Rutherford Laboratory

Technical Leaflet

A3

NIMROD INJECTOR

THE LINEAR ACCELERATOR, BUNCHER AND DEBUNCHER

The main component of the Nimrod Injector is the proton linear accelerator, which increases the energy of the protons leaving the Preinjector at 600 KeV to an energy of 15 MeV. At 15 MeV the protons have a velocity of about 1/6th the velocity of light. The linear accelerator ('linac') consists essentially of a copper cylinder with closed ends, 44 ft. long and 5 ft. 7 in. in diameter, made from $\frac{1}{8}$ in. thick sheet. Spaced along the axis of the cylinder are 48 'drift-tubes', each suspended on two support stems, and it is through the axial bores of these drift tubes that the protons are accelerated.

Within the copper cylinder, which is a resonant cavity, powerful radio-frequency electromagnetic fields, alternating at a frequency of 115 Mc/s, are excited. When the protons cross the gaps between adjacent drift-tubes they experience an accelerating force from the electric field and when they are shielded by the drift tubes, the field is in the direction which would cause deceleration.

The radio-frequency power required to excite the electromagnetic fields is provided by a large transmitter valve. Such is the magnitude of the power required, in excess of 1 MW, that it is only possible to operate the valve in short pulses of about 1/500th sec. Fortunately the synchrotron requires only a very short burst of 15 MeV protons, once every two seconds, and sufficient power is available to provide this.

To prevent the protons being slowed down and scattered from their path by air molecules, the linac is housed in a thick walled steel vacuum tank. This tank is maintained at a very low pressure, about 10^{-6} torr, by continuous pumping. Also the proton beam tends to be dispersed by the same electric fields that give them their acceleration. A quadrupole magnet is therefore placed inside each of the 48 drift-tubes and they focus the beam, preventing the protons from straying more than half an inch or so from the axis. These magnets consume a continuous electrical power of about 70 kW.

Buncher

A smaller copper cavity, situated a short distance in front of the linac, is called a 'buncher'. This is also excited with radio-frequency power and serves to form the proton beam into bunches, as it passes through the cavity. The bunches are arranged so that they arrive at the linac during that part of the radio-frequency oscillation when acceleration is possible. Without this device a large fraction of the protons would arrive at the linac at the wrong time and would not be accelerated.

Debuncher

Another resonant cavity, misnamed a 'debuncher', is situated between the linac and the synchrotron. The function of the debuncher is to reduce the spread in energy of the protons leaving the linac. Protons leave the linac with an energy spread of about 2% which is greater than is acceptable to the synchrotron. In each bunch of protons leaving the linac the more energetic ones reach the debuncher first. The electric field in the debuncher is then arranged to decelerate these early protons and to accelerate the late ones, the nett effect being that they all leave the debuncher with very nearly the same energy. The combined effect of the buncher and debuncher is to increase the number of useful protons arriving at the synchrotron by a factor of nearly ten.

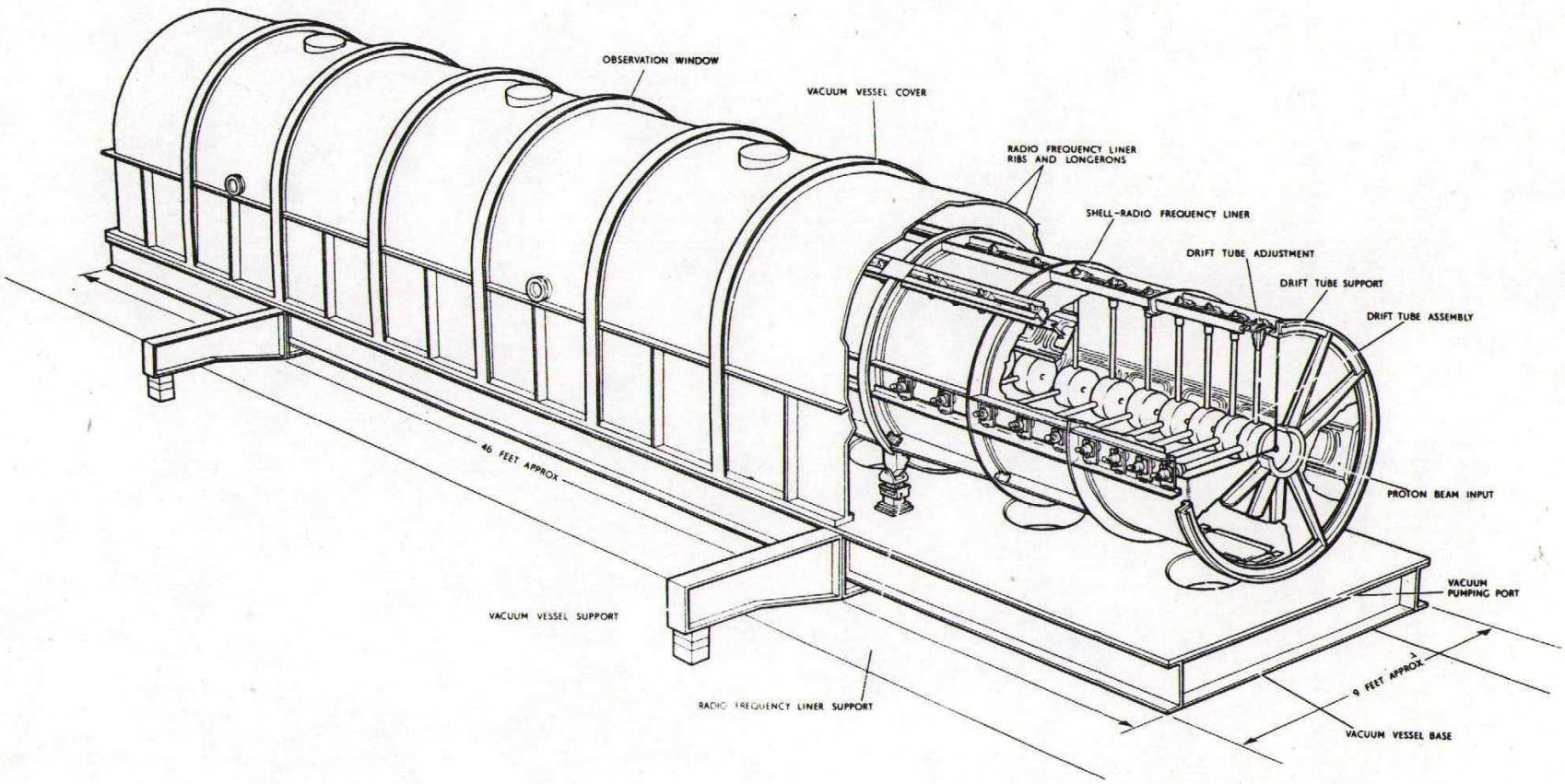

FIGURE 1. LINEAR ACCELERATOR INJECTOR · 7 G.e.V. PROTON SYNCHROTRON