100 MeV ELECTRON LINAC WITH THE DAW STRUCTURE AS AN INJECTOR FOR THE SIBERIA-2 STORAGE RING

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1. The complex «Siberia-2» as a source of synchrotron radiation [1] requires an injector at an energy of 80—100 MeV. Since the injection is performed with a frequency of 1 Hz into booster ring with revolution time of 30 ns the pulse length of injector current should not exceed 15 ns in order to avoid the influence of the inflector fronts on the beam dynamics.

The injector should provide the following beam parameters:

— beam current in a pulse 200 мA
— energy spread 1%
— transverse emittance 0.1 mrad·cm.

Our experience in developing the high current electron linear accelerator as a positron source for storage complex VEPP-4 [2] proved that for this purpose it is reasonable to use accelerators operating in a stored energy mode. Since we concentrated on use the only one S-band (2797 MHz) generator of 20 MW power [3] therefore the DAW structure proposed by V.G. Andreev [4] was selected.

The use of the DAW structure in the stored energy mode enables one to solve the following problems [5]:

— because of high shunt impedance one can reach maximum energy of electrons;
— because of a large energy stored one can accelerate the beam with maximum current;
— because of high group velocity there is availability to perform an accelerating structure in the form of resonance section with a single power input and thus to avoid phasing of separate sections and also to simplify the requirements to accuracy of manufacturing and tuning.

Based on the available data on the shunt impedance reached on the DAW structure we decided to make the structure 6 m long with radial stems that made it easy to manufacture since due to low repetition rate it is not necessary to cool discs.

The structures with radial stems are well known though in the structures described [6] the ratio of geometric sizes is evidently unoptimal.

2. As it is known from Ref. [7] the shunt impedance value for the DAW structure increases with the structure outer diameter R_c.

Although there are the following factors limiting outer radius length and consequently the shunt impedance value:

1) With large outer radii ($R_c \gg 0.88\lambda$ [8]) the operation frequency is overlapped with the upper branch of operation dispersion curve.

2) At $R_c > 0.64\lambda$ the intersection is occured of passband E_{11} of operation frequency.

Since the accelerating gradient is not so high of 15 MeV/m we have to increase the overvoltage factor K_m (i. e. ratio of maximum electric field strength on the resonator surface to accelerating field) by introducing the small drift-tube nose radius (1.2 mm). This enabled us to increase the shunt independence substantially compared to that of structure with low K_m.

In Table 1 geometrical sizes and its calculated parameters are given of the used DAW structure cell which is schematically presented in Fig. 1. It is seen from the table that the design (calculated with a LANS program [9]) value of the shunt impedance is 119 MΩ/m.

Table 1

L cm	R_c cm	R_d cm	R_w cm	R_a cm	t_w cm	Θ	t_g cm	z cm	r cm	ZT^2 MΩ/m	$Q\times10^{-3}$	K_m
2.68	6.8	5.66	4.62	0.44	0.35	30°	1.27	0.78	0.12	119	36	4.0

The investigation was performed of the structure quality factor as a function of diameter of radial stems d. It is revealed that at $d/\lambda \approx 0.04$ the losses on the stems are minimal. This optimum is connected with the fact that current flowing through the stem in inversely proportional to the logarithm of ratio of wave length and

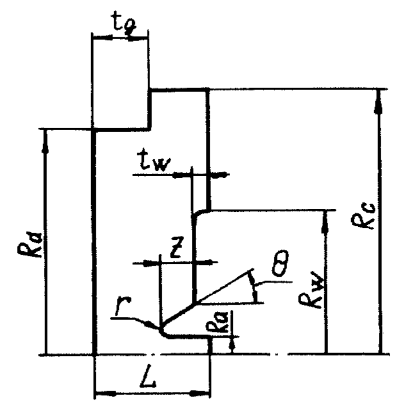

Fig. 1. Geometrical notation of a half-cell DAW cavities.

value d and a current carrying cross section area increases proportionally to value d.

Fig. 2 shows the quality factor as a function of stem diameter for the model structure of 166 mm diameter which consists of two halfcells. Geometric parameters of this structure and calculated electrodynamic parameters are given in Table 2.

