shown in Fig. 1,2. The industrial accelerators ELV-6, a high-voltage rectifier with voltage 1,0 MV and power 20 kW was used as power supply. The recuperation rectifier which was placed between the cathode and collector had its maximum voltage of 5 kV and power 20 kW. The distribution potential on electrodes of deaccelerating and accelerating tubes was made by high-resistance deviders. The guages of the beam current and supressor (electrode near collector) potential were made by

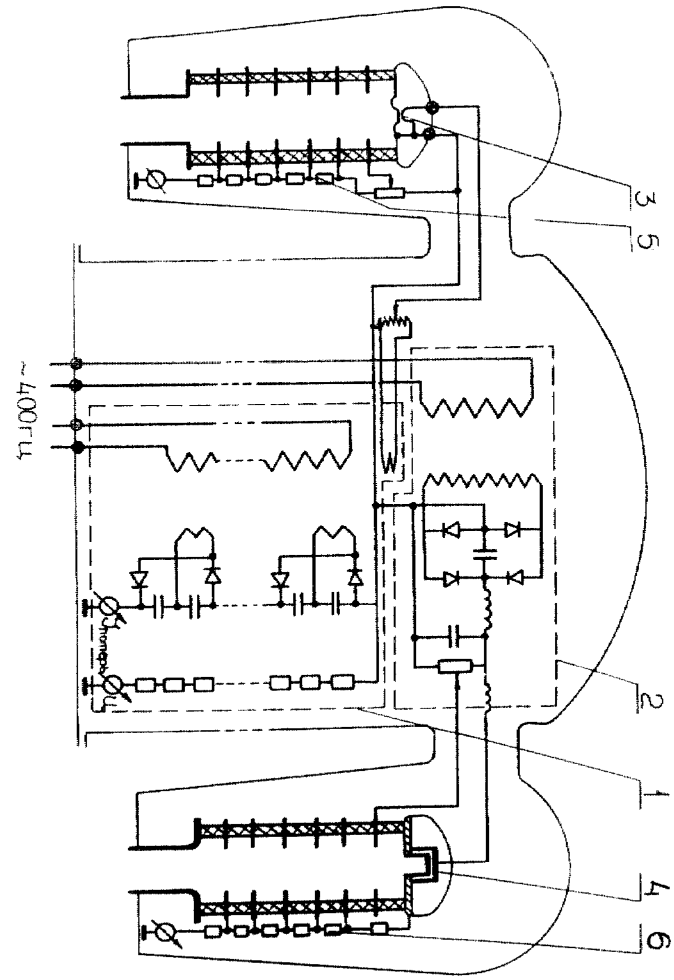

Fig. 1.

resistive commutator. The contactless guage measured beam current and was placed in cathode feeder. The vacuum chamber had U-shape, de- and accelerating tubes were placed in vertical parts. It allowed us to simplify essentially the design of high-voltage system, which includes H-V. rectifier, tubes and two feeders: to cathode and to collector. The cathode is placed in the longitudinal magnetic field, with an accompanied beam from the cathode to collector. The field maximum in regular part is 900 G. The field near the cathode and collector is changed by connecting to various bend of solenoid. The beam turn at 180° is made in two 90° turns with radius 1 m. There we have transversal magnetic field for centrifug drift compensation. The drift value is $\simeq$ 15 cm at an energy of 1 MeV and field

