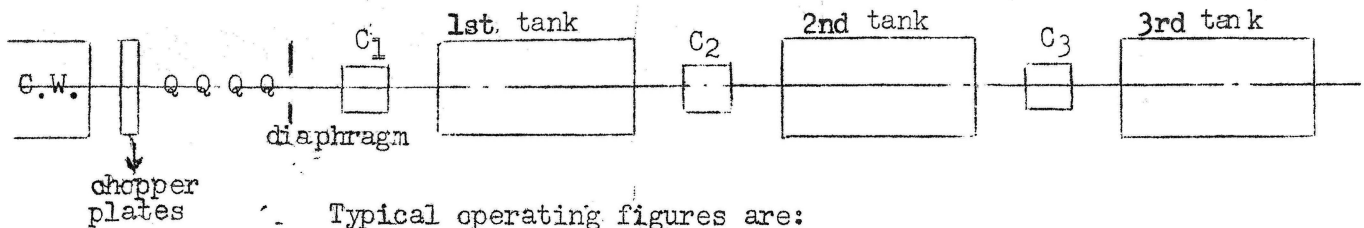S. Giordano (Brookhaven National Laboratory)

Harwell Linac experience

The following observations are the results of a three week visit at Harwell. The Harwell Linear accelerator consists of three seperate tanks with final particle energies of 10 Mev, 30 Mev, and 50 Mev. A layout showing also the preinjector is shown below.

Typical operating figures are:

pulse repetition rate	50 pps.
Beam Pulse	200 microseconds
rf pulse	400 microseconds; 202 Mc/s
current in C_1	5 ma.
current in C_2	100 microamp.

Variations occur from day to day in beam current output and an impression of this can be given by the ratio of C_2/C_1 which may vary between 1/40 and 1/100.

The preinjector is a conventional Cockcroft-Walton type rectifier set plus preaccelerator column. With a beam current of 6 ma. a droop of two KV during the 200 microsecond pulse was observed on the high voltage level of the C.W. output. Therefore a fast correction network, employing a series regulator tube between filter stack and ion source dome, was installed providing now a regulation of two parts in 10,000.

For time of flight measurements it is useful to have available very short beam pulses. At Harwell this has been done by feeding a subharmonic of the tank rf to set a horizontal and vertical chopper plates located after the preinjector (see diagram above). With these a Lissajous beam pattern is generated

and off setting this Lissajous pattern with a d.c. bias the beam is made to sweep rapidly across the diaphragm in front of the first Linac tank and consequently a short beam pulse is obtained. Depending on the frequency of the subharmonic used on the chopper plates the spacing of the beam pulses can be varied. In this method the phase stability of the connective elements between Linac rf and chopper plates is rather critical and due consideration must be given to the coupling elements.

The Linac rf system is designed around a power triode which was designed and built at Harwell. With a 200-microsecond pulse a peak power of 1.25 megawatts is obtained. Under certain conditions it is possible to obtain this with a 400 micro-second pulse. For shorter pulses maximium rf power outputs of 2.6 megawatts have been obtained. The power gain of the tube is about ten. Up till now this tube has averaged about 5000 hours of operation. Future plans call for an extension of the rf pulse to 600 microseconds in order to accomodate a beam pulse length of 400 microseconds.