Table 2

L cm	R_c cm	R_d cm	R_w cm	R_a cm	t_w cm	Θ	t_g cm	z cm	r cm	ZT^2 MΩ/m	$Q\times10^{-3}$	K_m
2.68	8.32	7.42	4.37	0.44	0.35	30°	1.27	0.66	0.22	127	48	3.6

3. The experimental study has been performed of accelerating structure for the choice of its geometry providing the absence of parasitic modes in the proximity of operation frequency at maxi-

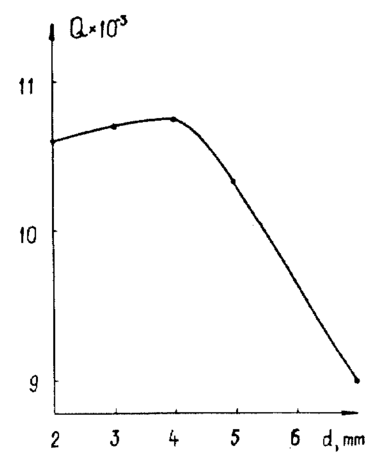

Fig. 2. The quality factor as a function of the stem diameter.

mum value of shunt impedance. For this purpose three model structures were manufactured with diameters 166, 136 and 130 mm.

Resonance frequencies were found with panoramic meter VSVR in the indication mode for frequency characteristics. Oscillation types were identified with the method of small perturbations.

The passband width for asimuthally-inhomogeneous modes decreases proportionally to R_c. This decrease is determined by the fact the 0-type frequencies are approximately inversely proportional to R_c and π-type frequencies weakly depend on R_c since they are determined by disc diameter.

It turned out that azimuthal stem shift in adjacent communication cells leads to the break of the dispersion curve of E_{11} type oscillations in the point $\pi/2$. The stop band size is proportional to R_c value and depends on the stem length.

By interpolation of data measurements for three structures with various diameters we have found that with 140 mm outer diameter the operation frequency turns to be inside the stop band. Though we failed to use this effect as the stop band width turns to be low (<10 MHz) due to the fact that the stem length is close to $\lambda/4$. In this case, the shunt impedance is only 3% higher than that for the structure with outer diameter of 136 mm.

Finally as an operation model we have chosen the structure with 136 mm diameter for which the parasitic mode frequency E_{110} is by 20 MHz higher than operation frequency. Experimentally found value for ZT^2 is 85 MΩ/m (for the long structure) that is 30% lower than the calculated value that is caused mainly by losses in stems.

One should note that the shunt impedance for the structure 136 mm in diameter negligibly lower that one for the structure with 166 mm in diameter. This is caused by the low losses in stems since with diameter of 136 mm the stem length is close to $\lambda/4$.

Fig. 3 shows the dispersion curves for the structure with 130 mm diameter (*a*) and for a 166 mm diameter structure with parallel stems (*b*) and with stems located in adjacent cells with 60° separation (*c*).

4. The accelerator structurally consists of six unit-brazed accelerating sections interconnected with indium packings located in minimal current zones. Each of them is fixed on three radial stems dispersed homogeneously along the circle. The design of the section details enables its manufacturing only by turning operations and also its final treatment (diamond turning with an average hight of micro-imperfections is 0.2 μm) provides high quality factor of the structure. The structure is schematically presented in Fig. 4.

Central discs (*1*) and outer cylinders of sections (*2*) are made of oxygenless copper. The stems (*3*) are the copper pipes with diameter 5 mm with brazed in them steel rods of 3 mm diameter. Such a design of stems together with provision of high quality factor and sufficient heat transfer from the discs gives also to stems mechanical rigidity required for keeping the given position of central discs in the process of brazing the section.

The section brazing is performed in three stages. First, steel rods are brazed in the copper pipes of stems with copper-nickel brazing alloy melting at 980°C. Next the central discs (via stems) are brazed to its outer rings keeping required accuracy in their mutual positions. In this case, the copper-silver eutectic is used at brazed temperature of 800°C. And finally, out of 8 the «washer-outer ring» elements obtained a 1 m section is brazed. Here the brazing is performed along the ends of outer rings with copper-silver brazing alloy with brazing temperature 750°C. On this stage on the outer part of the section it is brazed the water pipe for stabilizing the section temperature during the operation run.

