THE PROJECT OF TECHNOLOGICAL SUPERCONDUCTING LINEAR ELECTRON ACCELERATOR FOR 5 MeV ENERGY

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The conceptual scheme of electron linear accelerator for technological purpose with 5 MeV energy and 10 мкА beem current is considered. As an accelerating element the superconducting 14 cell 95 cm length 3 GHz "TESLA-shape" section is used. The accelerator is intended to irradiate superconducting materials based on high temperature ceramics (e.g. Y-Ba-Cu-O).

1. The Accelerator Topological Scheme

Accelerator functional scheme includes traditional used for many electron linear resonant accelerators systems (injection, preliminary beam formation, RF power input, vacuum, information, control, measurement) as well as systems especially dedicated to the conducting accelerators (high Q SC accelerating cavity, cryostat, RF chopper).

The accelerator topological scheme is shown in Fig. 1. It consists of 2 parts, horizontal and vertical. The presence of vertical part is defined by the accelerator purpose and by the choosen vertical position of cryostat.

The horizontal part along the beam line consists of 40 keV injector (1), first focusing system (2), water-cooled chopper cavity (3) which makes the beam fan-like, and bending magnet (5).

The vertical part contains 2 slots (6,7) cutting out of a beam the 20 grades bunches, second focusing system (8) ensuring the beam/section transverse matching and vertical-type helium cryostat.

Injector (1) creates CW electron beam with nominal energy 40 KeV and 1 mA current. Further goes the preliminary beam system: electron-optical focusing system (2), RF chopper (3) which cuts the beam bunches from CW current by means of particle velocity modulation in the room temperature cavity. As the chopping cavity (3) the prismatic H 101 mode cavity was choosen. The chopper uses the same frequency as the accelerating cavity does (9). The dimensions of the cavity walls are 75x75x20 mm. The electric field in the center is

20 KV/sm. The drift hole is near to the cavity wall so at the output the beam gets the fan-like form due to RF component of magnetic field. The electric modulation is negligible.

Then the beam goes though the bending magnet (5) which plays the role of a drift path. Besides this magnet gives an extra freedom degree in the beam centering with the vertical axis of the channel. To the same purpose the collimator split (7) is used which may be replaced by he beam position monitor during the tuning procedures.

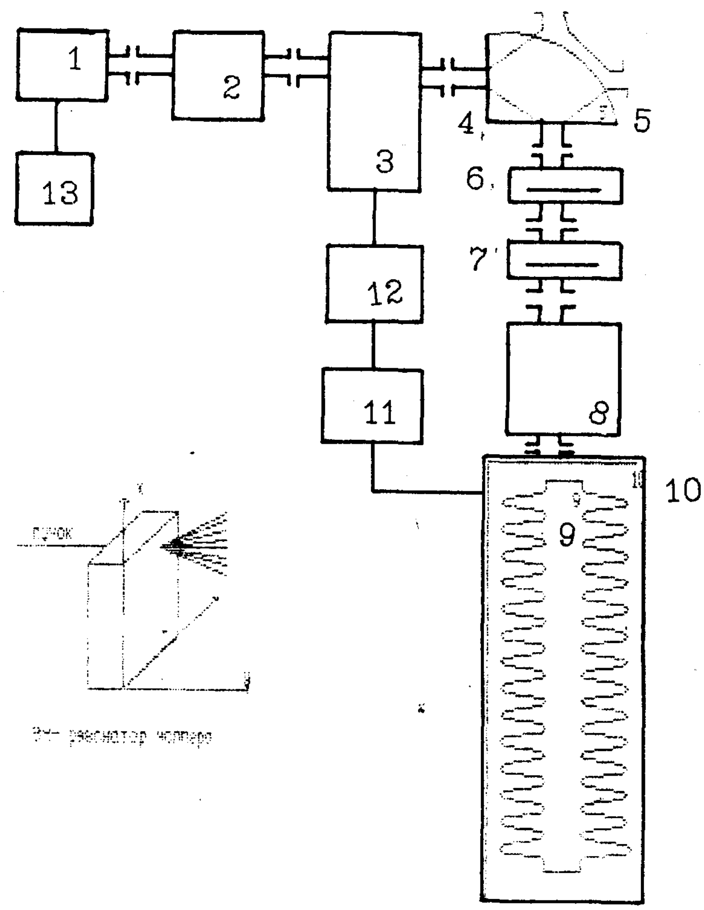

Fig. 1 Accelerator functional scheme

The pull-out Faraday-cup (14) is the element of the bunch length measurement scheme when the bunch goes into the acceleration section (9).

