EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-ISR-GE/82-20
Closed distribution

NOZZLES WITH VERY SMALL THROAT FOR HYDROGEN GAS JETS

by

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Abstract

The design and manufacture of nozzles with throat diameters of 24 micron and 12 micron which have been developed at CERN for hydrogen gas jets are presented.

(submitted to "Nuclear Instruments and Methods")

Geneva, December, 1982

For the last two years the fundamental research programme in particle physics at CERN has been enriched by the exploitation of an intense antiproton source.

One particular experiment in the ISR (Intersecting Storage Rings) studying charmonium spectroscopy (1) uses an original arrangement whereby a jet of clustered hydrogen molecules is passed perpendicularly through a 4 GeV/c beam of antiprotons circulating in one of the rings. Detectors situated around the collision point monitor the particles which originate from the collision of antiprotons with protons of hydrogen nuclei.

The hydrogen gas target was a joint project of Genova University, Istituto Nazionale Fisica Nucleare and CERN. The Engineering Group of ISR division was in charge to manufacture the nozzles used to form the hydrogen molecules jet. The nozzle plays an important role in the experiment. The hole size and the shape of the nozzle, together with the inlet gas pressure constitutes the main parameter for the creation of the high density jet. The nozzle is located inside a vacuum system (fig. 1) operating at 10^{-3} torr. Other parts of the system operate at much lower pressures. Thus a bake-out at 200°C is required.

The hydrogen gas at 10 atmosphere is pre-cooled to liquid nitrogen temperature before being ejected through the nozzle into the vacuum where the gas expansion results in the formation of clusters (2). To achieve this, the nozzle must have the theoretical form of a frustum of a 7° cone having a base of about 30 microns followed by a partial toroïdal section with 60 mm radius (fig. 2). The fabrication of precise miniature profiles and of orifices of a few tens of microns, while not common industrial practice, is however quite feasible (3) even though the combination of these two requirements does give rise to difficulties which limit manufacture.

There are various ways to overcome this problem but available techniques and the type of development work which could be carried out had to be born in mind. The basic idea was to electrolytically deposit copper onto a needle. Removal of this needle left a divergent blind hole which formed the nozzle outlet. The entry and the 24 microns orifice were machined simultaneously from the other end of the piece.

The following sequence of operations (3) sums up the technical procedures :

- Fabrication of a needle having the male form of the divergent region of the nozzle. This needle of aluminium alloy was made by copy turning and polishing (N4) the toroïdal form. The conical portion was then ground down to give a point having a diameter of less than 15 microns. A circular reference groove was then machined near the base of the needle, to allow the theoretical position of the point to be known.

- An electrolytic coating of a few microns of tin was then applied to the needle to ease the future extraction. Sufficient copper was next electrolytically deposited on to enable a cylinder of 4 mm diameter to be machined. The needle was extracted mechanically at room temperature leaving the complete divergent region of the nozzle. Chemical cleaning is sometimes needed to remove any remaining particles of the needle which may stick to the nozzle.

- The convergent region of the nozzle was made at the same time as the orifice by spark-etching with a conical tool. Advancing the tool by 10 microns enlarged the orifice by about 1 micron.

Nozzles with the following nominal throat diameters were made :
32 micron, 24 micron and 12 micron (fig. 3a and fig. 3b). The ovality of the respective throat varied as follows: 29 and 32 micron, 22 and 24 micron, 11 and 13 micron.
The 24 micron nozzle which corresponds to the basic conception of the experiment has been used during a first test run in October 1982. A dense jet of hydrogen with $2{,}3.10^{20}$ molecules s^{-1} was obtained giving an equivalent pressure of 8.10^{-4} torr.

<u>References</u>

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(2) W. Obert, Properties of cluster beam formed with supersonic nozzles, submitted to rarefied Gas Dynamics Symposium, Cannes, France 1978.

(3) LECHLER GmbH & Co., D-7012-Fellbach.

(4) A. Boulmier, N. Mezin, J-C. Brunet, Fabrication de buses.

