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SHORT COLUMN PROGRESS (9)

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AGS DIVISION TECHNICAL NOTE

No. 38

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Duoplasmatron Source

In the test rig facility an effort was made to determine the cause of the high frequency (~5-10 Mc) oscillations in high current beams (>100 mA):

a. In case of cyclotron oscillations, there should be a linear relationship between the frequency and the magnetic field; there was no such effect.

b. In case of radial sound oscillations, the diameter of the plasma column should influence the frequency; the diameter could be reduced by a smaller diameter of the canal in the intermediate electrode; we reduced it to half the size, however, the frequency ($f \sim \frac{1}{R}$) did not change.

c. There was no frequency change when hydrogen gas was replaced for H_e, N_2 or Argon, indicating that the origin is not sound oscillations.

d. The geometries inside the source and expansion cup geometries influence the amplitude of the oscillations, but not its frequency.

A modified experimental duoplasmatron source is under construction a) to compensate for the measured magnetic stray field in the expansion cup, (some tens of gauss); it is necessary to use high melting point materials as anode b) to diminish beam losses on the side walls of the cup, so to increase beam currents for future requirements (>200 mA) c) to compare beam qualities.

Figure 1 shows the new source with two magnetic circuits; the intermediate electrode is cooled by freon in copper tubing; critical parts on the anode side of the source is made demountable to ease modifications. For comparison Fig. 2 shows the original source.

With the higher beam currents, it becomes more and more important to study the effect of density distribution on the beam transport along the preinjector. Recent calculations are made by Blewett, Turner and Bennett. Further studies are under way by Moore and Norman. Hardly any practical experience has been made up to now.

In the coming months the density distribution of beams will be determined after the source extractor. Dick Lane has assembled now a set of small Faraday-cups, (ϕ 1mm) similar to the unit prepared for the 750 kV beam.

Short Column

A. Support of the high gradient tube by means of a nylon rope hanging from the pit-enclosure seems to be possible only by adequately protecting the rope with a phenolic tube and a "donut" connection.

B. The pulsed solenoid as focussing element has been replaced for the more practical triplet. The middle of the first quadrupole (effective length of 7.96 cm) is located 17 cm after the last electrode. That pole misalignments are critical parts in the apparent emittance is demonstrated in Fig. 3, showing the image of a horizontal focussed beam on a quartz window after traversing a slotted plate; the first quadrupole was 3 or 4^{o} skewed with respect to the second quadrupole; the proton pattern is the "butterfly" in the center; the s-shaped lines are caused by the molecules and the very light straight lines originate from the H_3^+. Figure 4 shows the slit-images of the same beam with improved quadrupole alignment.

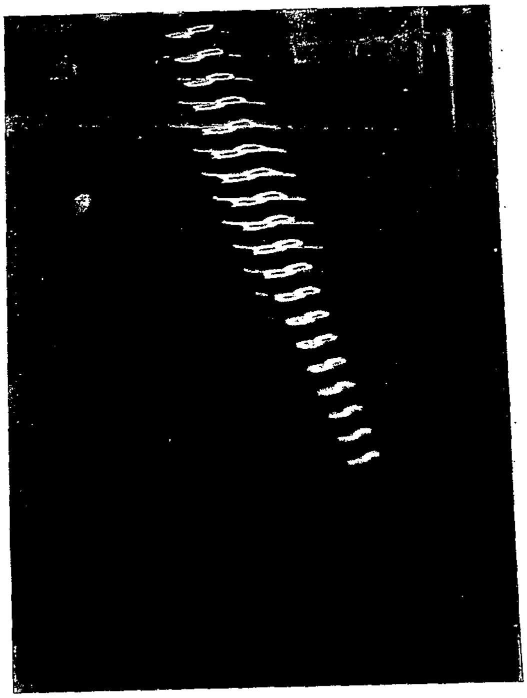

Figure 3. Slit images of a 100 mA beam after some degrees skewed quadrupoles. The images should be straight lines.