The functional purpose of electron-optical system is the matching of the bunch to accelerating cavity channel. The matching is realized with the lens of 35 kV potential of control electrode.

The RF feeding scheme is based on the principle of autogenerator with the superconducting cavity in the feedback circuit. Autogenerator has an integrated loop to regulate the cavity field amplitude. This loop automatically compensates the current and the inlet phase of accelerated beam. The part of the autogenerator RF power is extracted and used as referee signal for the chopper cavity feeding system.

2. The Accelerating RF Superconducting structure

Calculation of electron dynamics in accelerating system allows to define the geometrical dimensions of the accelerating structure cells as well as the main electrodynamical performances of this structure which are shown in Table 1.

Table 1

Electrodynamical performances of acceleration structure

1. Maximum electron output energy, MeV	5
2. Particle capture into acceleration , degr.	40
3. Number of cells in accelerating structure	14
4. Length of accelerating structure, mm	684
5. Beam energy spread, %	
100 degr. level	0.3
10 degr. level	0.01
6. Cavity power loss with Q= 10 - 10 ,W	14-1.4
7. Operation frequancy, MHz	2 795
8. Accelerated particle current, micro A	10
9. Energy icrease. MV/M	7.3
10. E s/E acc.	2.2

Fig.2 shows the geometry of 14 cell accelerating structure, fig.3 shows the distribution of the accelerating field along the structure axis.

From fig.2,3 it is clear that the first 3 cells are responasible for particle pre-acceleration and their bunching. The futher acceleration is realized by a constant synchronous phase nearing to zero. The maximum of accelerating field is in the 3-rd cell, while minimum is in the 1-st cell.

The accelerating channel aperture radius changes from 14.9 to 18.8 mm.

