Rutherford Laboratory

Technical Leaflet

A11

SEPARATORS

Certain experiments in high energy physics require 'pure' beams consisting of one type of particle of mass (m), with a definite velocity (v), derived from an original 'impure' beam. A static magnetic field will focus and define beams of given momentum (mv) only. Thus a beam so defined might consist of light particles travelling quickly, together with heavier particles travelling more slowly but with the same momentum. As well as this momentum analysis therefore, it is necessary to have a velocity sensitive deflecting system. Though there are various ways of producing such a system, the method commonly used with momenta less than 5 GeV/c is the static electric field particle separator. The amount of deflection in an electric field is proportional to the time the particles spend in the deflecting région. Slower particles are deflected more than faster ones. However the overall deflection is much greater than the angular separation produced between particles of different velocities. This is illustrated in Figure 1. Compensating magnetic fields are used to simplify the construction of the separators, and their use in actual beams. Two ways of achieving this are illustrated in the figure, both systems can be used with the NIMROD particle separators.

Unfortunately the highest electric fields that have so far been produced in a vacuum (*) are much weaker than quite normal magnetic fields. For instance the maximum voltage that can be applied across a gap of 10 cms. is at present about 600,000 volts. This electric field produces a deflection of high energy particles which is only equivalent to that of a magnetic field of 500 gauss. (16,000 gauss is commonly available in bending magnets).

The length of the separator which transmits the most particles of the wanted type varies with momentum. In order to meet this requirement the NIMROD separators are made in 10 ft. modules which can be fitted together in any multiple of the basic module. This in general allows fairly optimum conditions to be reached.

The basic problem of constructing a separator is that of obtaining the highest possible electric field in a large vacuum system, and supporting the electrodes on suitable insulators. Figure 2, shows a simplified view of the construction of the separators.

The maximum voltage available is 600 kV, positive for one electrode and negative for the other, supplied by two high voltage generators, (which are high frequency voltage multipliers using selenium rectifiers, immersed in oil). The electrodes are made of polished stainless steel, supported on insulators made of high tension porcelain. Each separator is pumped by two oil diffusion pumps with a total pumping speed of over 3,500 litres/sec, which are capable of producing an ultimate vacuum of 5×10^{-7} torr. Whilst low pressures are necessary for the initial conditioning of the high voltage system of the separator, in normal use the best operating conditions are usually obtained by operating at a pressure of about 5×10^{-4} torr.

Examples of the various components are on display, together with a complete separator.

(*) In order to produce higher electric fields than those attainable in vacuum, solid, liquid, or compressed gas insulation has to be used, and this would cause too much scattering in the particle beam.

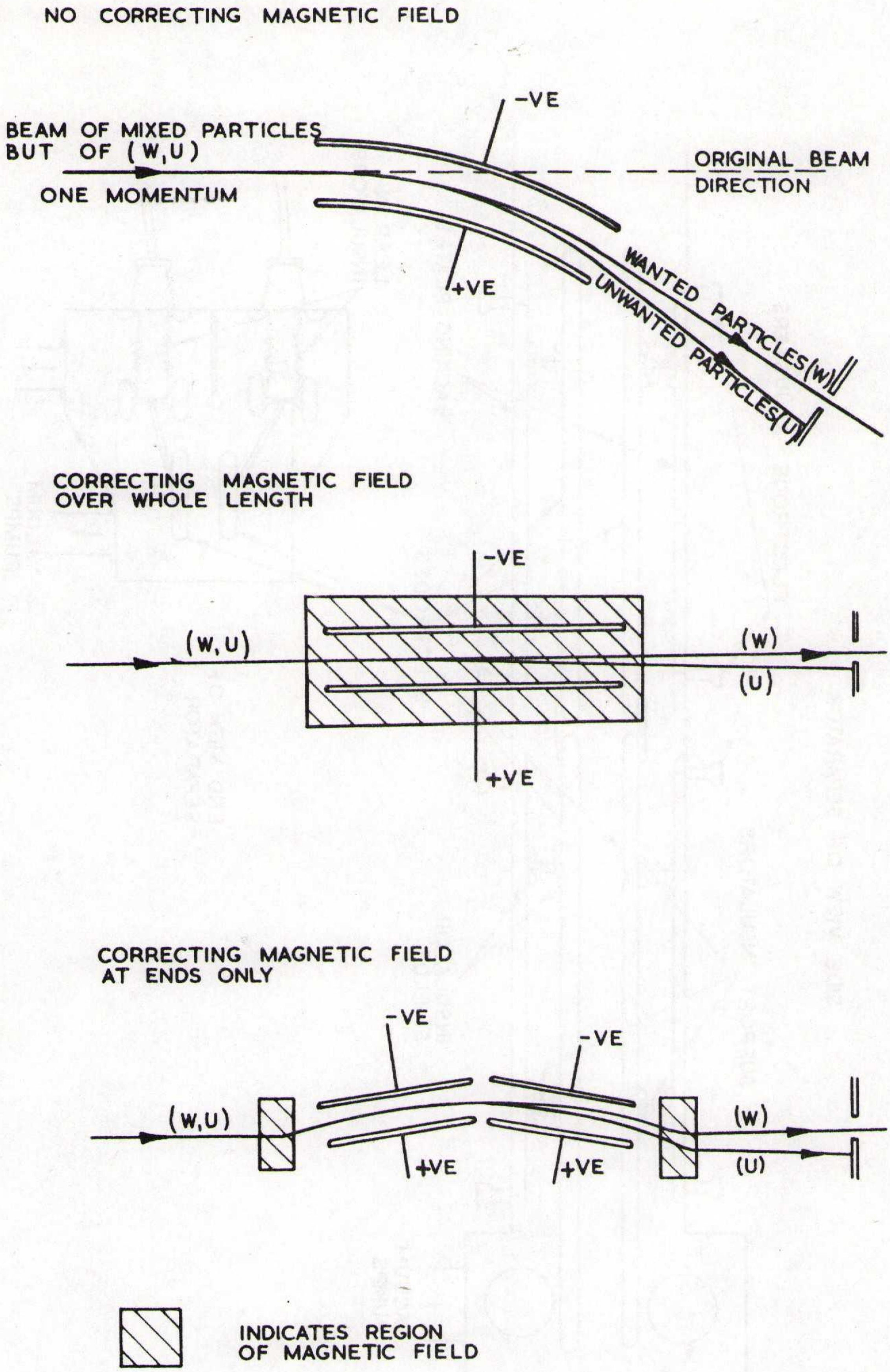
NO CORRECTING MAGNETIC FIELD
BEAM OF MIXED PARTICLES
BUT OF (W,U)
ONE MOMENTUM
-VE
+VE
ORIGINAL BEAM
DIRECTION
WANTED PARTICLES(W)
UNWANTED PARTICLES(U)
CORRECTING MAGNETIC FIELD
OVER WHOLE LENGTH
-VE
+VE
(W,U)
(W)
(U)
CORRECTING MAGNETIC FIELD
AT ENDS ONLY
-VE
-VE
+VE
+VE
(W,U)
(W)
(U)
INDICATES REGION
OF MAGNETIC FIELD

