LABORATOIRE NATIONAL SATURNE

91191 Gif-sur-Yvette Cedex France

LIQUID HYDROGEN TARGET FOR THE DISTO COLLABORATION

P. CHESNY, J.M. GHELLER, G. GUILLIER
Laboratoire National Saturne
DSM-CEA & IN2P3-CNRS
CE Saclay, 91191 Gif-sur-Yvette Cedex, France

Soumis pour publication : NIM-A

LNS/SSGD/93-73

Centre National de la Recherche Scientifique

Commissariat à l'Energie Atomique

LIQUID HYDROGEN TARGET FOR THE DISTO COLLABORATION

P. CHESNY, J.M. GHELLER, G. GUILLIER
Laboratoire National Saturne
DSM-CEA & IN2P3-CNRS
CE Saclay, 91191 Gif-sur-Yvette Cedex, France

Foreword

The DISTO collaboration program (Dubna, Indiana, Saclay, TOrino) is focused on strangeness production Λ and Σ hyperons.

At Saturne, we have a polarised proton beam whose exceptional quality has enabled us, for the first time, to undertake a methodical study which takes into account all the possible sources of Λ and Σ hyperons polarisation.

The reaction which has been studied is the associated production : $pp \rightarrow p K^+ Y$ (Λ or Σ)

For that matter we have a big acceptance magnet in the centre of which a liquid hydrogen target (∅ 20 mm., 20 mm. long) is housed (Fig.1).

Target description

One way of reducing the liquid hydrogen volume is to use an AIR PRODUCTS cryogenerator for the gas liquefaction.The cryogenerator is composed of a 208 L cold head and an HC8 compressor. This set-up has a cooling power near 10 Watts at 20K.

On account of its size, the liquefactor is settled out of the spectrometer gap. The motor unit of the cold head takes place far from the mid plane to avoid zones where the fringe field is too important (the maximum B tolerated by the cold head is 0.1 T)

Then a "thermosiphon" supplies the target through a 1.2 metre transfer line. The condenser is placed 30 cm above the mid plane and a 2 mbar hydrostatic pressure can be reached thanks to the liquid column (Fig.2).

The outer enclosure of the vacuum chamber is an hemispherical shaped, 1 cm thick wall made of Klegecell, that is a cellular structure of polyvinyl chloride whose density is 0.075.Its component has been chosen in order to reduce the background and its geometry compels the created particles to go through the same material quantity, whatever their emission angle could be.The sphere dimension is significant compared with the target's one to distinguish particles created on the target from others in recombining trajectories.

Crash tests have clearly stated that such an enclosure can endure a 3 bar differential pressure and allows a 10^{-6} torr vacuum to be reached.

The liquid hydrogen enclosure is a Mylar wall which was thermoformed at 160°C by mechanical stamping. Series of tests have proved that deep stamping technology (length > diameter) works properly. Thanks to a 120 µm mylar sheet, the final thickness is 100 µm homogeneous on the useful part.

The target shape takes the appearance of a glove finger , so all analysis angles are freed.

In case of dysfunction on the entrance window (50 µm mylar) or on the external enclosure, the target is divided into two parts so it can be easily taken down. On the first part, there are a filling and a return gas tube and the entrance window, the second one is the mylar enclosure. When the two parts are assembled, the tightness is secured by a "spring" joint (Helicoflex model) coated with aluminium.

The target is tightly kept in the centre of a metallic frame by a nylon thread : this leads to reduce the thermal conduction losses about 30 mWatts (Fig. 3).

The gas tubes are connected to the transfer line by the mean of two Kenol connectors. An aluminium cupel keeps the system in a cold-tight state.

The primary beam is led across a tube through a 10^{-1} torr vacuum to avoid any air influence on it. This beam pipe is made of carbon fibres impregnated with epoxy resin and covered by an air-tight film. The tube axis has been designed on the beam trajectory in the magnetic field. Its 1 mm thickness has been chosen to bear vacuum stresses and to reduce the interaction effects when created particles have a trajectory which meet the beam pipe.

Cryogenic tests report

Three silicium diodes have been placed on the target, on the condenser and on the thermal shield.

A temperature regulation has been made by a chromium, gold and iron thermocouple with a 25 Watts heater both mounted on the 2^{nd} stage of the cold head.