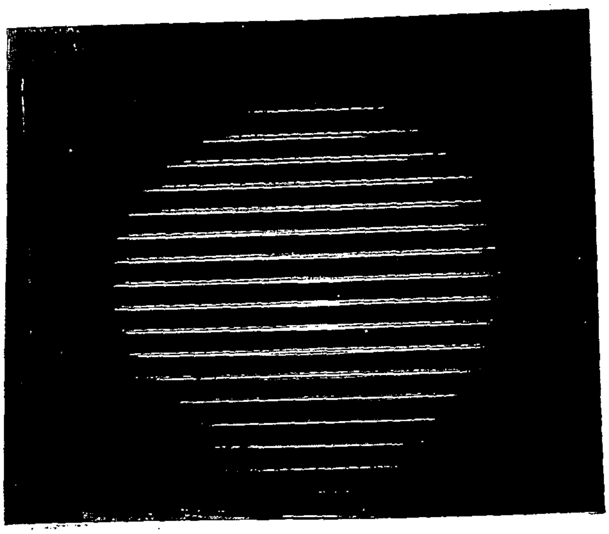

Figure 4. A 100 mA beam with improved quadrupole alignment.

C. The electronics for the fast bouncer has been built and it will be tried out during August.

The slow bouncer system, based on the discharge of a condenser by triggered spark gaps, works properly. The top trace of Fig. 5 shows the beam pulse and the bottom is its corresponding voltage drop measured with a large capacitive pick-up plate. Figure 6 is another voltage drop with and without compensation, reducing the drop from about 30 kV to 2 kV. The results show the feasibility of the spark gap arrangement as a stand-by of the fast beam loading compensator.