5. For developing technology and testing with high power level the accelerating structure was produced 60 cm long with outer diameter of 166 mm. Power input is in the middle of the section. At present this section is ready for tests on high power level.

6. With an approximate choice of sizes the DAW structure with three radial stems can provide the shunt impedance value 85 MΩ/м that is slightly lower than that for complex structures with large outer diameter [10] in view of its substantial simplicity in technology and design. This enables one to produce on its base a simple and relatively compact linear accelerator as an injector for the storage ring «Siberia-2».

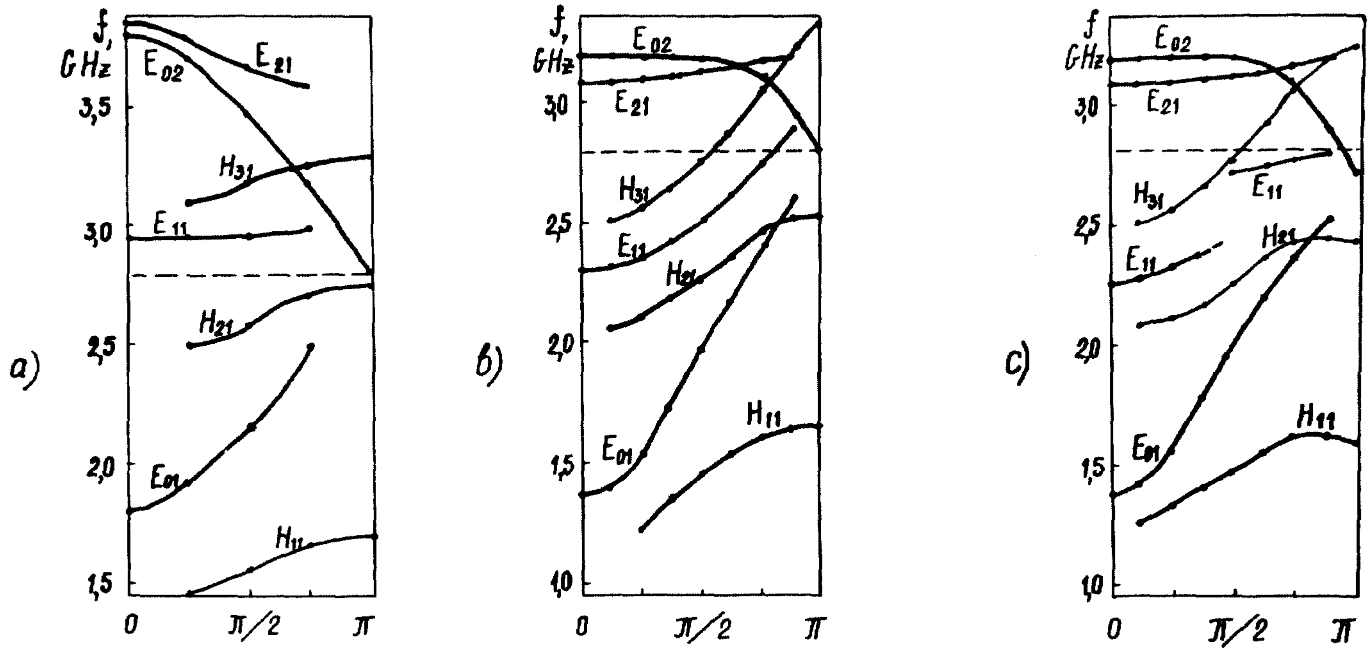

Fig. 3. Mode spectra.

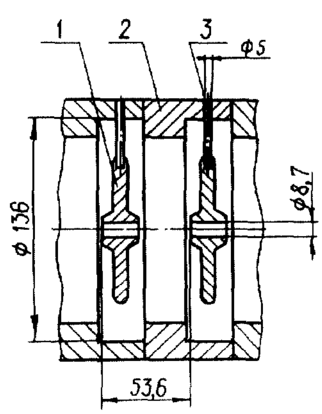

Fig. 4. Cross-section of the structure:
1—disc, *2*—outer cilinder, *3*—stem.

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