THE SOURCE OF NEGATIVE IONS

by

V. P. Golubev, G. A. Nalivaiko and S. G. Tsepakin

D. V. Efremov Scientific Research Institute
of Electrophysical Apparatus
Leningrad, USSR

At present negative ion sources of the duoplasmatron type, with extraction of negative ions from the periphery of the arc discharge, are widely used.[1-5]

Beams of negative ions, H_1^-, with a current of 1-2 mA have been obtained. Further increase of the current can be obtained by employing an annular hole for extraction of negative ions,[5] but in this case the effective emittance of the obtained beam increases. Construction of this source is difficult owing to high thermal loads on the anode at the point where the arc discharge contacts it.

The production of the arc discharge within a hollow tubular structure, and extraction of negative ions from its internal region, makes it possible to avoid the above-mentioned disadvantages and to obtain beams of negative ions of comparatively high intensity.

The source of H_1^- negative ions within a hollow tubular discharge was studied on the laboratory model of the duoplasmatron source with a system of ion beam formation. The separation of ion and electron beams, obtained from the source, was accomplished by two pairs of permanent magnets. The separation efficiency was tested on electron beams of corresponding energy with a current of some amperes. The beam current was measured by an electric method. The target was at a distance of 1 m from the source. The emittance of the obtained beam was estimated by means of diaphragms having small diameter apertures and by a luminescent screen.

The region of the formation of the tubular discharge and extraction of the negative ions in the model of the source is shown in Fig. 1. As can be seen, a rod is installed into the intermediate electrode hole. Relation between the rod and anode-emission-hole diameters and the rod-to-anode distance greatly effects the values of electron and ion currents obtained from this source and should be optimized later on.

The model of the source operates in a pulse mode (τ = 100 μsec, f = 1 pulse/sec). The arc discharge current is 20-100 A. Gas leakage into the source is continuous. In the source an impregnated tungsten-barium cathode is used. The magnetic coil of the source has 8000 turns.

Primary experiments show that from this source beams of H_1^- negative ions of current of several milliamperes at normalized emittance of no more than 0.1 cm·mrad can be steadily obtained. For example, the focused beam of H_1^- ions with current of 6 mA and normalized emittance of about 0.07 cm·mrad was obtained at an electron load current of no more than 500 mA.

Fig. 2 shows the H_1^- beam current and electron load current versus the magnet coil current of the source. This dependence is taken when the flow rate of H_2 into the source is 500 cm^3/hour at atmospheric pressure, the arc discharge current is 100 A and the extraction voltage is 30 kV.

The H_1^- beam current and electron load current versus the leakage of H_2 into the source at the magnetic coil current of the source of 200 mA and the discharge current of 100 A are given in Fig. 3.

Fig. 4 shows the H_1^- beam current and electron load current versus the value of the extraction voltage. This dependence is taken when the flow rate of H_2 into the source is 500 cm^3/hour at atmospheric pressure, the arc discharge current is 100 A and the magnetic coil current of the source is 200 mA.

It should be noted that the character of the dependence of the H_1^- beam current in the range of 0 - 15 kV is determined by action of the field of the first pair of separating magnets, mounted in the extracting electrode.

The results of primary experiments show that a source of this type is promising for obtaining intense beams of negative ions with good phase characteristics.

REFERENCES

1. G. P. Lawrence, R. K. Beauchamp, I. L. Mc Kibben, Nucl. Instr. Meth. 32, 357 (1965).

2. L. E. Collins, R. H. Gobbet, Nucl. Instr. Meth. 35, 277 (1965).

3. M. Dubarry, G. Gautherin, Première Conférence Internationale sur les Sources d'Ions, Saclay, France, 133, 1969.

4. V. P. Golubev, V. L. Komarov, S. G. Tsepakin, Première Conférence Internationale sur les Sources d'Ions, Saclay, France, 129, 1969.

