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V.E.Balakin, O.N.Brezhnev,
A.V.Novokhatsky, Yu.I.Semenov

ACCELERATING STRUCTURE OF A COLLIDING LINEAR ELECTRON-POSITRON BEAM (VLEPP). INVESTIGATION OF THE MAXIMUM ATTAINABLE ACCELERATION RATE

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V.E.Balakin, O.N.Brezhnev, A.V.Novokhatsky, Yu.I.Semenov

Institute of Nuclear Physics,
630090, Novosibirsk, USSR

A b s t r a c t

The optimal shape of the accelerating structure for obtaining the minimum overvoltage along the surface of the structure is found. The results of the study of the electric strength of a single cavity in the 10 cm range are described. Its geometry was selected so as to obtain the maximum electric field strength on a plane copper surface. The cavity was made sectional to allow the study of the effect of the machining and processes of surface preparation. The cavity electric field strength was measured by the autoemission current stectrometry. The electric field strength achieved on the cavity axis is 1.5 MV/cm. The electric field strength is limited as a result of loading of the cavity by the autoemission current.

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The selection of the VLEPP accelerating structure is shaped by the requirements imposed on the accelerator as a whole, i.e., the attainment of a high acceleration rate and maximum luminosity. Analysis of the longitudinal and transverse forces acting on a charge during travel through the accelerating structure shows that the π -structure with large apertures in the diaphragm is optimal.

The shape of the accelerating cavity was optimized by means of computer programs /1/ for obtaining the minimum overvoltage factor, i.e., the ratio of the peak value of the electric field at the diaphragm to the effective value of the accelerating field on the cavity axis

$$E_{eff} = \frac{1}{L} \int_0^L E_z(0,z) \sin\left(\frac{\pi}{L} z\right) dz$$

at the maximum aperture in the diaphragm. Ring resonators are used to provide coupling between the accelerating cavities. /2,3/

A profile of the diaphragm and a graph of the field along the surface of the diaphragm are shown in Fig.1.

Some design parameters of the cavity are:

Frequency	5600 MHz
Acceleration rate	1 MeV/cm
Overvoltage factor	1.6
Power capacity	0.7 J/cm
Q-factor	8000
Effective shunt resistance	32 MΩ/m

The low value of the shunt resistance and the high power capacity are connected with the fact that when the aperture of the diaphragm is large the field is "dumped" from the cavity and the effective value of the accelerating field decreases. When this occurs the Q-factor is not significantly worsened. It should be noted that for a different structure such as $\pi/2$, given the same aperture in the diaphragm it is impossible to obtain a relatively small overvoltage factor, as for π -structure. /4/

The influence of the frequency spread of the cavities and consequently of the fabrication tolerances on the energy redistribution in the accelerating section was studied through numerical simulation. It turns out that when cavities having a frequency spread in the range $\pm 2 \times 10^{-3}$ are randomly arranged, the fraction of the energy in the coupling cavities is on average 8.5% for a section 2.5 m long and a coupling factor of 10%. The requirement for fabrication precision can be eased if the following arrangement procedure is used. Of the available set of cavities, the cavity with the minimum frequency deviation is selected first, followed by a cavity such that the total deviation is minimal, and then the procedure is repeated. This arrangement is easily carried out by means of a computer for a set of cavities at measured frequencies. By using

this procedure for the previous case, we find that the energy fraction in the coupling cavities is 0.5% on average.

The conditions for filling the power cavities are selected so that in a time equal to the SHF pulse length the wave front propagates along the section and back. In this case the total voltage in the accelerating cavities is present for half of the pulse length. The losses to heat are 30% for a pulse length of 0.2 msec.

A stand the block diagram for which is shown in Fig.2 was assembled to study the dielectric strength of the cavity. A single cavity in the 10cm range whose geometry was selected so as to obtain the maximum electric field strength on a plane surface is excited with a KIU-12 klystron. The accelerated autoemission electrons are analyzed with a magnetic spectrometer. The power entering the cavity is monitored from the incident and reflected waves. The power absorbed in the cavity is measured with a calorimeter. The cavity was made sectional to allow the study of the effect of the machining and processes of surface preparation. The hydraulic clamp of the cavity cover provides a vacuum-tight electrical contact. The vacuum in the cavity is 5×10^{-8} torrs and pumpdown is with an NORD-250-type MRN. The cavity surface was machined so that the height of the microroughnesses was $\sim 1.25\,\mu$m, and the finished with diamond paste to a roughness of $\sim 0.02\,\mu$m. After ultrasonic washing using a surfactant and washing in running deionized water, the cavity is vacuum-annealed at $T = 450$°C. The cavity is assembled in a dust-proof chamber. The foundation of the cavity is made of BRKh-05 and the lid is made of MB copper. Figure 3 shows a typical autoemission electron spectrum of a cavity and also the calculated spectra at a field strength of 1, 1.5, and 2 MV/cm at the center of the plane surface. The experimental dependence of the emission current on the cavity electric field strength was used for the calculations. The field strength achieved is 1.5 MV/cm, and breakdown is not observed. A further increase in the excitation power has a weak effect toward increasing the electric field strength as a result of loading of the cavity by the autoemission current.

