

Sep. 11, 1950

TO: Project M Members
FROM: E. L. Ginzton
SUBJECT: Project M Specifications

The attached data are to be considered as preliminary "working" specifications for the Project M accelerator and power components. It is anticipated that many changes will be desirable or necessary as the various specialist groups begin to analyze the problems in greater detail.

It will also be necessary to develop a detailed specifications for all other systems and components used with the accelerator.

TENTATIVE PROJECT M SPECIFICATIONS -- Summary

A. <u>General</u>	<u>Stage I</u>	<u>Stage II</u>	<u>Note</u>
Accelerator Length	10,000 feet	10,000 feet	
Length between Feeds	10 feet	10 feet	
Number of Accelerator Sections	960	960	
Number of Klystrons	240	960	
Peak Power per Klystron	6-24 Mw	6-24 Mw	
Pulse Repetition Rate	1-360 p.p.s.	1-360 p.p.s.	1
R.F. Pulse Length	2.5 μ sec	2.5 μ sec	2
Electron Energy, Unloaded	12-24 Gev	24-48 Gev	3
Electron Energy, Loaded	11-22 Gev	22-44 Gev	3
Peak Beam Current	25-50 ma	50-100 ma	4
Average Beam Current	15-30 μ a	30-60 μ a	4
Average Beam Power	0.3-0.6 Mw	1.2-2.4 Mw	4
Filling Time	0.83 μ sec	0.83 μ sec	
Electron Beam Pulse Length	0.01-2.1 μ sec	0.01-2.1 μ sec	5
Electron Beam Energy Spread (max)	$\pm 0.5\%$	$\pm 0.5\%$	6
No. of Electron Energy Levels (max)	6	6	
Operating Frequency	2856 mc/sec	2856 mc/sec	
Klystron Life (min.)	2000 hrs	2000 hrs.	
Operating Schedule	24 hrs/day	24 hrs/day	7

B. Accelerator

Design frequency (f)	2856 Mc/sec
Number of sections (n)	960
Length of section (l)	10 feet
Attenuation parameter (α I)	0.57 nepers
α	0.00187 nepers/cm
Mode of operation	$2\pi/3$
Shunt impedance per unit length (r)	0.595 Megohms/cm
Q	13,000
Normalized group velocity (v_g/c)	0.0122
Filling time (τ)	0.83 μ sec
Uniform disk loading	
Aperture in disk (2a)	0.890 inches
Diameter of accel. guide (2b)	3.247 inches
Disk spacing	1.373 inches
Disk thickness	0.2200 inches
Each section equipped with input and output couplers	
Cooling water jacket over entire length.	

C. Klystron Amplifier

	<u>Stage I</u>	<u>Stage II</u>	<u>Note</u>
Number required initially	264	1056	3
Design frequency		2856 Mc/sec	
Peak power output (max.)		24 Mw	
Gain (min.)		50 db	
Efficiency (min.)		38 percent	
R.F. pulse length, flat top (min.)		2.5 μ sec	
Average power output (max.)		21.6 kw	
Peak beam voltage (max. rating of modulator)		248 kv	

C. Klyatron Amplifier - Cont'd

Peak beam current (max. rating of modulator)	258 amps.
Perveance	2×10^{-6} amp/volts ^{3/2}
Fix-tuned cavities	
Life (min.)	2000 hrs.

D. Klyatron Modulator

	<u>Stage I</u>	<u>Stage II</u>	<u>Note</u>
Number required	240	960	
Peak power output (max.)	64 Mw		9
Average power output (max.)	74 Mw		10
Output pulse voltage range	158 - 248 kv		
Output pulse current range	120 - 258 amps		
Load impedance range	1320 - 965 ohms		
Pulse transformer turns ratio	9:1		11
Modulator switch voltage range	35.1 - 55.2 kv		11
Modulator switch current range	1080 - 2325 amp.		11
Pulse length, flat top	2.5 μ sec		
Rise and fall times (max.)	0.7 μ sec		
Pulse repetition rate (max.)	360 p.p.s.		12
Pulse height deviation from flatness (max.)	$\pm 0.5\%$		
Pulse time jitter (max.)	± 10 n μ sec		
Pulse amplitude jitter (max.)	$\pm 0.25\%$		

E. Modulator Power Supplies

	<u>Stage I</u>	<u>Stage II</u>	<u>Note</u>
Total Number required	11	41	13
Number of modulators per power supply	24		14
Average power output per power supply (max.)	1872 kv		15
Output voltage range (before charging choke)	19.5 - 30.7 kv		16
Input voltage	480 volts, 3 phase		
Total Connected Input Power to Modulator Power Supplies	20.9 Mw	83.6 Mw	17

NOTES

1. Electron beam pulse repetition rate shall be adjustable in multiples and submultiples of 60 p.p.s. It shall also be possible to turn on the beam for a pre-determined number of pulses. The pulse repetition rate of the klystron modulators shall be adjustable in multiples of 60 p.p.s. between 60 and 360 p.p.s. Electron beam pulse rates below 60 p.p.s. shall be obtained by appropriate adjustment of the pulse repetition rate of the R.F. drive and/or the electron gun.
2. This is length of flat-top region of r.f. pulse.
3. In both Stages I and II the accelerator shall be capable of supplying electrons with energies as low as 1 Gev without sacrifice of maximum current.
4. At design loading and maximum electron pulse length; the actual currents obtained during operation are expected to be lower. However, for very short pulse lengths, even higher currents should be obtainable.
5. These are extreme limits of beam pulse length. Longer pulse than usual is provided to allow injection when accelerator sections are partially filled, thus reducing transient energy spread.
6. After transient period.
7. Design objective
8. Including 10% spares.
9. The peak power rating of the modulator is based on a klystron peak power output of 24.0 megawatts (max. design rating) and 38% efficiency.
10. The average power rating of the modulator is based on 64 megawatts modulator peak power output, 360 p.p.s., and 3.2 μ sec pulse length.
11. This specification is subject to the availability of a satisfactory modulator switch in the indicated voltage range.
12. The maximum pulse repetition rate of the modulator shall be 360 p.p.s. It shall also be possible to operate at all multiples of 60 p.p.s. between 60 p.p.s. and 360 p.p.s.
13. Including one spare.
14. This number (24) appears to be the optimum number of modulators per power supply on the basis of economy. Further studies will be made to check this preliminary conclusion.
15. Power supply average power output is based on obtaining 74 Kw output from each klystron modulator and 95% modulator efficiency.

16. Output voltage range assumes that a factor 1.8 increase in voltage can be obtained in the charging choke.
17. Total average input power to modulator power supplies is based upon 74 kw output power per modulator and 85% combined modulator-power supply efficiency.