Rutherford Laboratory

Technical Leaflet

A8

NIMROD TARGET MECHANISMS AND THE PROTON EXTRACTION SYSTEM

1. Target Mechanisms

It is necessary to have apparatus in the synchrotron in order that the accelerated protons may be used for nuclear physics experiments.

A small piece of solid material is raised so that the beam strikes it. When the accelerated protons pass through matter they are liable to undergo interactions resulting in the production of "secondary particles". These may be any of the fundamental particles which the protons are energetic enough to produce. Those which are travelling at a favourable angle come out of the synchrotron down a beam pipe to be focused on the experimental apparatus.

The "mechanisms" which bring the target into position must meet strict specifications. They are located in the field of the main magnet and must therefore be made of non-magnetic materials. Their construction must not allow large eddy currents to develop. Since the inner vacuum vessel is thin walled the target support positions must be widely separated. Furthermore serious vibrations must not be allowed to occur even when the target is raised in as little as one tenth of a second.

The target is mounted on the end of a small arm which can be rotated through a right angle. The actuating mechanism is a hydraulic cylinder which is coupled to a shaft by a sliding linkage which minimises shock vibration. This hydraulic cylinder is driven by a pump through a solenoid valve, which in turn is operated by electronic circuits in the main control room so that the whole device can be precisely synchronised to the accelerator cycle.

The actuating device is located outside the vacuum vessel and the main shaft passes through a special seal into the high vacuum. These seals are extremely reliable and under test have performed millions of operations without fail representing months of normal use.

2. Proton Extraction System

For some experimental purposes it may be better to bring the accelerated protons out of the machine and place the target nearer the experimental apparatus. The proton extraction system is designed to achieve this. It consists of a target and two magnets which are located inside the straight sections of the synchrotron. The target is a small piece of beryllium on a mechanism similar to the ones used for other targets.

When the beam strikes the target most of the protons pass right through it, only a fraction having nuclear interactions. The protons emerging have been slowed down very slightly and therefore take a different path travelling rather closer to the centre of the synchrotron. About halfway round the ring they pass through the aperture of a small magnet which focuses them into the gap of another magnet one quarter of a revolution further on. The field in this magnet is in the opposite direction to the field in the main magnet and consequently deflects the protons outwards so that they ultimately emerge from the synchrotron.

A group of four quadruple magnets focuses the proton beam on to a target in the experimental area.

The magnets in the straight sections, when in their working position, occupy part of the aperture which is used during acceleration so that they must be moved in and out during each magnet cycle. This requires hydraulic mechanisms of 350 h.p. designed to push the magnets weighing up to one ton a distance of 20 inches in one quarter of a second. The hydraulic system consists of a large ram driven by a swash-plate pump which is controlled by a secondary hydraulic system using an electromechanical valve. The electrical signals applied to this control the acceleration, velocity and position of the magnet to close limits.

The positions of the magnets are measured by means of a Moire fringe grating and at two hundred intervals during the movement their positions are compared with the predetermined ones. Any difference results in an error signal which is applied to the controlling valve to correct the position.

The rapidly moving magnet could do great damage if it was not stopped at the correct point, hence a number of safeguards are used. If at any time the error exceeds acceptable limits the magnet is brought to rest. If the mechanism should fail completely the magnet will be arrested safely by a clutch which slips when a predetermined overload force is reached.

The magnets used take very large currents up to 200 amps. and are water cooled. The flexible connections and hoses are supported by a spring steel arch which carries the current and water from the supplies to the plunging shaft. This shaft 5" in diameter has to pass through the wall of the vacuum vessel and a high vacuum seal is therefore necessary which will allow the shaft to move without affecting the vacuum.