A diagram of the tube is shown below.
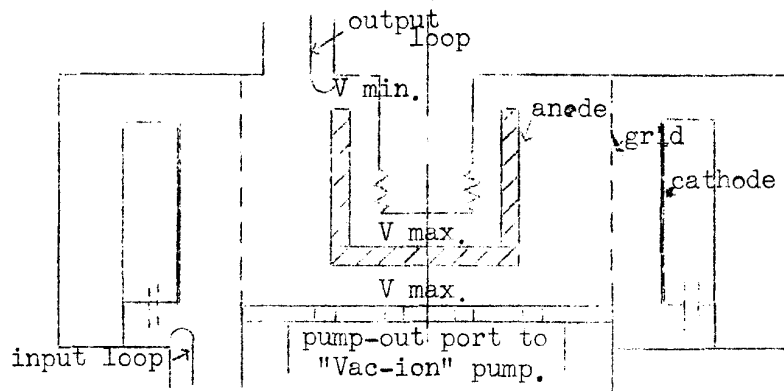
Rf power is measured with dissipative loads designed at Harwell. An example of this is illustrated below :
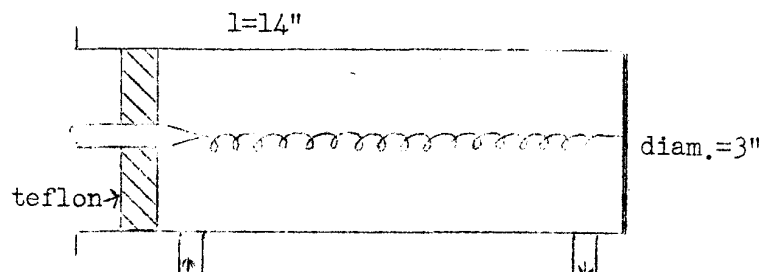
The impedance of this element is (17 + j17) ohms. By the use of a matching section this is transformed to fifty ohms. The input VSWR to the load varies from 1:1 to 1.1:1 with cooling water temperature variations from $20^{\circ} - 60^{\circ}$ F. It has been possible to dissipate a peak power of one megawatt in this design. With similar designs, using a six ft. long section, peak power dissipation of two megawatts was measured.

To couple the rf power into the Linac a coaxial "window" is used as a vacuum seal. This window is illustrated below. The advantages of such a window as compared to a flat window placed directly across the coaxial line is that the tangential fields on the surface of the insulator are considerably reduced.
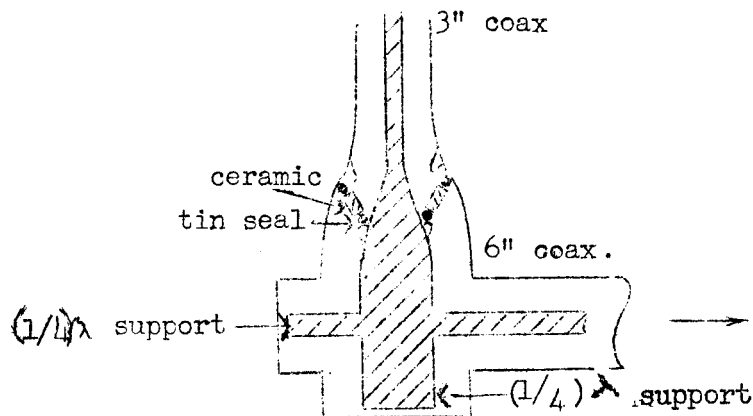

Extensive use is made at Harwell of a coaxial four terminal network. These networks are used for combining the rf power output of two separate sources and also for dividing of the rf output of one source into two separate outputs.

As said before the Linac is a three tank design. The first tank uses grid focussing and is designed in such a way as to give linear particle velocity increase with drift tube number. The ratio g/l = 0.25 and in order to get the right resonance frequency the drift tube diameters vary in a smooth fashion. This tank is being operated with a fifteen per cent droop in axial field.

Tanks two and three have drift tubes of constant diameter and g/l varies with drift tube number. These tanks were designed to give a linear energy increase and therefore are being operated with a fifteen per cent rise in axial field.

A new accelerator of 7 Bev final energy is under construction at Harwell ("Nimrod"). The injector for this machine will be a linear accelerator of final particle energy of 14.7 Mev. A total of 48 drift tubes with d.c. quadruple focusing will be used. These drift tubes are soft copper spinnings and will be

