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QUESTIONS CONCERNING THE INCREASE OF THE LIMITING CURRENT IN MULTISECTION LINEAR ACCELERATORS

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ABSTRACT

A description is given of the experiment on increasing the limiting current in a multisection linear accelerator upon the replacement of the first accelerating section with a section in which the frequency of the hybrid EH_{II} wave differs from the frequency of hybrid waves excited by the beam in the remaining sections by 180 megacycles. This modification of the accelerator enables us to triple the pulse current, with which the shortening of the current pulse begins.

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We know that the maximum current value in linear electron accelerators with a running wave is limited by the current instability caused by the interaction between the beam and the electromagnetic field of the EH_{II} wave excited by the beam in the diaphragm-type waveguide [1,2]. This instability, which causes a decrease of the current pulse length, is especially manifest in high-energy accelerators, which use a large number of identical accelerating sections [3]. Here the multisection accelerator can be regarded as a multicascade generator, in which the communication between the cascades (accelerating sections) is maintained with the beam, and the primary cause of excitation of the hybrid EH_{II} wave are noises, both in the diaphragm-type waveguide and in the electron beam.

It is natural to assume that the greatest effect of the transverse modulation of the beam takes place in the first sections of the accelerator, in which the electron energy is still low. The parasitic oscillation frequency which corresponds to the phase velocity of the hybrid wave, which approaches the speed of light, is determined by the electrodynamic characteristics of the diaphragm-type waveguides.

Therefore we can expect that the modification of the usual system of a multisection accelerator composed of identical sections, consisting of a change of the parameters of the diaphragm-type waveguide of one or several initial accelerating sections, will enable us to increase substantially the critical current of the entire apparatus. The criterion for the required change of the parameters of the sections is the assurance of a sufficient difference between the frequencies of the hybrid waves which may be excited by the beam in the initial and main parts of the accelerator.

As it was shown in the experiment with an external source of excitation [4], the interaction of the beam with the hybrid wave field has a resonance character and takes place in the frequency band not exceeding 15 megacycles. Proceeding from this we can consider that the difference between the frequencies of hybrid waves excited in the adjacent sections of the initial part of the accelerator, of the order of several tens of megacycles will prove sufficient for elimination of communication over the beam.

To verify this assumption we performed measurements of the critical current of the accelerator, which consisted of an injector with an energy of 6 Mev and nine identical sections with a uniform structure of the diaphragm-type waveguide of Table 1. The energy increment in each section amounted to 28 Mev.

In Fig. 1 we adduce the dependence of the critical current at the output of the accelerator on the number of operating sections. Curve 1 corresponds to the instance when all the sections are identical, and curve 2 to the instance when the first section of the accelerator differs with respect to the hybrid wave frequency from the other sections by 180 megacycles. The parameters of this section are given in column II of Table 1.

Table 1

Name of parameters	I Main sections	II Auxiliary section
Waveguide diameter	86.20 mm	84.67 mm
Opening diameter	30.04 mm	24.95 mm
Structure period	26.77 mm	26.77 mm
Section length	441 cm	350 cm
E_{01} wave frequency	2797 Mc	2797 Mc
EH_{11} wave frequency	3922 Mc	5104 Mc
E_{01} wave oscillation type	$\pi/2$	$\pi/2$

Measurements were also performed for the instance when the accelerating waveguide with parameters given in column II of Table 1 is installed in place of the second section. The results of the measurements are shown with curve 3. A comparison of the curves in Fig. 1 substantiates the assumption of the greatest effect of precisely the first and the following sections on the critical current of the accelerator.