FIGURE 1

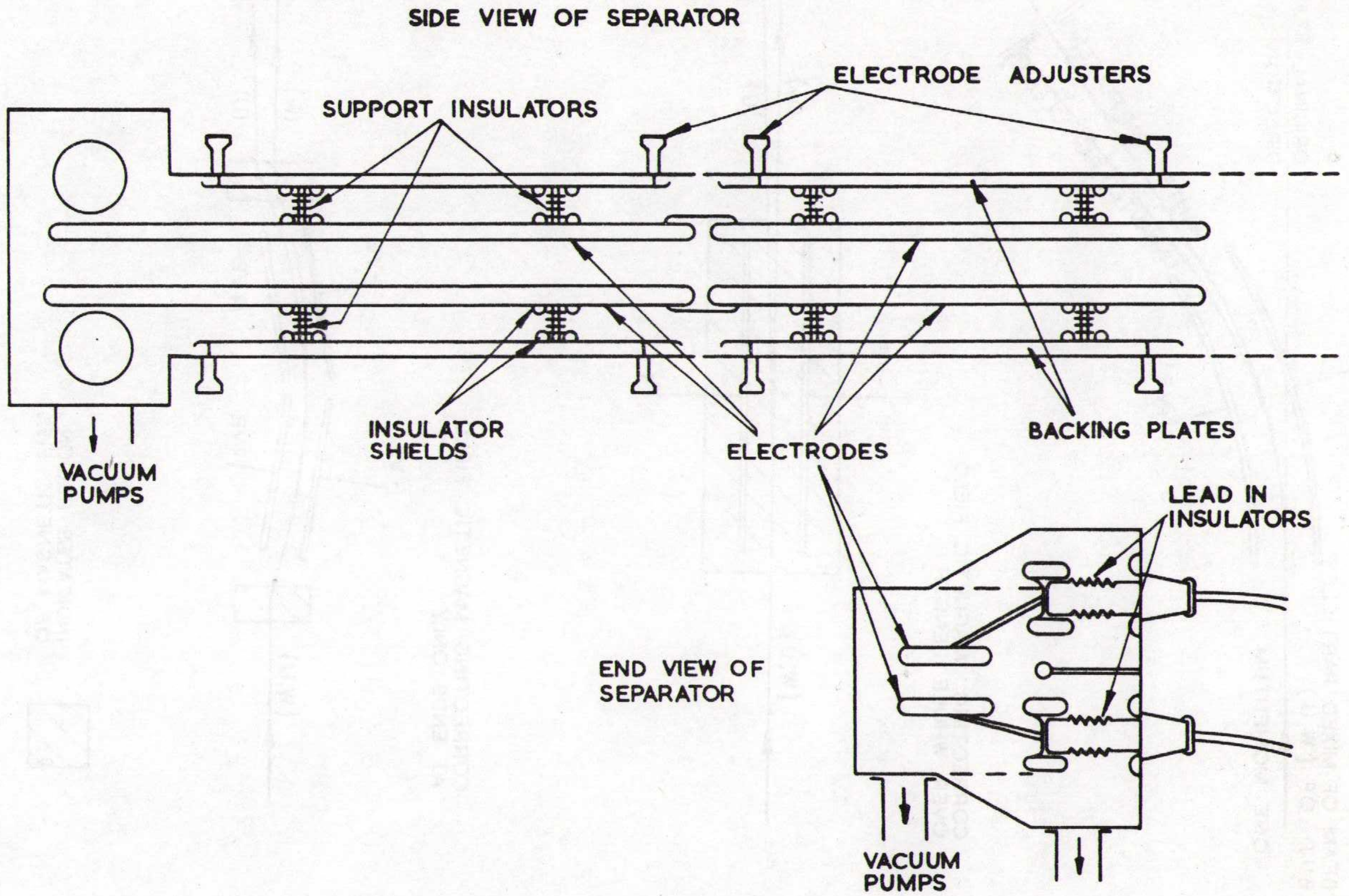
SIDE VIEW OF SEPARATOR
SUPPORT INSULATORS
ELECTRODE ADJUSTERS
INSULATOR SHIELDS
ELECTRODES
BACKING PLATES
VACUUM PUMPS
LEAD IN INSULATORS
END VIEW OF SEPARATOR
VACUUM PUMPS

FIGURE 2