5. M. A. Abroyan, G. A. Nalivaiko, S. G. Tsepakin, Zh. Tekh. Fiz. 42, 4, 876 (1972).

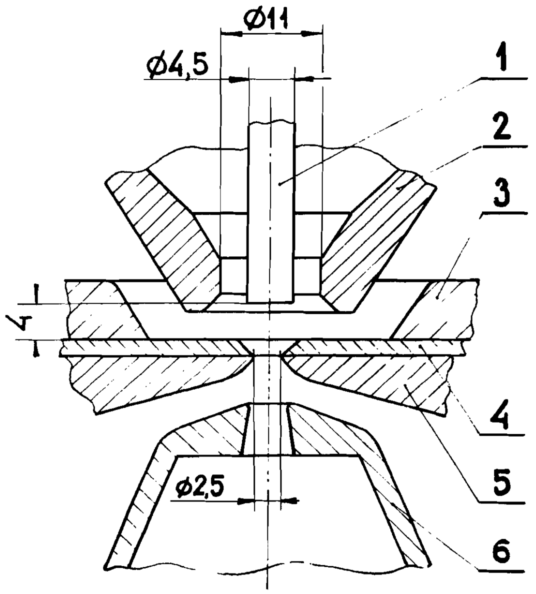

Fig. 1. The region of formation of hollow tubular discharge and extraction of negative ions: 1) tantalum rod; 2) intermediate electrode (steel); 3) copper anode; 4) tantalum anode insert; 5) magnetic circuit (steel); and 6) extracting electrode (stainless steel).

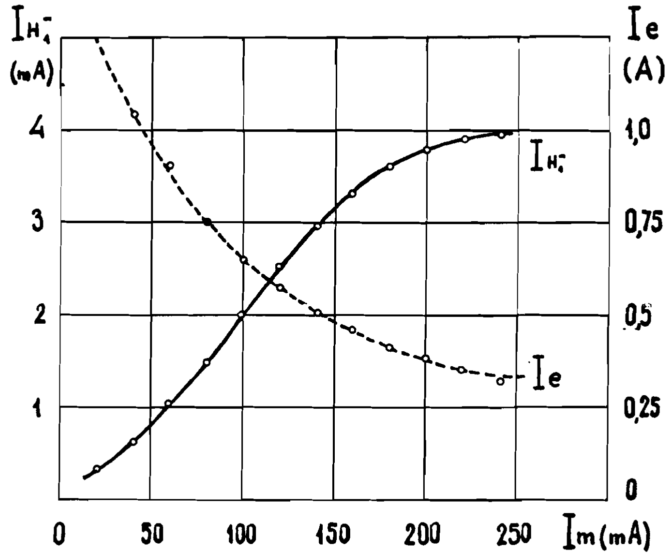

Fig. 2. H_1 beam current and electron load current vs magnetic coil current of the source.

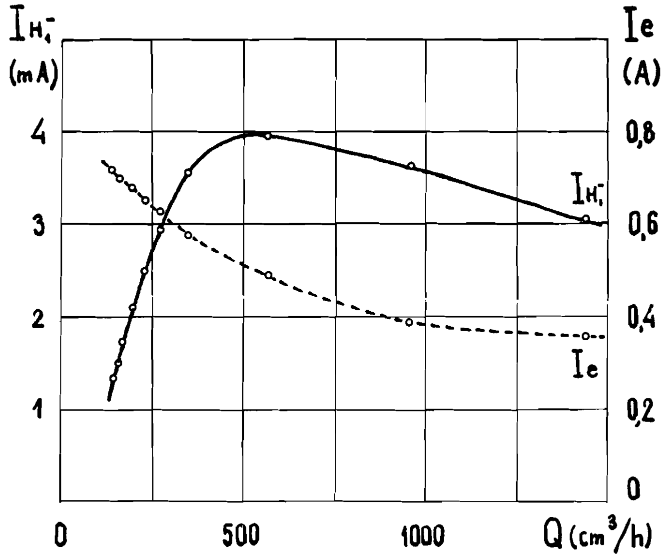

Fig. 3. H_1^- beam current and electron load current vs the flow of H_2 into the source.

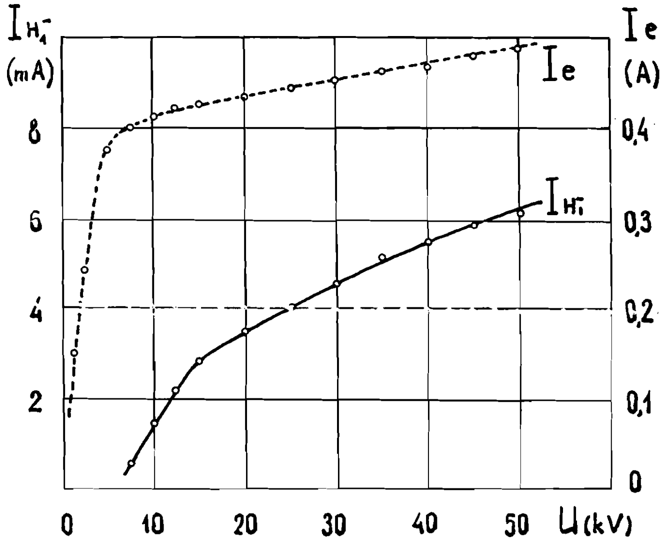

Fig. 4. H_1 beam current and electron load current vs extraction voltage.