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QUARTERLY STATUS REPORT (10) PREINJECTOR GROUP

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AGS DIVISION TECHNICAL NOTE

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General

The objectives of the group to obtain 200-250 mA beam currents within a reasonable emittance have been obtained at 750 kV in the test column (see Internal Report AGS-Div. 67-6). In addition a three section tube has been successfully tested mechanically; on the basis of these results a final column is assembled; this unit will be fully tested in the first quarter of next year. The hitherto mechanical results will be published in technical notes by R. Amari and S. Senator. The modified low energy transport system for the 50 MeV linac is designed and in the workshop. A general layout of the tube and transport system is shown in the attached drawing.

A fast bouncer system, spark gaps and shunted hard tube modulator has been installed in the operational AGS machine during the Nov-Dec shutdown.

During continued beam tests with the short column in the test area, a drastic decrease in beam output occurred. It was found that the ceramic insulator between anode and intermediate electrode was partly coated with a metal deposit (Mo?) disturbing the field distribution between the electrodes. After cleaning, the source characteristics were back to normal. We suspect metal vapors from the expansion cup has penetrated the anode aperture.

The design and construction of the 200 MeV preinjector (ion source and accelerator tube) has been started.

A Theoretical Explanation for the Obtained Absolute Emittance Values as Described in AGS-Div. 67-6

Gabovich ("Plasma Ion Sources" p.43, AD-623822, 1965) explains the existence of a negative potential drop close to the anode exit (see Fig. 1).

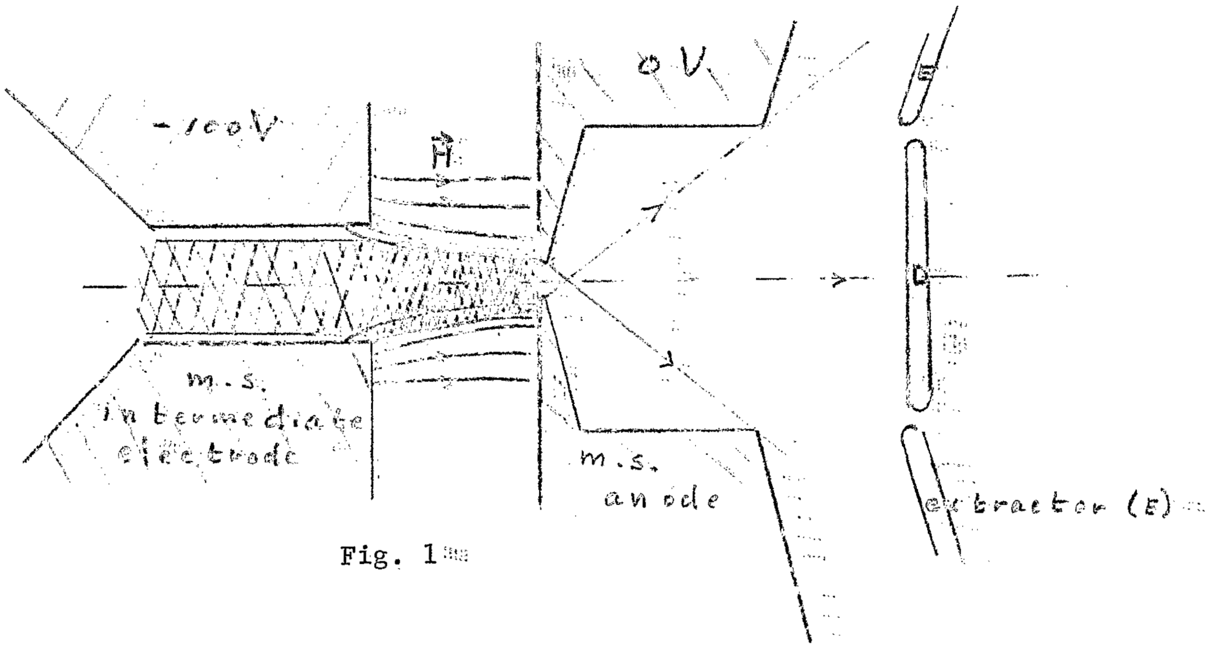


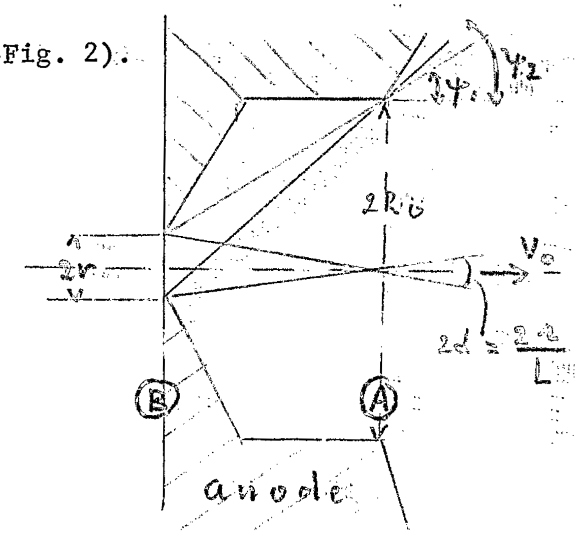
Fig. 1

It is caused by the amplification of ionization towards the anode (increased electron energy) and contraction of the plasma by the non-uniform magnetic field. This configuration forms a high concentration of charged particles just inside or in front of the anode aperture.

