Rutherford Laboratory

Technical Leaflet

NIMROD VACUUM SYSTEM

The NIMROD vacuum system is complex and the vacuum vessel is perhaps the largest ever made in epoxy resin and glass fibre laminate.

Figure 1 shows a cross section through a typical magnet assembly. The vessel is double walled within the magnet gap. The outer vessel is thin ($\frac{1}{8}$") since it is supported by the pole tips which are jacked apart at the back of the magnet throat and bolted through vacuum seals to the magnet coil brackets at the front. The pole face windings, which are clamped to the inner faces of the pole tips consist of water cooled copper conductors laminated in epoxy resin and fibreglass and together with steel laminated pole tips represent very gassy surfaces. These are enclosed between the outer and inner vessels and the space is pumped by mechanical pumps to a pressure of less than 1 torr.

The inner vessel being required to support only its own weight can also be relatively thin ($\frac{1}{4}$") and thus the minimum of magnet gap is consumed by the thickness of the vacuum vessels. The header vessel on the other hand withstands full atmospheric pressure and is up to 2" thick.

A special seal made of PVC/Nitrile rubber joins all three vessels together. To improve the vacuum properties of the epoxy laminate and prevent accumulation of electrostatic charges the high vacuum surfaces of the inner and header are covered with 4" wide strips of stainless steel foil 0.002" thick bonded in position with small gaps between adjacent strips.

The vacuum vessels were made in 50 foot (approx.) lengths and subtend 45° on a 60 ft. inner radius so that eight sections form the complete torus. The cross sectional area of each vessel is approximately 3'6" x 1 ft.

To achieve accuracy in dimension the vessels were manufactured using matched moulding tools after a considerable development programme. Many resin formulations were examined for vacuum properties and irradiation resistance before a final choice was made. Early test laminates displayed leakage properties which led to the discovery of hollow fibres in the glass cloth. Techniques were evolved to prevent ends of fibres from being exposed and for sealing drilled holes wherever possible with thin brass sleeves or at least a coating of epoxy varnish.

All vessels had to be vacuum tested before installation to avoid difficulties of testing and repair due to inaccessibility. This required the design and construction of special rigs and internal supports. Test and repair techniques were developed on a prototype vessel and led to the improvement of manufacturing techniques on subsequent vessels.

Outer vessel leak rates were better than 5×10^{-3} torr litres/sec. and header and inner vessel better than 5×10^{-4} torr litres/sec.

Outer vessels were again tested after installation in the octant when the vacuum seals on the pole tip holding bolts and pole face winding conductors were proved (about 500 seals per octant).

Four octants are provided with header vessels to facilitate beam extraction and the others are fitted with $1\frac{1}{4}$" thick polythene closing plates. Final tests gave leak rates less than 3×10^{-3} torr litres/sec. for each octant.

On pump down the inner and header vessels are connected to the outer vessels by equalising valves and the whole pumped to 1 torr by 16 rotating vane pumps each of 60 litres/sec. capacity. The equalising valves then close, the outer vessels continuing to be pumped as before but the inner vessels being opened to 8 roots-rotary combinations of 100 litres/sec. each. These pumps operate to about 0.02 torr when the high vacuum pumps are used.

Each pumping unit consists of a 24 inch fractionating oil diffusion pump backed by a vapour booster and 150 litre per min rotary pump and is provided with a sliding gate valve and chevron baffle cooled to -25°C to limit back-streaming. 5 units are fitted to each octant and each has a speed of not less that 3000 litres per sec at 10^{-6} torr which is the maximum operating pressure of the synchrotron. The lowest pressure recorded has been about 3×10^{-7} torr.

As additional experimental equipment is being fitted in straight section boxes, further 12" oil pumping units are provided to reduce the pump down time.

Pairs of octants or alternate straight boxes can be isolated from the rest of the system using special shut off valves.

With the type of construction described precautions against damage must be incorporated in the control system. The inner vessel will be damaged if the pressure differential exceeds 8 torr from outside or 30 torr from inside especially after irradiation begins to reduce the strength of the laminate. Pressure switches operating at 1 torr controlling the equalising valves are the first line of defence but should these fail or a sudden pressure rise occur a mechanical device, operated directly by the pressure difference cuts a copper diaphragm and interconnects outer and inner vessels. All pumping units are designed to be self protecting in the event of a fault or pressure rise above preset valves.