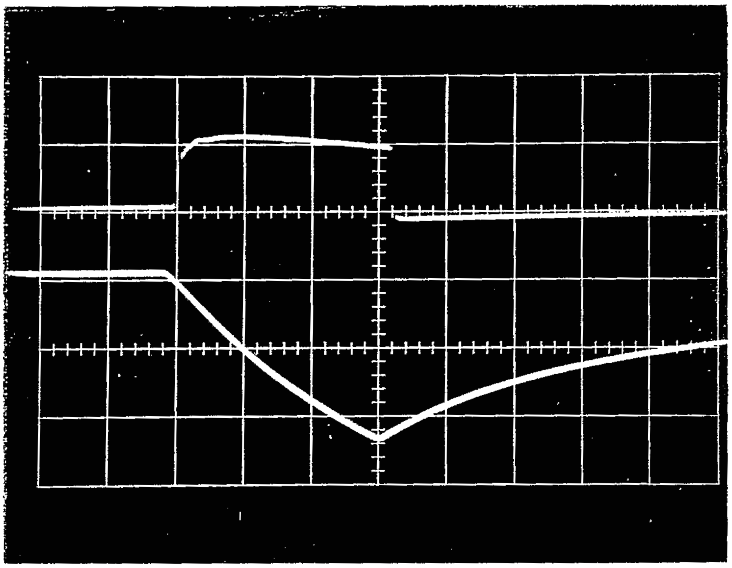

Figure 5. Top trace: beam current 100 mA/cm

Bottom trace: voltage drop: 16 kV/cm

Sweep: 40 μs/cm

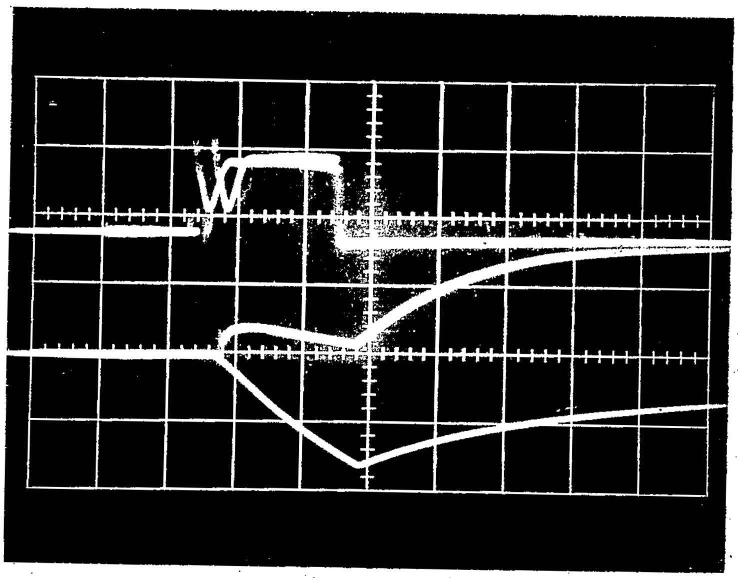

Figure 6. Top trace: beam current 100 mA/cm

Bottom trace: voltage drop with and without beam load compensation.

Sweep: 40 μs/cm.

D. Beam Measurement at 700-750 kV

It has been found that previous beam current measurements were too high in value due to inadequate electron trapping of 200 gauss permanent magnets behind the beam transformers. After installation of the triplet the beam current measurements on the beam transformers were reliable.

The maximum current focussed by the triplet 130 cm after the high gradient column is about 150 mA. The source in the test stand can produce an easy 200 mA (calorimetric measurement) with identical source and extractor parameters. Some beam is lost on the beam transport pipe. It was also notified that the beam current could not be increased significant above a relatively low extractor voltage (say 20 or 30 kV). This can be explained as follows:

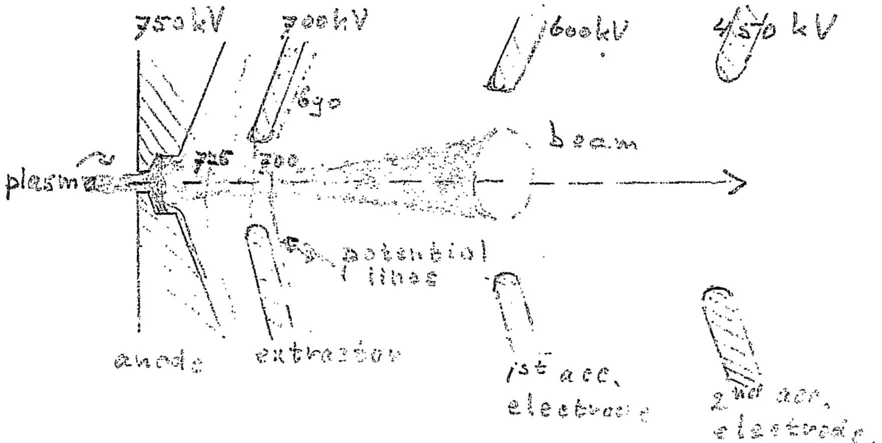

Fig. 7a Potential lines with 50kV extract

Scale ~ 1:1

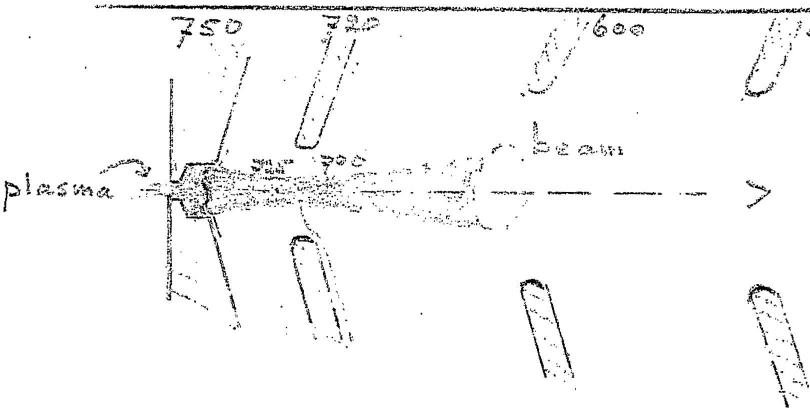

Fig. 7b. Potential lines with 30 kV extract

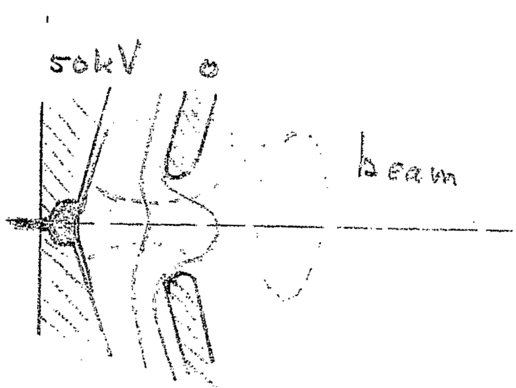

Fig. 7c. Potential lines in the source test rig.

Lowering the extractor-voltage increases the gradient between extractor and 1st accelerating electrode, but e.g. the 700 kV potential is only slightly moved downstream without significantly changing the pattern around the expansion chamber and, therefore, the total beam output (see Fig. 7a and Fig. 7b). In the source test rig the situation of Fig. 7c is valid, changing the beam performance completely.
With an increased extractor aperture (ø 1") the inertness of the extractor voltage on the beam intensity was even more pronounced (no output current variations above the 15 kV extractor voltage).
One can make the extractor region independent of the accelerating region by using a grid in the extractor; we don't like this, because we have to build a low impedance pulsed 60 kV power supply and secondly the lifetime of the grid is short by high energy backstreaming electrons. We will try to avoid this difficulty by improving the plasma expansion cup geometry. We prepare now some electrolytic tank measurements to determine the effect of various geometries on the potential distribution.

E. The mechanical construction of the second column has made a steady progress.

1. Separate and combined tension and shear tests were made on small ceramic - metal (AL, Ti, Kovar) joints using four types of epoxies: CIBA, CONAP, GRODAN and the previous failed epoxy W19 as reference; several techniques were tried out and special care was given to:

a) Surface preparation of both ceramic and metal (sandblasting etching etc.)

b) Surface flatness (<.002")

c) Thickness of the epoxy layer (0.005 to .010").

d) Cleaning procedures (e.g. outgassing in vacuum etc.).

e) Timing

f) Epoxy solvent

From these first tests CONAP and GRODAN were superior in strength by a factor of two.

Temperature - strain tests simulating the large ceramic - metal ring joint and using the above mentioned epoxies and procedures, made a clear-cut in our first choice among the epoxies: the W19 failed after the first temperature cycle up to 45°C; the other joints followed after several cycles, except GRODAN.

On basis of these results GRODAN was chosen as the bond for a second three section column assembling.

More knowledge of this critical part of the large diameter column assembling is necessary for future columns; therefore, present rigs have to be extended with scaled-up test facilities using large ceramic rings (a first unit has already been made by Amari for the three-section column). Also long-term small and large scale creep measurements (combined with tension and shear) will be studied by Senator, who prepares a technical note of the above mentioned small ceramic-metal joint study. He will continue on small joints as a guide for the scaled-up versions. It is still felt that the bond can be improved (e.g. by using wetted fiberglass clothes as spacer.)

2. A clean assembling area has been built alongside the high voltage test facility in the 905A building. This facility allows us to assemble the column in a more controlled way. Everything is set now to start the assembling and testing of an improved three section test unit.

3. Kovar end plates replacing the Al end plates are in the machine shop and they will be finished by the end of August. At that time assembling of the second 15 section column will start, if the three section column passes the required strength tests.

4. A special source servicing rig for handling ion sources and holder inside the high voltage instrument terminal has been designed; a re-entrant electrical insulated quadrupole holder, which is at the same time the support of the last electrode is under construction; the center of the first quadrupole will be 8½ cm after the last accelerating electrode.

Looking down on the Catskills with Stewart was more interesting than looking in the CONAP epoxy outfit of Olean, N.Y.