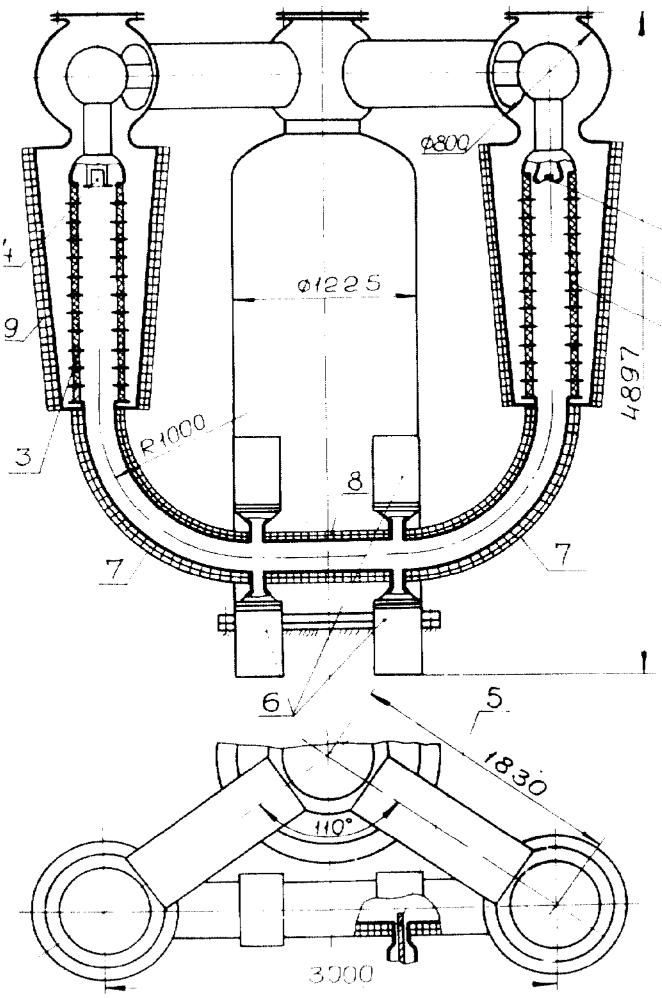

Fig. 2.

900 G.

For particles reflected from collector the drift direction is the same as the direction of transversal field. Therefore, particles move on water cooled vacuum camera walls and travelling through the chamber cannot reach the accelerating tube.

Cooling of collector (steel cylynder with internal diameter 60 mm and height 150 mm) was made by freon refrigerator. Freon was given on H.V. potential through the polyethilen pipes. It puts high demands to refrigerator regime. Overheating decrease mechanical strength, overcooling is impossible because of condensation on external surface of pipes and break-down along tubes.

We began work with the device by the measurement of magnetic field and low energy (7 kV) electron beam tracing. For this purpose the screen with 5 holes was placed on the surface of cathode. The collector was changed by the glass plate with luminescent material. The magnet system of device has 4 technological breaks each of them creating disturbance of longitudinal field $\frac{\Delta H}{H} \simeq$ 30% with length $\simeq$30 cm. The beam receives addmittance angles which can sum or compensate in dependence on phase between disturbance. Measurements confirmed periodical dependence of beam dimention on the magnetic field value. In further work we used the obtained parameters ρ , at which exists total compensation.

The work in recuperation regime we performed in several steps. The cathode and collector were the same, but we changed the length of de- and accelerating tubes. So, maximum energy of beam also changed in steps. We detected that with an increase in beam current the switching off occured without vacuum deterioration. Since the question of electrical strength of tubes was one of main it was found that switching off is not de- or accelerating tubes breack-down. In the case of break-down we have fast ($\tau \leq$ 10 mks) voltage drop and vacuum deterioration $\Delta p \geq 10^{-5}$ top, but in our situation the voltage drop time was $\tau \simeq$ 10 ms and $\Delta p \leq 10^{-6}$. As was found out the first cause of switching were instabilities of energy or magnetic field. The instability of these parameters displaced the beam in collector, desorbed gas from its surface. It changed the ion concentration, consequently and potential distribution, near the collector input. The current losses (current of reflective electron) was increased. The system of energy stabilization had regulation time $\sim$ 0.5 s and it did not work at shorter time. So the level of energy decreased beam displaced and losses increased. As a result of this positive backcoupling is an increase in losses of current over its addmittance level and switching-off device. Frequency of switching-off was determined by vacuum conditions in collector and was decreased during operation. The time necessary for getting the stationary regime depends on the beam current. The current 0.5-0.6 A at vacuum 10^{-6} demands some hours of continuous operation, but currents 1 A and higher - some tens hours.

The situation is improved by scanning beam in collector with dimensions of some millimeters.

Maximum results achieved with tubes of various length are given in Table 1.

Table 1

Tubes (cm) accel.	deaccel.	U_o, kV	I_o, A		I_{los}, kV	ρ sm
30	30	80	1,4	$2{,}5\cdot10^{-3}$	3	1,5
		80	1	10^{-3}	3,4	4,5
		300	1,3	$5\cdot10^{-3}$	4,4	2,8
		300	1,05	$5\cdot10^{-3}$	4,4	4,4
106	128	500	1	$2\cdot10^{-3}$	2,4	4
		700	1	$1{,}5\cdot10^{-3}$	2,4	5,8
114	150	1000	0,5	10^{-3}	3,5	6,1
		1000	1,0	10^{-3}	3,5	6,1

Losses showen in the table were defined assuming the stability operation and cooling the vacuum camera walls. The current minimum loss in this experiments was 10^{-4} of total beam current. The regime 1.0 MV x 0.5 A is stationary. Regime 1.0 MV x 1,0 A achieved the stability when time between switching-off about 1/2 hour and on this step the work was finished.

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