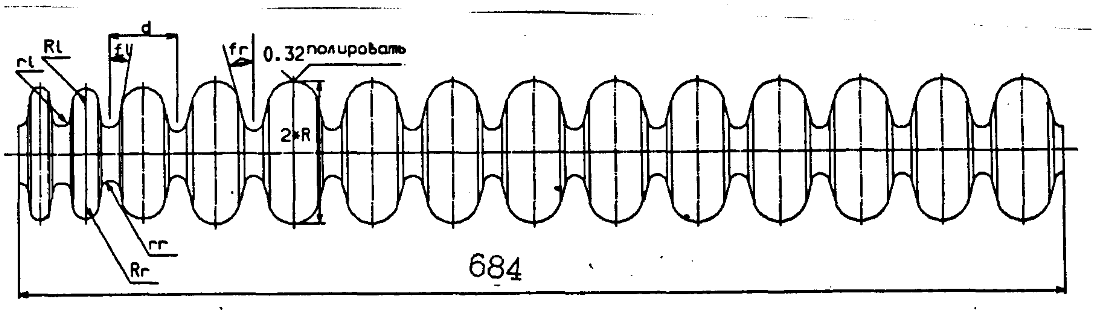

Fig. 2 The SC technological 5 MeV electron accelerator geometry

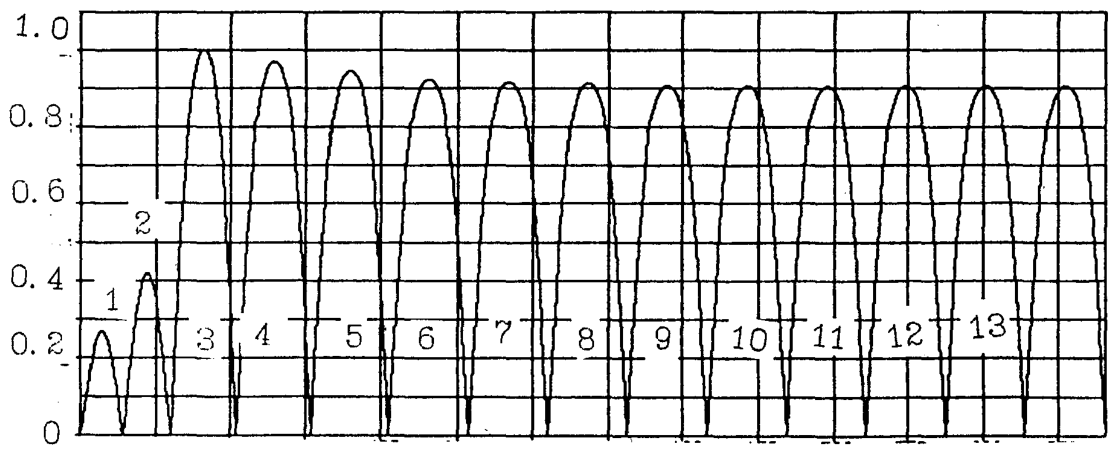

Fig. 3 The accelerating field distribution

The accelerating RF structure is manufactured in accordance with the technological processes developed by Federate Problem Laboratory for Technology and Study of SCC at the Russian Federation Ministry for Atomic Energy /1,2/. The copper shell of superconducting RF structure will be manufactured by the method of galvanoplastic shaping technique /3,4/ followed by deposition of superconducting coating using magnetron sputtering process /5/. Moreover to increase regularly accelerating field it is planned at the first stage to construct RF structure on Nb/Cu base /6/, then on H2B/Cu base /7/ and the last stage on HTSC/Cu base /8/.

The structure of the vertical cryostat allows to operate all three versions of RF accelerating structures.

3. The Accelerator Cryogenic-Vacuum System

Fig.4 shows the accelerator cryogenic system. SC RF accelerating structure (2) is immersed into the vertical cryostat (3) in which there are a level monitor and a heater (5). The auxiliary He storage vessel (11) has a level monotor, heater (10), a contact monometer (8), the dosing valve (9), the level regulator, the syphon with the vacuum pocket (4). The L He flows to cryostat throug the syphon.

Cryogenic system is supplied by backward He-pumping for the return of worked He into IHEP central cryogenic station. Vacuum system development foresees the pumping by means of magnetic-discharge and cryogenic pumps.

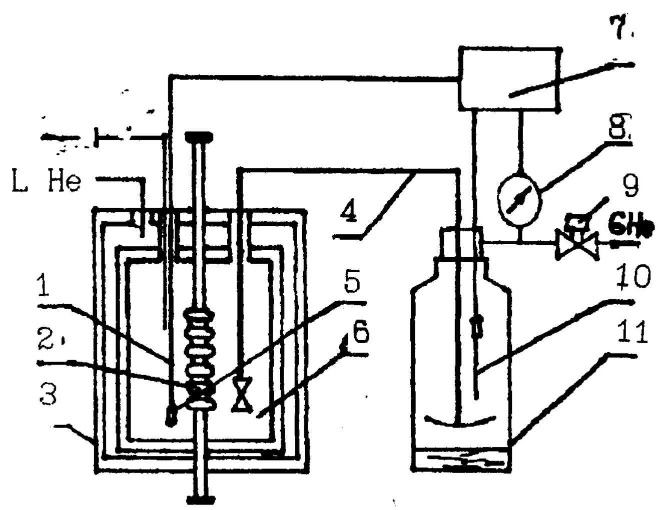

Fig.4 The cryogenic system of technological linear electron accelerator.

Conclusion

The autors are grateful to Mr. I. Volkov and Mrs. L. Pakhomova of Russia Space Agency Durability Centre for the help in mechanical and heat testes ot the copper cover of SC accelerating cavities which we have manufactured by means of the galvanoplastic formation method.

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