THE REP-5 HEAVY-CURRENT RELATIVISTIC-ELECTRON
PULSE ACCELERATOR, WITH A BEAM CURRENT OF
ABOUT 50 kA

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Interest has recently arisen in extremely powerful beams of relativistic electrons in view of the pros-
spects of using these in controlled thermonuclear fusion reactions, the acceleration of heavy ions, and so
forth [1-3]. Beams of this kind are obtained if electrons are directly accelerated by charge pulses lasting
a few tens of nanoseconds, generated by pulse-shaping lines with distributed circuit parameters.

The REP-5 accelerator is based on the EG-5 electrostatic generator, and is intended to produce a
heavy-current beam of relativistic electrons at an energy of some 2-3 MeV. The basic arrangement of
the REP-5 is similar to that of the accelerator described in [4].

In this paper we shall set out some results obtained
during the first stages in the use of the installation, with a
charge voltage of \( U_C \approx 3 \) MeV. The source of the charge
voltage is a van de Graaf generator in a high-pressure tank
2.2 m in diameter (Fig. 1). A high-voltage electrode 1.6
m in diameter together with the accelerator tank forms a
coaxial shaping line some 3 m long with a wave impedance
of about 20 \( \Omega \). The line may be charged to a voltage of
about 4 MeV, the stored energy then being about 4 kJ. Elec-
trical insulation is provided by a gas mixture (25\% CO₂
+ 75\% N₂) under a pressure of up to 16 atm. The accelera-
tor tube is separated from the electrode by a gas space of
\( \sim 30 \) \( \Omega \). Switching of the high voltage is effected by means
of a modulated-Q laser, the output radiation of which com-
prises four or five pulses each 25 nsec long with a total
energy of 2.5 J. At first the laser beam was directed
across the lines of force of the electric field of the dis-
charge gap at an angle of 20° to the surface normal (Fig. 1)
and focussed on the end of the electrode by means of a lens
with a focal length of 500 mm. In the next series of experi-
ments the laser beam was directed along the accelerator
axis, which reduced the trip time of the discharge gap to
about 400 nsec. The ignition system ensures reliable
switching of the voltage (\( U_b = 1.3-1.5 \), where \( U_b \) is the
breakdown voltage of the gas gap in MV).

Two forms of accelerator-tube insulator construction
were developed for the accelerator: 1) from cylindrical
porcelain rings, and 2) from epoxy resin rings, with a

Fig. 1. Sketch of the accelerator: 1) charge
generator; 2) high-pressure tank; 3) high-
voltage electrode; 4) accelerator tube; 5)
capacitive sensor; 6) anode foil; 7) Rogow-
ski belt; 8) calorimeter; 9) drift chamber;
10) shunt; 11) titanium pump; 12) system
of laser ignition; 13) lens.
Fig. 3. Amplitude of the electron current as a function of the charge voltage of the generator.

The stainless steel cathodes have a cylindrical shape, with a sharp edge. The anode is a titanium or aluminum foil 50 µ thick (Fig. 1). The cathode—anode gap may be varied between 1 and 5 cm without breaking the vacuum. The beam passes through the anode foil into a metal drift chamber containing the diagnostic apparatus. The working pressure in the accelerating tube is held at $10^{-6}-10^{-8}$ mm Hg by means of a NORD-250 titanium pump. In the drift chamber the pressure varies from $10^{-3}$ mm Hg to atmospheric.

The energy stored in the beam is measured by means of a calorimeter with two thermocouples. A graphite disc 60 mm in diameter is fixed to a mobile metal rod so as to enable the calorimeter to move smoothly over the whole length of the chamber without breaking the vacuum. The beam current was determined with a low-inductance shunt connected between the calorimeter rod and the flange of the drift chamber. For measuring currents of $\sim 10$ kA a shunt comprising twenty parallel ULI-0.5 resistances of 2 Ω each was employed. For measuring currents of $\sim 50$ kA the resistance of the shunt was reduced to 20 mΩ. The time constant was about $10^{-9}$ sec.

For determining the current a Rogowski belt similar to that described in [5] was also employed. The belt was fixed to an independent moving rod. The shape of the current pulse was regulated by an auxiliary magnetic loop. The shape of the pulse of accelerating voltage was recorded with a capacitive sensor made of aluminum foil $20 \times 80$ cm in size, glued to the wall of the tank with insulating adhesive. The pulse signals were passed to an I2-7 oscillograph and photographed on aerial photographic film with a sensitivity of 2000 All-Union State Standard units. For a charge voltage of $\sim 3$ MV an electron beam with a current amplitude of about 50 kA and a pulse length of about 20 nsec was obtained.

Figure 2 shows the oscillograms of the current pulses in the drift chamber and the voltage on the gun. Figure 3 shows how the amplitude of the electron current depends on the charge voltage for an anode—cathode distance of 18 mm and a pressure in the chamber of about $3 \cdot 10^{-2}$ mm Hg, for which the defocusing of the beam is still appreciable. Thus the shunt only recorded that part of the current which fell on a calorimeter situated at 8 cm from the anode foil. The scattering of electrons in the anode foil also leads to a loss of some 30% of the particles injected into the drift chamber [6].