The temperature on the shield and on the condenser had been decreased for 2 hours. The shield reached stability about 40 K. Then the target took 6 hours to reach 20 K thanks to the exchanging gas put in the system (Fig.4).

So a 60 litres volume of STP gas had been liquefied in 20 minutes. Globally speaking, the liquefying power P_L taken at the 2^{nd} stage of the cryogenerator can be described as following :

$$P_L = \dot{m} \left(\Delta H_{20}^{40} + Lv \right)$$

$$\dot{m} \text{ (massic flow)} = \frac{60 \times 0,085}{20 \times 60} = 4,25.\ 10^{-3}\ g.s^{-1}$$

$\Delta H_{20}^{40} = 220\ J.g^{-1}$ (enthalpy shift between 20 and 40 K at 1 atm)

$Lv = 450\ J.g^{-1}$ (heat of vaporization)

$P_L = 3$ Watts

The liquefaction had been carried out near 19 K with a heating regulation power of 2.5 Watts. On the same diagram, (fig.5) we reported the heating power values which are necessary to regulate the bath temperature between 14 and 20 K as well as the cooling power values, given by the 208L designer APD, which are available at the 2^{nd} stage.
The curves are approximately parallel and the shift between them represents an estimation of thermal leaks which is about 4 Watts.

For the whole liquefaction time, we could verify that the cooling power which was 9.5 Watts at 19 K could be identified as the sum of the 3 following elements :

$P_h + P_T + P_L$

$P_h = 2,5$ Watts (regulated heating power)

$P_T = 4$ Watts (thermal leaks)

$P_L = 3$ Watts (liquefaction power)

To get a background valuation, the target has to be completely drained off. Such a test had been carried out for 3 hours.

A 38 Ω heater was put around the target. The compressor was switched off and a 6 Watts heating power was brought, so the target evaporation took no more than one minute. When the entire volume of gas had gone back to the tank, we isolated it and we drove away the cold vapour from the target by means of a primary pump.

Then the compressor was switched on and the target temperature rose up to 137 K three hours after.

So that the target be filled again, we quickly liquefied the gas on the condenser, which had been stabilised at 20 K. The target temperature quickly dropped to the condenser one in 45 minutes : in order to do that, we used the gas enthalpic reserve as well as the evaporation heat of the liquid.

These tests allowed us to define positively all the thermodynamic characteristics and to prove the reliability of this system. Consequently the physicians could see liquid hydrogen through a porthole !

ACKNOWLEDGEMENTS

We express our gratitude to S. BUHLER for the indications given about KLEGECELL, to J.L. PEYRAT and R. GAUBERT. for many helpful discussions about stamping techniques. Special thanks to P. PARISET for his work as a designer and M. FONTAINE for his contribution to this paper