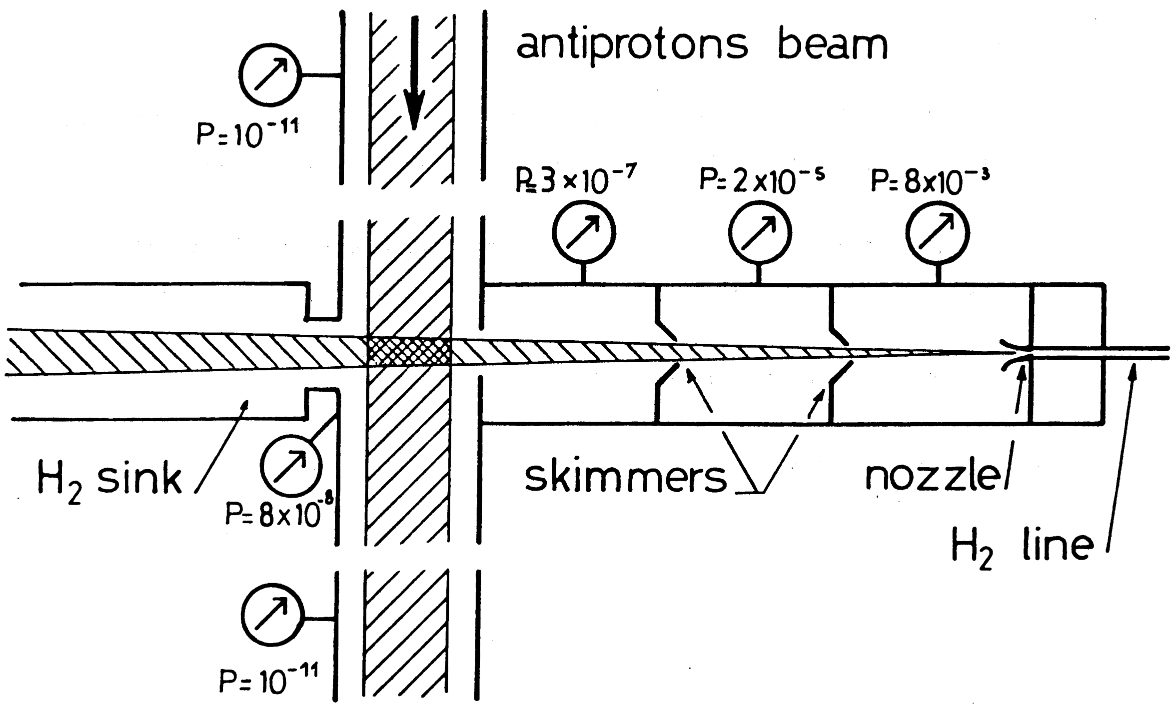

Fig.1 General layout of the H_2 target

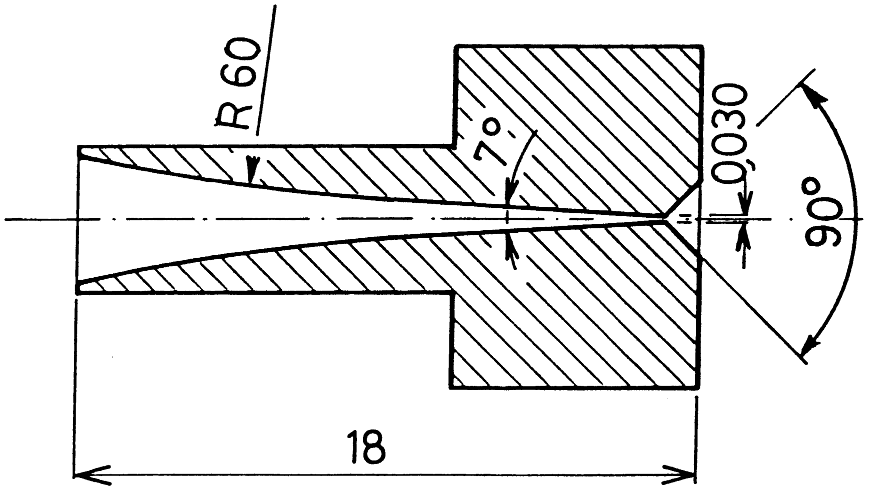

Fig. 2 Nozzle