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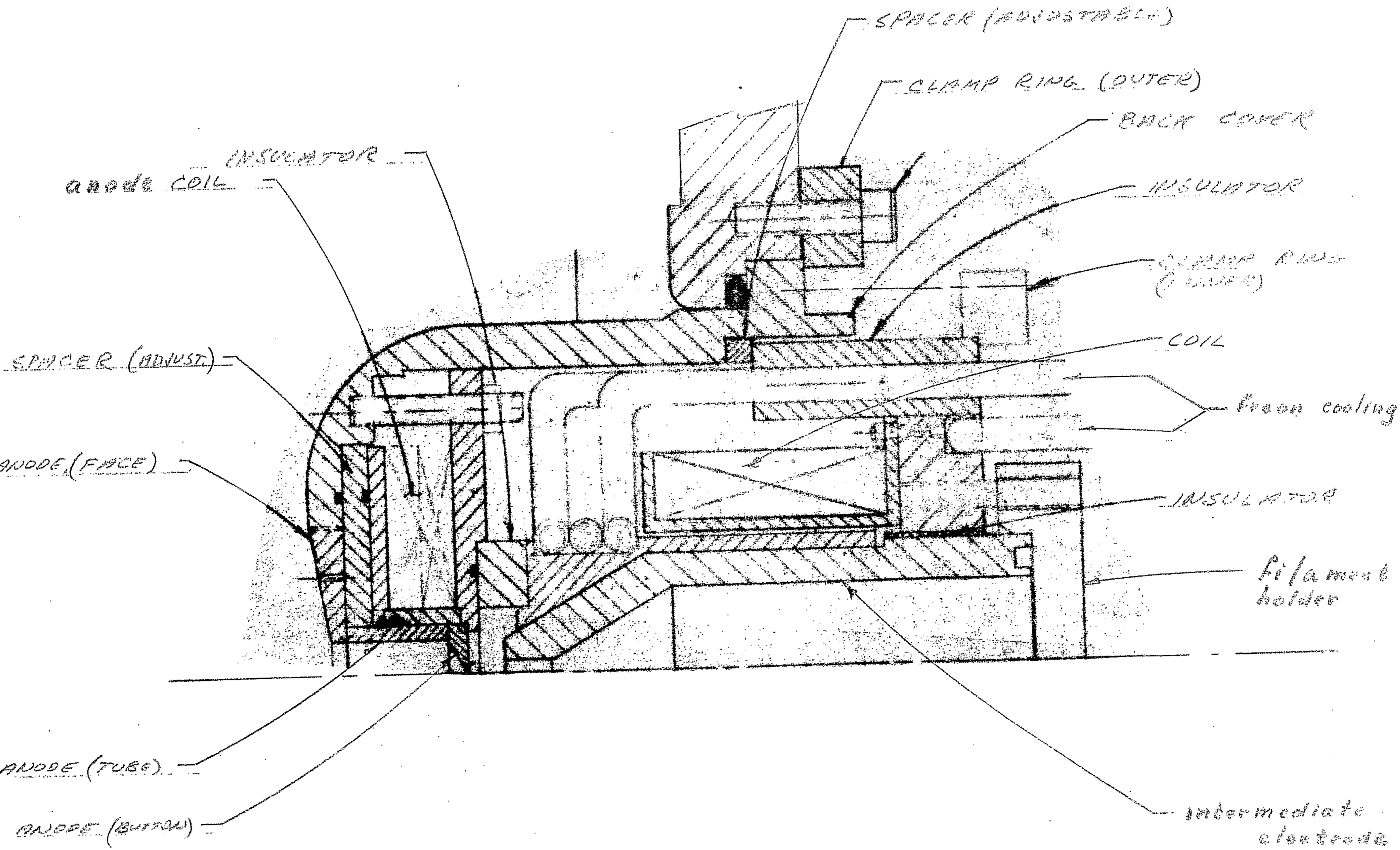

FIG. 1 — ION SOURCE (EXPERIMENTAL)

