M-174

MARK IV REDESIGN COMMITTEE

MINUTES OF MEETING NO. 9

December 17, 1959

In attendance: F. Adams, B. Bunker, A. Crabtree, P. E. Edwards, D. Goerz, O. Kraus, G. Loew, R. B. Neal, P. Zinder

The minutes for meeting No. 8 were accepted as they had been written. It was noted that, due to an error in the numbering system, there are no minutes for a meeting No. 5.

Discussion:

Dr. Neal presented a calculation on the result of not cooling the first cavity of the accelerator. At the highest power level of 22 kw per section, the phase shift is approximately 1.2°, therefore it is negligible, and the mismatch introduced at the coupler will be negligible. A copy of this calculation is included as an enclosure to these minutes.

The drawing of the water jacket was laid out and discussed with respect to the water flow, the sequence of assembly, and the target dates for the assembly of the first accelerator section. It was noted that the recirculating water system was designed to operate at 50 psi at approximately 90 gal. per min.

The next item for discussion was a drawing of the accelerator stand utilizing the major and minor adjustments for both vertical and horizontal positioning of the accelerator. Generally this appeared to be quite acceptable. Also briefly discussed were low power windows, cross-guide couplers, the Varian coaxial-type coupler, and a bracket for the accelerator flange to support the waveguide coupler.

Decisions:

1. To start production on a 10-foot accelerator section as well as the test section in order to save time.

2. To add a second inlet at the center portion of the 10-foot section to get additional water flow in the event it is necessary.

3. To have flow meters installed to check on the present water flow of the recirculating system.

4. To accept the general design of the accelerator support stand and continue with the detailing of these items.

5. To not cool the first cavity in the accelerator because the phase shift and mismatch would be negligible.

6. To braze a bracket on the waveguide coupler to bolt to the accelerator flange and provide more stability.

The next meeting is scheduled for January 7, 1960 at 10:30 A.M.

Effect of Not Cooling the Coupler Cavity

Assume 22 kw of power per accelerator section. Therefore average of 2.2 kw/foot.

At 8.7 cavities/foot ($2\pi/3$ mode) this reduces to $\frac{2.2\text{kw}}{8.7 \text{ cavities}} = 253$ watts lost in the first cavity.

This is equal to 253 joules/sec & at 4.185 joules/calories

this is $\frac{253}{4.185} = 60.3$ calories/sec.

Accel. Tube and Wall Area

D = outer diameter

d = inner diameter

= 4.29 sq. in. = 27.6 sq. cm.

Distance heat is transmitted = $\delta x = 1.378" = 3.5$ cm.

$$Q = KA \frac{\delta T}{\delta x} \quad \therefore \delta T = \frac{Q \delta x}{KA} = \frac{(60.3)(3.5)}{(1)(27.6)} = 7.67^{\circ}\text{C}$$

Now $\frac{\delta \lambda}{\lambda} = 1.6 \times 10^{-5} \times 7.67 = 1.21 \times 10^{-4}$

& $\delta \phi_p = \frac{2\pi}{3} Bw \frac{c}{v_g} \frac{\delta \lambda}{\lambda} = (120)(81.8)(1.21 \times 10^{-4}) = 1.19^{\circ}$

$\therefore$ Phase Shift $\delta \phi_p = 1.19^{\circ}$ due to non-cooling of the coupler cavity.

Reflection of R. F. Power

A change of temperature of $7.67^{\circ}C$ will cause the coupler cavity diameter to change by the amount:

$$\delta d = 1.6 \times 10^{-5} \times 3.247 \times 7.67 = 0.398 \text{ mils}$$

This is equivalent to a change of wavelength of

$$\frac{\delta \lambda}{\lambda} = 1.6 \times 10^{-5} \times 7.67 = 1.23 \times 10^{-4}$$

Assume that the cavity is perfectly matched when cold. Then, during operation the normalized effective impedence $\frac{Z}{Z_o}$ at the "detuned short" will be:

$$\frac{Z}{Z_o} = \frac{1}{1 + j \Sigma Q_L \delta}$$

where $\delta = \frac{\delta \lambda}{\lambda}$

and Q_L is the loaded Q

The effective Q_o of the cavity, Q_o', is given by:

$$\frac{1}{Q_o' (1 - e^{-2\Gamma d})}$$

Where Γ is the voltage attenuation factor in the accelerator structure, and d is the distance between cavities

with $\Gamma = .00188 \text{ cm.}^{-1}$, $d = 3.5$ cm. and $Q_o = 13{,}000$,

we then obtain $Q_o' \cong 170$

When the coupler is matched, $Q_L = \frac{Q_o'}{2} = 85$

Then $\frac{Z}{Z_o} = \frac{1}{1 + j\, 170\, \delta}$

For $\delta = 1.23 \times 10^{-4}$

$$\frac{Z}{Z_o} = \frac{1}{1 + j(.0209)}$$

or $\left|\frac{Z}{Z_o}\right| = 1.00022$ which is also the value of the V.S.W.r.

$\therefore$ the reflection coefficient would then be

$$\Gamma = \frac{Z/Z_o - 1}{Z/Z_o + 1} \cong .00011$$

and the fraction of the incident power reflected would thus be

$\Gamma^2 = 1.2 \times 10^{-8}$ which is negligible.