G. Wheeler (Yale U)

R.F. Power Sources

The proposed Yale University linear accelerator will have a final particle energy in the range of 600 to 800 Mev., a beam pulse length of 2 millisec and duty cycle of about 6%. The consequent requirement on rf power will be of the order of 50 megawatts peak power total. Converted into average power, this would be of the order of 3 megawatts. Assuming an efficiency of 25% for the conversion of net power to rf power, this would mean a drain on the power net of 12 megawatts at an estimated cost of approximately $300,000 per year. It is obvious from these figures that the choice of rf power components should be guided not only by initial·cost but also by reliability and possible high power conversion efficiency.

At present the choice of linac rf power frequency will have to be made partly on the basis of available power tubes. Available frequencies are in the region of 250 Mc/s, 400 Mc/s and 1000 Mc/s (L band). A table of available tubes and klystrons is given on the next page.

Referring to this table a few remarks follow. This list of power tubes was made up with the design requirement in mind of a 2 millisec pulse length. Lifetime data are not available on most tubes because most of those given are of recent design. Regarding the tube A2346F a lifetime of about 5000 hours has been reported. Failures are normally due to grid-cathode shorts rather than a loss of filament emission.

TYPE	Freq. Mcps	Pulse Length μ sec	Duty Factor %	Power Output M.W.	Drive Power K.W.	Approx. Cost	
A2342/ 6950	200	2500	6	1.5	100	$37,500	Shielded Grid Triode Grid Drive
A2346F/ 7865	250	2000	6	5	150	$50,000	Cathode Drive, Triode
A2346N/ 2054	440 440 550	2000 10000 2000	6 6 6	5 2.5 2.5	200 140 225	$60,000	Cathode Drive, Triode
A15040	425 475	25 8300	.8 16	10 .4	400 25	$60,000	Grid Drive Triode ← CEA operation
A15025	250	18	.6	5-10	125-300		Triode
A15038	450 -600	30	.8	5	500	$75,000	Triode-Coaxitron
A2335	550 450	Cw 2000	100 6	.075 .250	6.5 20	~ $8,000	Triode-Cathode Drive ← estimated
2041	450 450	2000 200	6 1	.180 .300	1.8 2.5	$8,000	Tetrode
A2590	425 940	13 20	.4 .5	2 1	20 25		Tetrode
L3403	425 425	2000 2000	6 6	1.25 2.5	gain 35db	~ $30,000	Litton klystron ← expected
VA842	425	2000	6	1.25		~ $30,000	Varian klystron
L3401	1300 1300	500 2000	6 6	5 1.5	36db	~ $30,000	Litton klystron

Several tubes (e.g. the Resnatron) have been made demountable, such that the cathode structure could be replaced or filaments interchanged. The results are normally discouraging in connection with reliability. A longer tube life is normally obtained with a closed vacuum structure and proper bakeout procedures. In this connection it is worth mentioning that some tubes include a small "Vac-ion" pump, which provides continuous pumping on the tube. This seems to have a beneficial effect on tube life. Alternatively, the tube itself can be used temporarily as a getter pump.

In general, cleanliness in tube manufacture and bakeout procedures are extremely important for long cathode life. In the 400Mc/s region it is worthwhile to give some thoughts to the relative merits of triodes(tetrodes) and klystrons, both available in this region. The triode is more efficient than the klystron but has a lower power gain, consequently requires more input power. From the point of view of power consumption both systems would be comparable. Klystrons use higher dc voltages which are more expensive per kilowatt to generate, however both Litton tubes L3403 and L3401 use modulating anodes, which simplify the modulator requirement. For longer pulse lengths pulse transformers are unsuitable therefore pulse forming networks and modulators must be designed for the full dc voltage.

In the 1000 Mc/s region there is no competition from vacuum tubes and klystrons are clearly indicated. For shorter pulse lengths "amplitrons" (Raytheon Company) offer also a possibility especially because of their inherent phase stability, however, a disadvantage is inherent low gain.

The attitude at Yale is to design on the basis of tubes presently available instead of relying on design projections.