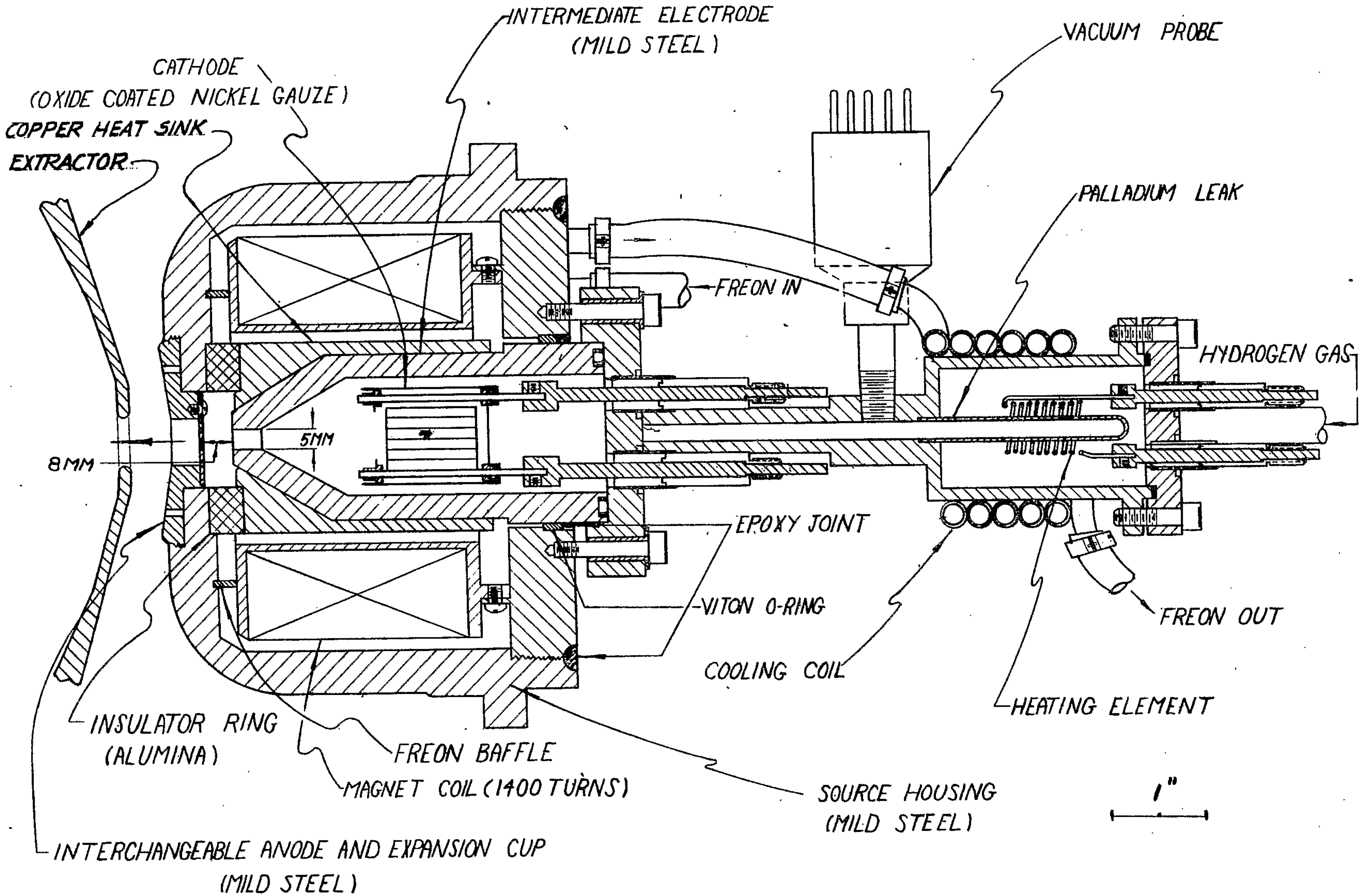

FIG. 1 THE DUOPLASMATRON ION SOURCE AND EXTRACTOR