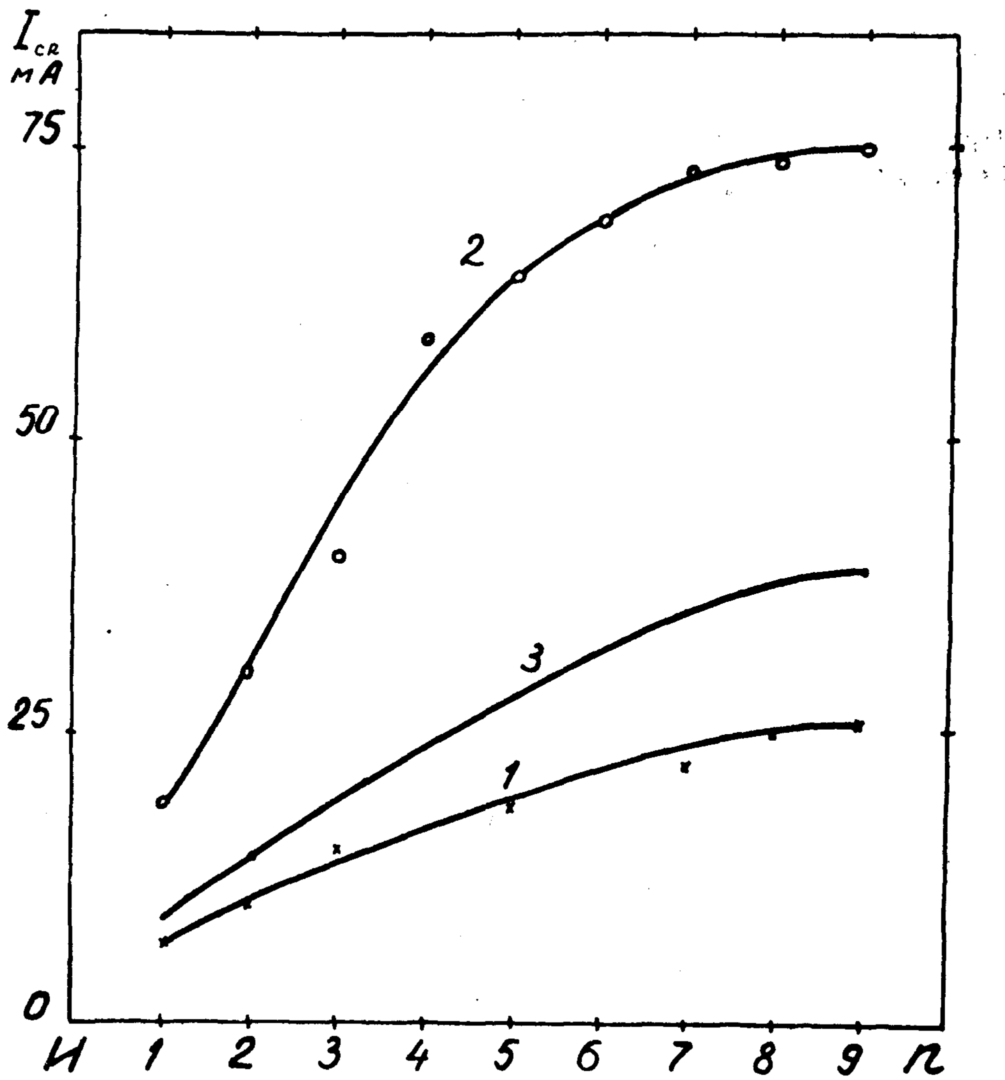

Fig. 1.

Dependence of the Critical Current at the Output of the Accelerator on the Number of the Working Sections. 1 - All Nine Accelerating Sections Have Identical Parameters; 2 - the Parameters pf the First Accelerating Section Differ From the Parameters of the Other Sections With Respect to the EH_{11} Hybrid Wave Frequency; 3 - the Parameters of the Second Accelerating Section Differ From the Parameters of the Other Sections With Respect to the Hybrid Wave Frequency.

On the basis of this work we can draw the following conclusions.

The current limit value in multisection linear accelerators can be substantially increased by using one or several first sections with parameters differing from the parameters of all the other accelerating sections.

The difference between the parameters should assure the difference between the frequencies of hybrid EH_{11} waves, with which the phase velocities of these waves are near the speed of light, in two neighboring sections, by not less than 50 megacycles. The difference in the frequencies of hybrid waves can be attained either by changing the dimensions of the diaphragm-type waveguide, as it was described in the present work, or through a change of the working type of the accelerating wave, for example, $\frac{2\pi}{2}$; $\frac{3\pi}{4}$; etc

BIBLIOGRAPHY

1. M.G.Kellther, R. Beadle. Nature, 187, 1099, 1960. I.R.Jarvis, G. Saxon, M.C.Crowley-Milling. Proc. IEE, 112, 1795, 1965.
2. W.K.H.Panofsky et al. SLAC-Pub-197 (Submitted to Science).
3. V.A.Vishnyakov, I.A.Grishayev, A.I.Zykov. ZhTF (Zhurnal Tekhnicheskoy fiziki; Journal of Technical Physics) XXXYI, iss.II, 1966.

4. V.A.Vishnyakov, A.I.Zykov, V.M.Grizhko, I.A.Grishayev. ZhTF (in print).

5. A.K.Val'ter, I.A.Grishayev, G.K.Dem'yanenko, A.I.Zykov, L.A.Makhnenko. Trudy Mezhdunarodnoy konferentsii po uskoritelyam (Transactions of the International Conference on Accelerators). Dubna, 1963. Atomic Power Publishing House, Moscow, 1964, page 435.

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