FIGURES

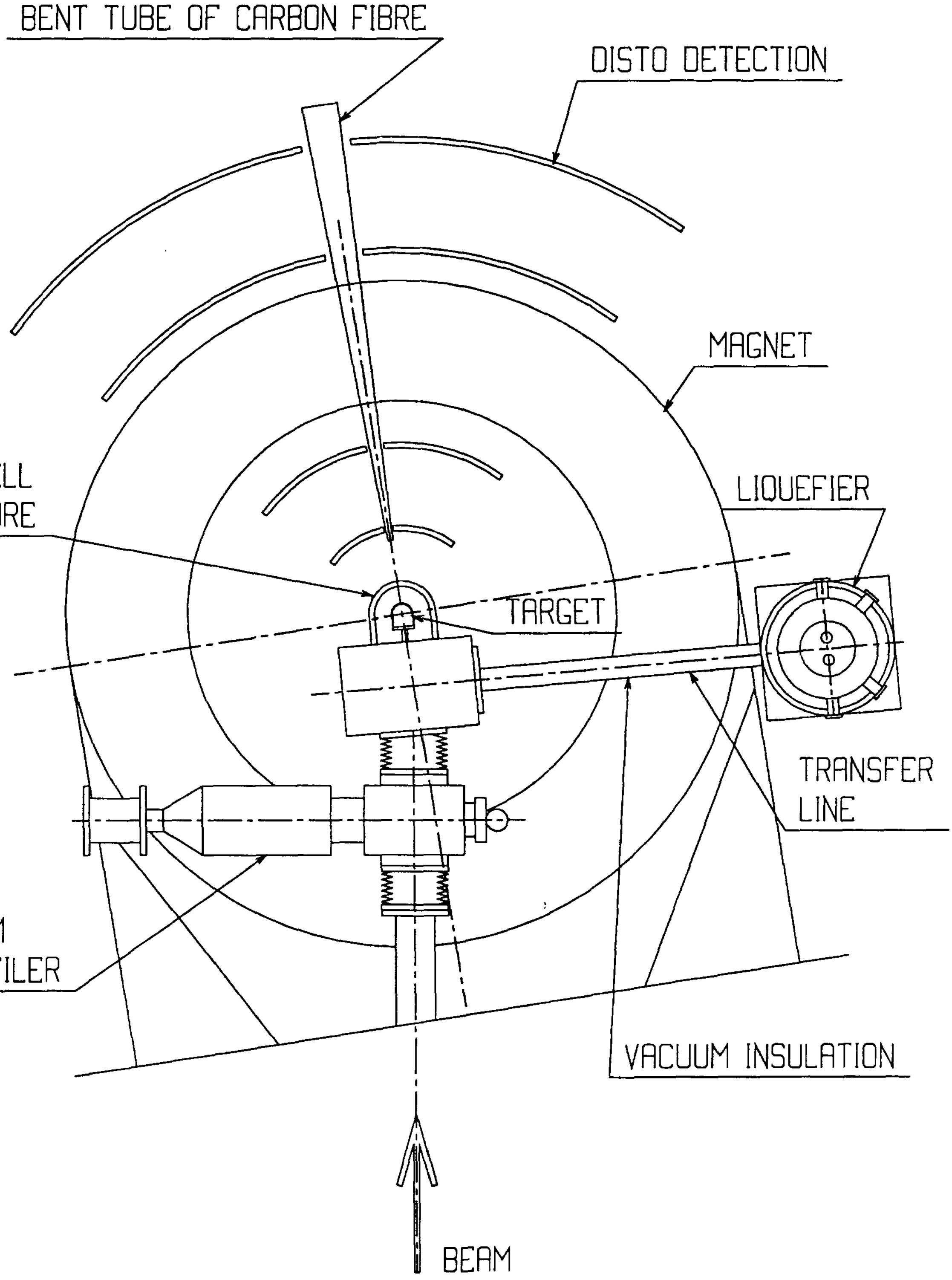

BENT TUBE OF CARBON FIBRE
DISTO DETECTION
MAGNET
KLEGECELL
ENCLOSURE
LIQUEFIER
TARGET
TRANSFER
LINE
BEAM
PROFILER
VACUUM INSULATION
BEAM