asymmetrically supported as indicated below:
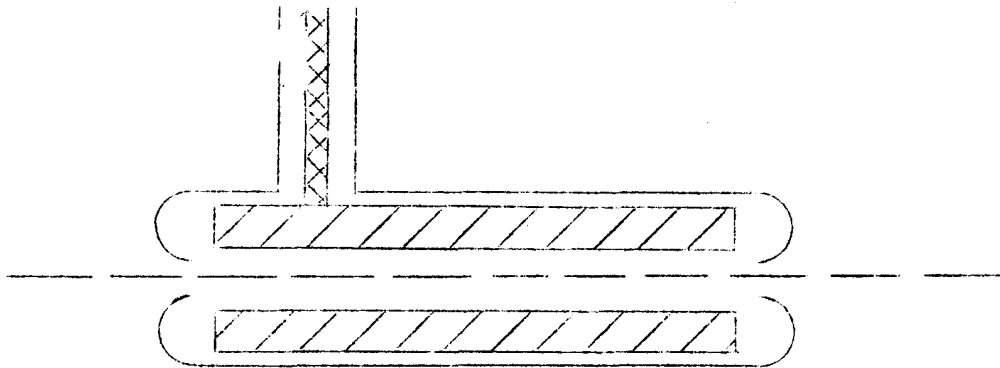
The linear accelerator tank will be a double tank structure with an inner copper rf cavity and outer vacuum tank. The rf system will use a Siemens as an rf power amplifier operating at 115 Mc/s with pulse width of 2.5 milliseconds with peak power capability of 1.75 magawatts. The tube is operated as a grounded grid amplifier. The plate grid coaxial cavity has an electrical length of λ and the tube is located approximately $\lambda/4$ from one end of the coaxial cavity

as illustrated below. To couple the rf power into the Linac a loop is located at one end of the coaxial cavity of the tube and this loop is then directly coupled to the Linac.

Vacuum Window
Quartz plate
Epoxy, Fiberglass
rf Tank
Outer Vacuum Tank
Vacuum Bellows
Plate Grid Coax. Cav.
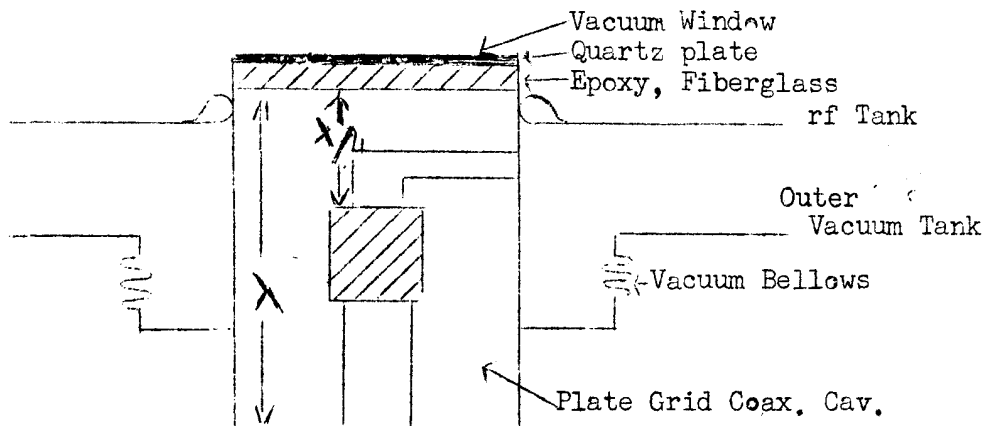
Harwell has constructed a demountable 200 $Mc/_s$ Klystron. This Klystron was tested with resistive rf loads and found to have a peak power of 1.8 megawatts. This Klystron has not yet been used to drive the Linear accelerator.

A short visit was also made to CERN and the following observations were made:

CERN experienced difficulties with multipactoring in their first linac tank resulting in a starting jitter of the rf pulse of about 20 microseconds. A pre-exiter was being built for the first tank and this seems to stop the jitter.

Some interesting measurements made on the rf envelope showed that with an injected beam current of 10 ma. a two per cent droop occurred in the rf envelope.

B. Poliakov, visiting CERN at the same time, provided the following information regarding a 20 Mev linac under construction in Russia. The linac has an rf partition at the eight Mev point. The physical structure of the machine includes an inner rf tank and an outer vacuum tank. Current measuring transformers will be located in some of the drift tubes. This machine may be used as an injector for the 7 Bev strong focusing accelerator.