One type of pressure switch was developed at this Laboratory. It uses thermistors and can be set for pressures between 10^{-2} and 5 torr, using two types of head with a common D.C. amplifier. A simple modification allows its use as a differential switch, with different operating levels for rising and falling pressure.

Overall control of the vacuum system is allowed from a marshalling kiosk with display panel in the magnet hall and from the main control room where individual pumping units can be started or stopped as required. A mimic diagram shows the state of the system both as regards units operating and pressure switches made.

Pressure measurement is by Bayard-Alpert ionisation gauge with remote ON/OFF facilities and logarithmic output to strip chart recorders.

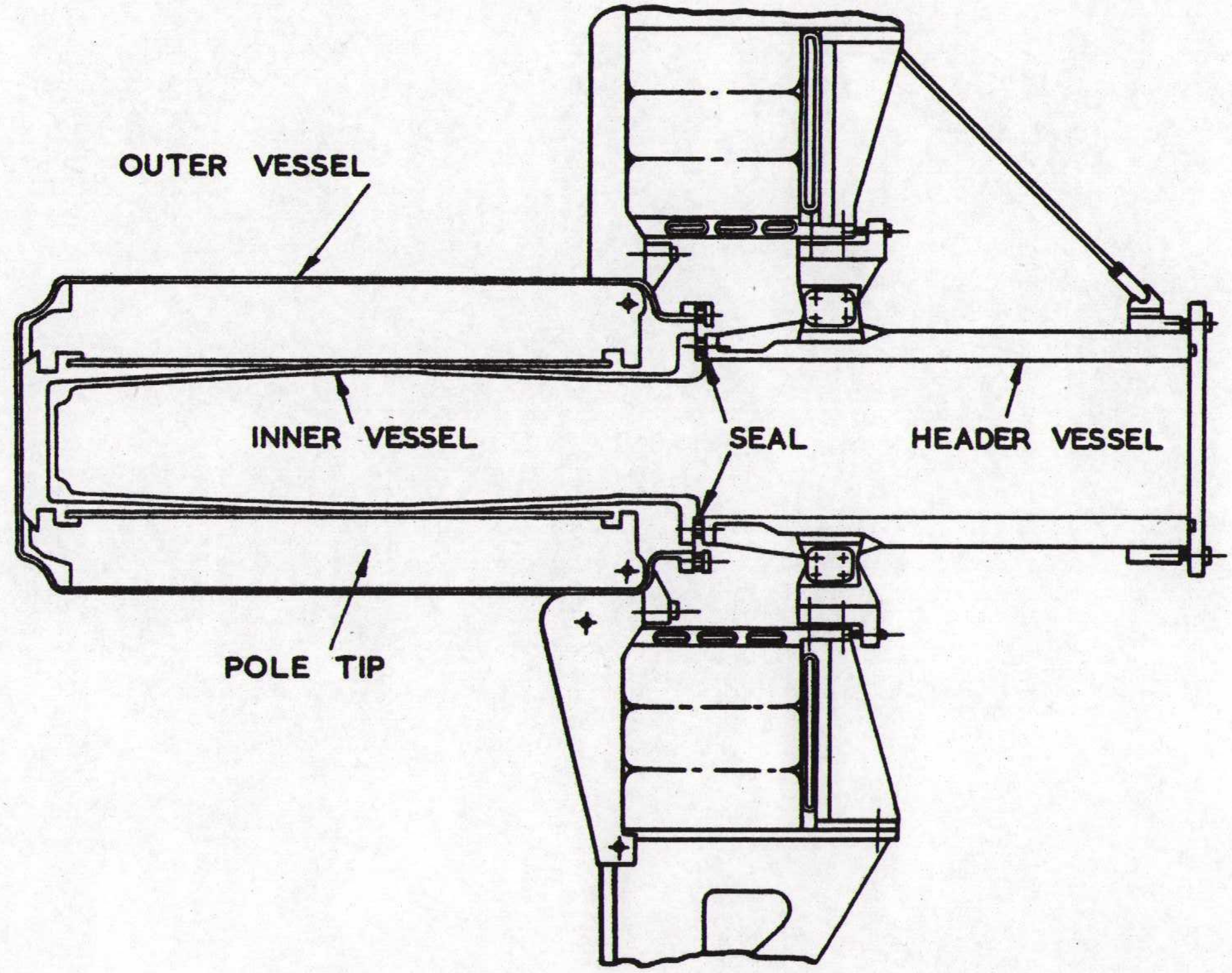

FIGURE 1