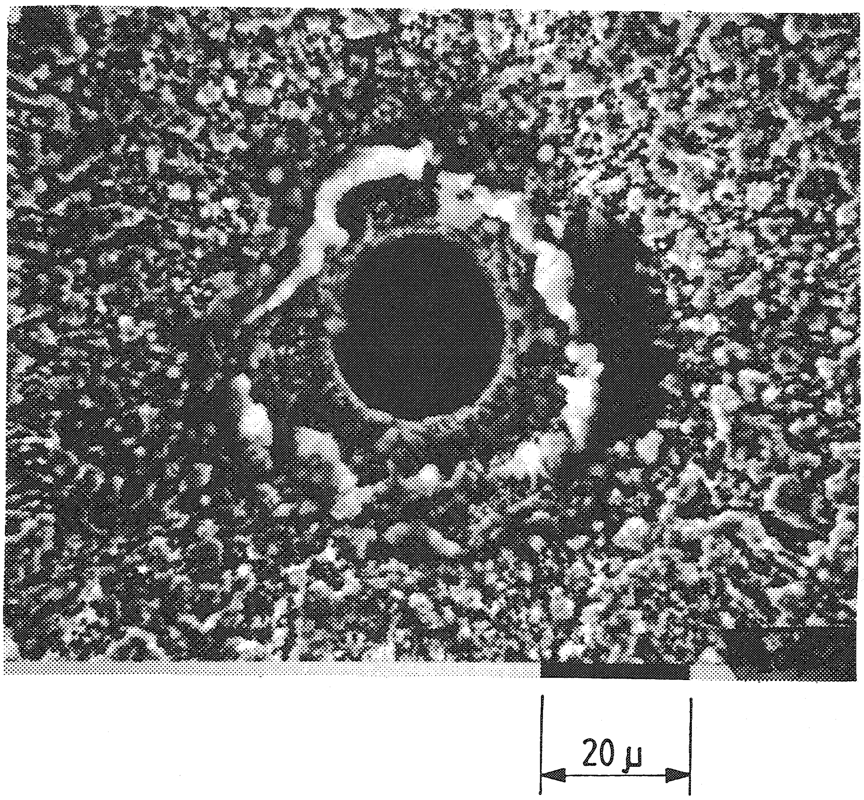

Fig. 3a Nozzle Ø 24 μ

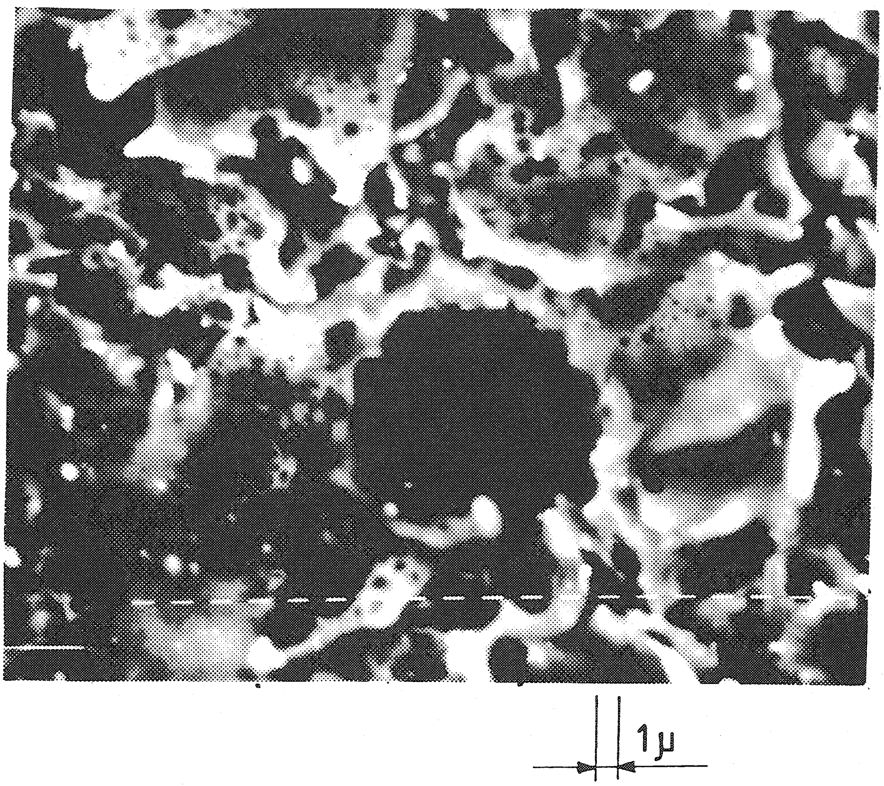

Fig. 3b Nozzle Ø 12 μ