FIGURE 1

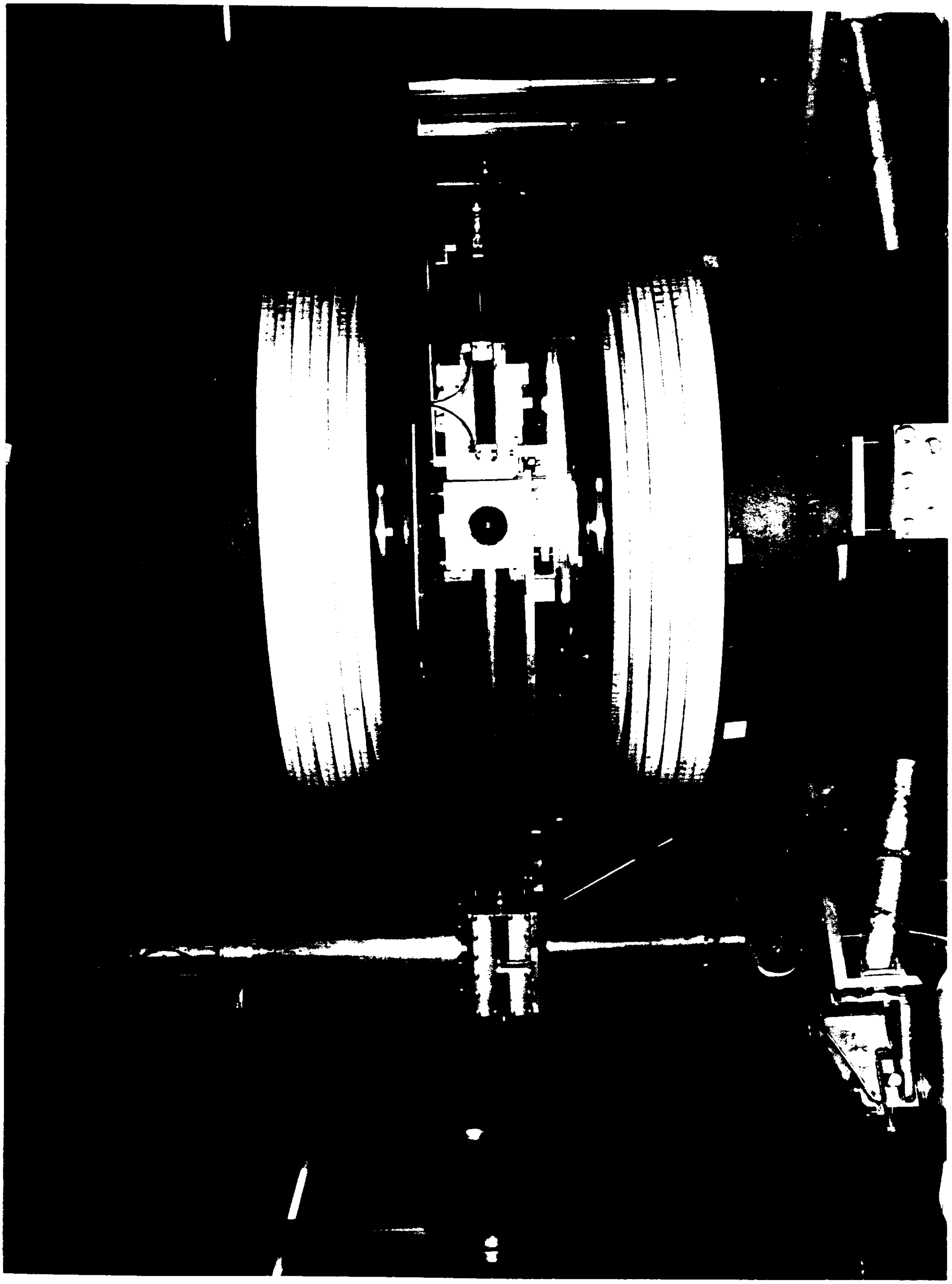


FIGURE 2

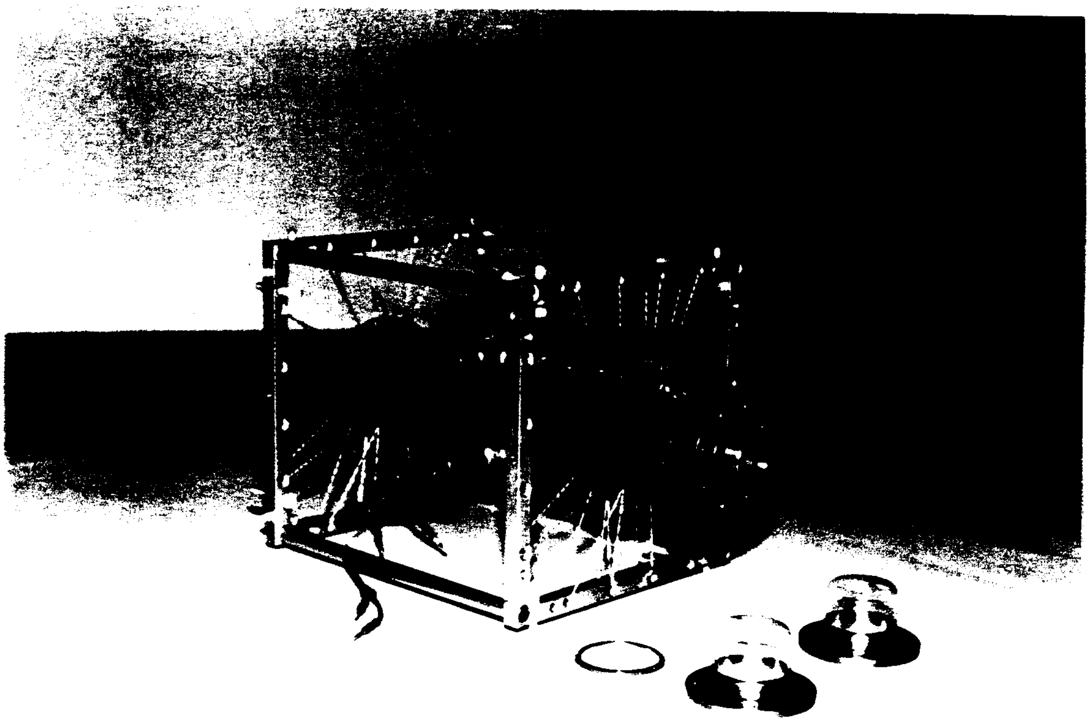
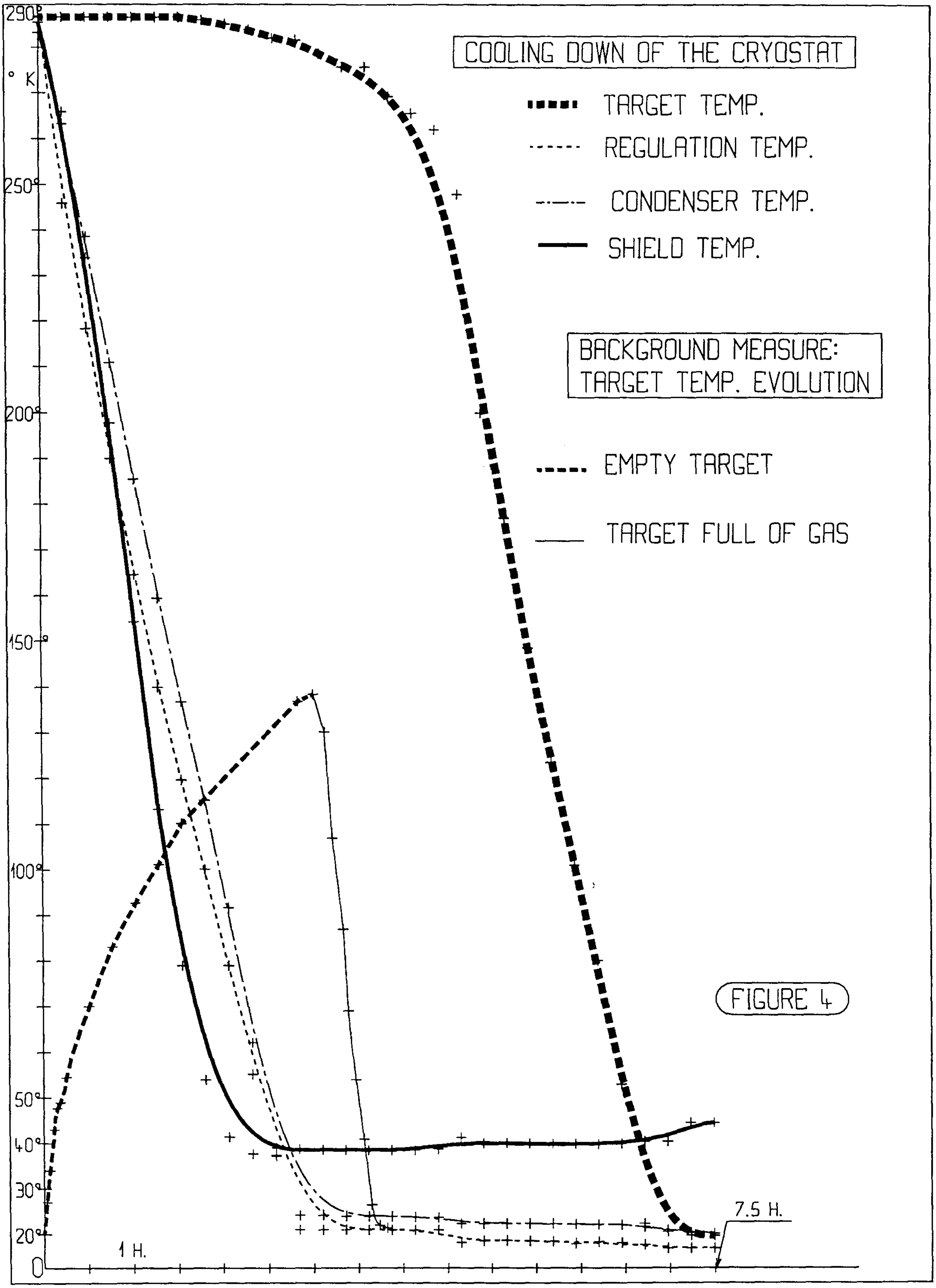
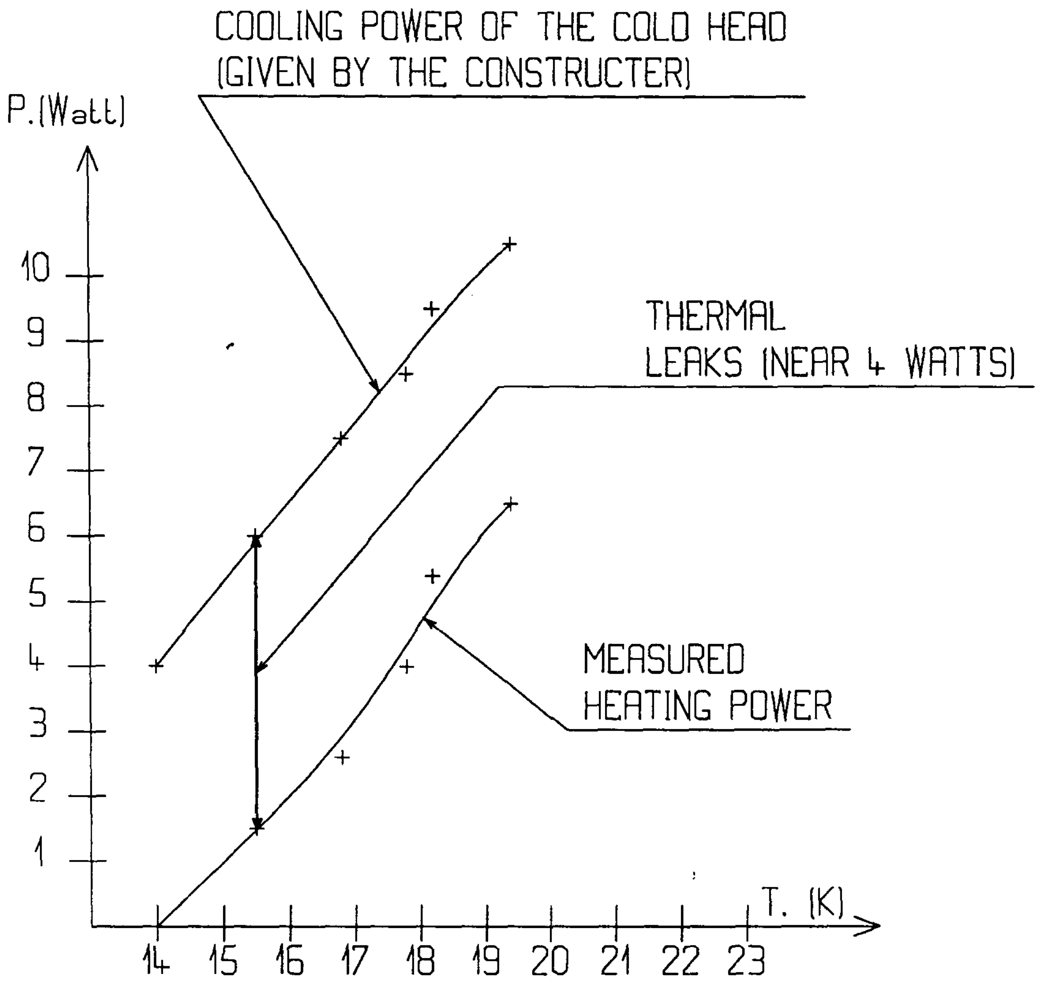


FIGURE 3



COOLING DOWN OF THE CRYOSTAT
TARGET TEMP.
REGULATION TEMP.
CONDENSER TEMP.
SHIELD TEMP.
BACKGROUND MEASURE:
TARGET TEMP. EVOLUTION
EMPTY TARGET
TARGET FULL OF GAS
290°
° K
250°
200°
150°
100°
50°
40°
30°
20°
0
1 H.
7.5 H.

FIGURE 4



COOLING POWER OF THE COLD HEAD (GIVEN BY THE CONSTRUCTER)
P.(Watt)
10
9
8
7
6
5
4
3
2
1
THERMAL LEAKS (NEAR 4 WATTS)
MEASURED HEATING POWER
T. (K)
14
15
16
17
18
19
20
21
22
23

FIGURE 5