With the larger electron mobility and the outer imposed potential distribution a plasma sheath is formed close to the aperture and directed ion and electron beams move in opposite directions with an energy equal to the voltage drop across the sheath (several tens of volts).

P. Clarke brought some experimental evidence of the plasma jet idea in the detection of considerable positive beam currents on the zero potential extractor (E) and detector (D), which could be suppressed by about + 10 V potential.

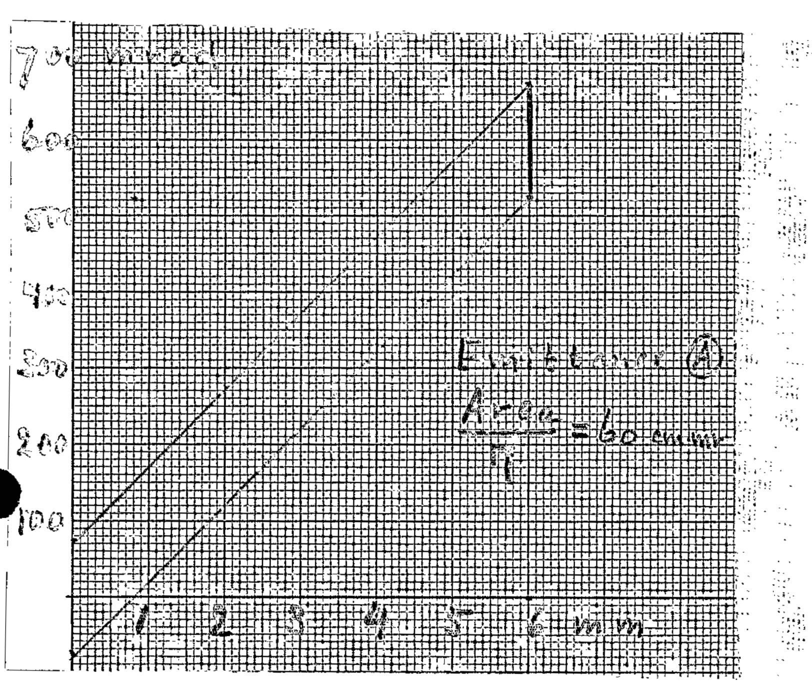
When the ions leave the source in laminar flow the optimum emittance value can be estimated from the geometry of the expansion cup (see Fig. 2).



The normalized emittance without external fields at (A) is:

$$\varepsilon_2 = \beta\gamma \frac{\text{area}}{\pi} = \frac{v_o}{c} \frac{\text{area}}{\pi} \quad (\gamma = 1)$$

For $L = 10$ mm, $2r = 1.5$ mm, $2R_o = 12$ mm $\Big\}$ $\frac{\text{area}}{\pi} = 60$ cm-mrad



Suppose a maximum longitudinal plasma velocity v_o:

$$(v_o)_{max} = 2\sqrt{\frac{2kT_i}{m}} \approx 10^5 \text{ m/sec}$$

(ion temperature $T_i = 10^5$ °K.)

Finally:

$$\varepsilon_2 = \frac{10^5}{3.10^8}\, 60 = .020 \text{ cm-mrad}$$

In Fig. 5 of our publication AGS-Div. 67-6 the measured $\varepsilon_2 = .062$ cm-mrad is surprisingly close to the theoretical value.

In Fig. 4 of the same publication the emittance is $\varepsilon_2 = .036$ cm-mrad, which corresponds again excellent in this jet theory; the cup is namely two times deeper, reducing the emittance by a factor of two! Under identical discharge conditions however the intensity is reduced by a factor of four because the solid angle at which the plasma emerges <u>the cup</u> is reduced by a factor of four:

$$\Omega = \pi \left(\frac{R_o}{L}\right)^2$$

This means that the brightness does not improve (brightness $\div \dfrac{\text{intensity}}{(\text{emittance})^2}$). In practice, however, one reduces the loss of particles in a longer cup by some additional magnetic field (in our case more stray-field from the source magnet).

<u>Note</u>

Comparison of emittances is only possible for apparent non-aberrant beams. For currents larger than 100 mA distortion in the core of the beam started to appear in the emittance pattern (double images).

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