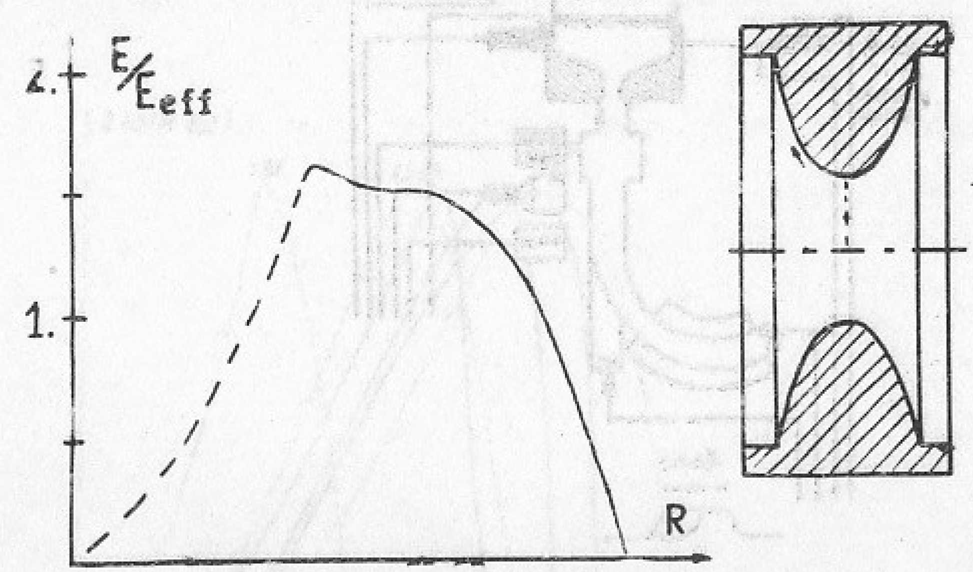

Fig.1 A profile of the diaphragm and a graph of the field along the surface of the diaphragm.

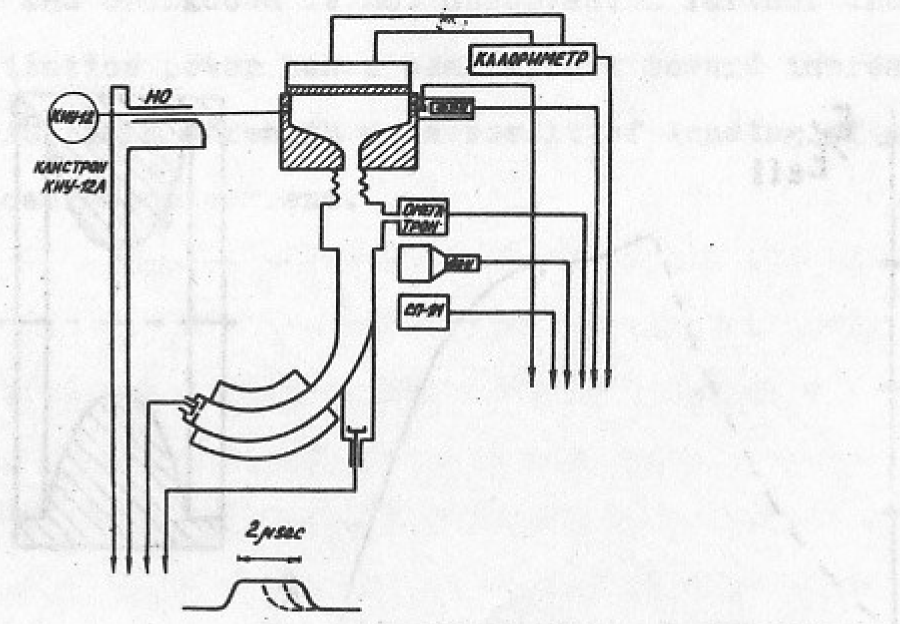

Fig.2 A block-diagram of the test stand.

a - KIU-12 e - Omegatron

b - KIU-12A klystron f - SP-1M

c - Calorimeter g - Measuring circuits

d - Photomultiplier h - 2 sec

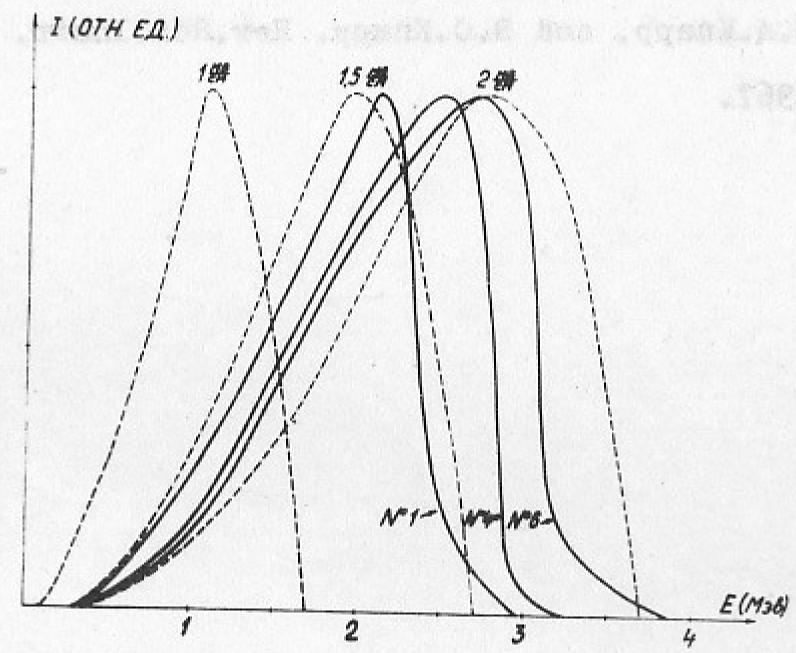

Fig.3 The spectra of autoemission current (dense lines) and the calculated spectra (dot lines).

a - I (relative units)

b - MeV/cm

c - E (MeV)

R e f e r e n c e

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