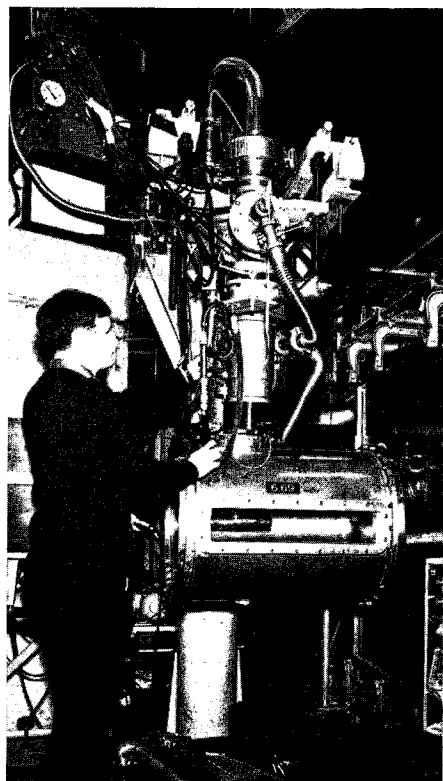


The new type of hydrogen target, which will be used in the CERN/Serpukhov experiment, photographed in the actual experimental conditions during tests at CERN in February. Inside the vacuum tank (the horizontal cylinder in the foreground) a small black horizontal cylinder filled with liquid hydrogen forming the target proper may be seen through the Mylar window. The liquefier is visible at the top left of the photograph, standing on a concrete block.



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Hydrogen target

Liquid hydrogen targets are used in many experiments carried out with particle accelerators, taking advantage of the simplicity of the hydrogen nucleus of a single proton. An experiment then looks at the collision of an incident particle (an accelerated proton or a secondary particle such as a pion or a kaon) with a proton in the target. If the target nucleus was complex (consisting of several protons and neutrons), the effects of the very strong binding force between the protons and neutrons would make it much more difficult to study the interaction between the incident particle and a particle in the nucleus.

Liquid hydrogen (providing a much denser concentration of the target nuclei than gaseous hydrogen) is usually contained in a small cylindrical flask located horizontally in the path of the beam. Hydrogen becomes liquid, at normal pressure, at a temperature of 20.4°K . In spite of the heat insulation provided around the target system, some hydrogen will

gradually evaporate away, and the liquid hydrogen in the target has periodically to be replenished. Large dewars of hydrogen are thus generally to be found alongside a target, connected to the target by pipes.

A mixture of hydrogen and air is inflammable (explosive) and the hydrogen system has to be treated with great care especially during changing from a dewar to another containing about 200 litres of liquid. Any escaping gas is encouraged to find its way out into the open air. In addition to the explosion hazard, escaping hydrogen represents a considerable financial loss.

In order to simplify the safety problems, hydrogen targets have been developed in which the hydrogen is in a closed circuit — when it changes to the gaseous state it is recondensed in a heat exchanger from which the excess heat is removed by a circuit containing helium, which is not explosive. This does mean, however, that the hydrogen loss is replaced by a leakage of helium (even more expensive than hydrogen) and, even if the problems of safety are thereby simplified, there is still the inconvenience of the periodic change-over of dewars. The ideal solution, therefore, is to find some way of becoming totally independent of any need for replenishment from outside.

These problems have been solved in a new target design which is, for example, being used for the target of the new CERN/Serpukhov experiment to be carried out on the Serpukhov 76 GeV accelerator. It contains only a litre of hydrogen and is very simple to operate.

The target (constructed at CERN under the responsibility of the group of L. Mazzone) consists of two sections — the target proper surrounded by a vacuum tank with very thin Mylar windows (0.12 mm) to allow particles to pass through the front and sides with very low probability of scattering; a liquefier, similar to that of a refrigerator, which uses helium as the medium fluid and is designed to recondense the gaseous hydrogen leaving the target. The two sections are interconnected by vacuum-insulated pipes through which the hydrogen is circulated by gravity. The vacuum providing

the insulation for the liquefier and for the target and connecting pipes is produced by an oil diffusion pump generating about 10^{-6} torr. Both the helium and hydrogen circuits are closed systems and neither needs regular replenishment.

The experimental physicists are very satisfied with the performance of this new type of target. It has proved so reliable as to become part of the equipment they can forget about.

Computer takes over

On 29 January, a rather unusual test was made during one of the machine development periods on the CERN proton synchrotron.

All the dipolar corrections guiding the beam in the horizontal plane were switched off and it was then impossible to accelerate the beam to full energy. The beam would make only thirty revolutions in the machine (lasting about $200\text{ }\mu\text{s}$). The IBM 1800 machine control computer was then asked (politely and in a language it understands) to bring the beam back on. After successive optimization procedures, the computer succeeded in accelerating a beam with an intensity of 96×10^{10} protons per pulse. The intensity before beginning the tests had been about 80×10^{10} protons per pulse.

The program used optimizes the beam intensity at one point in the machine cycle by altering parameters which define the horizontal injection trajectory (involving 28 dipolar windings and 3 electrostatic deflectors).

The test was part of the research programme of the controls group concerning the use of on-line computers in accelerator control. Though the experiment does not foreshadow computer controlled operation in the near future, it does show how the use of computers can help in accelerator control. Similar work is being done in several other Laboratories (see CERN COURIER vol. 9, pages 166 and 381) but this is believed to be the first time that the intensity of an accelerator in use for physics has been optimized by computer.