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MARK I HIGH VOLTAGE TEST (1/10 SCALE MODEL)

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Berkeley, California

MARK I HIGH VOLTAGE TEST (1/10 SCALE MODEL)

Raymond D. Robertson

Department of Physics, Radiation Laboratory
University of California, Berkeley, California

May 9, 1951

Introduction

The 1/10 scale model used for the Mark I model r.f. tests was converted for use with the geometry for the high voltage test in Mark I. The design considerations for this test are discussed in UCRL-1092 and UCRL-1066 Revised.

The following tests were made:

1. Determination of the correct stem position for #2 drift tube.
2. Frequency measurement.
3. Q measurement.
4. Investigation of the gap splitter as a tuning element.
5. Investigation of the gap splitter and drift tube stem bypass currents.

All results will be given in terms of the full scale machine. (Scaling factors are discussed in UCRL-1173, Section II.)

1. Mechanical Design

The general mechanical arrangement, procedures for alignment, and methods of measurement are exactly the same as detailed in UCRL-1173 and will not be repeated here.

The following drawings detail the design and assembly of the 1/10 scale model for these tests:

5H9364	Drift tube geometry.
5M1456	Full drift tube assembly.
5M1464	Half drift tube assembly and installation.
5M1474	Full drift tube body.
5M1484	Half drift tube body.
5M1494	Drift tube head (end bell).
5M1502	Clamp angle.
5M1511	Clamp block.

5M1522	Lucite stem.
5M2613	Stem shield.
Sketch	Metal stem.
Sketch	Gap splitter.

Figures 1, 2, 3, and 4 show the general mechanical arrangement. Fig. 1 is a sketch of the geometry with dimensions. Fig. 2 was taken with the drift tube suspended from the lucite stem. The cavity was rotated 90^{o} (open face of Fig. 1 up) for the final geometry with the metal stem. Fig. 3 shows the half-drift tube and stem shield as they were in the final assembly. Fig. 4 shows the full drift tube with metal stem.

The system was modified after design to allow adjustment of the end bell positions from outside the cavity. The half-drift tube was adjusted from the entrance end. Both ends of the full drift tube were adjusted from the exit end. Each adjustment consisted of three equally spaced socket head bolts. Fig. 5 shows these bolts for the full drift tube.

Two models of the gap splitter were used. The first was a hollow disc in which a hot gas welded polyethylene bladder was inserted. A tube was run through the hollow stem to an air supply and vacuum pump to facilitate inflation and deflation of the bladder. This model (shown in Figs. 6 and 7) was used in the frequency perturbation tests. The second model was a single disc of flat copper which was joined to the stem by a hinge. This model (see Fig. 8) was used for stem bypass current measurements.

2. Stem Position Determination. (See UCRL-1173, Section IX.)

The procedure was simplified over that outlined in UCRL-1173 in this case because there was only one full drift tube. The measured offset was 1-9/16" toward the exit end. The bypass current as measured with metal stem at the predicted offset and with the theoretical geometry was approximately 100 amperes assuming an 18,000 uuf bypass capacitor.

In addition to the stem position with a lucite stem a further test was made of the feasibility of determining the correct stem position with a dummy metal stem in one plane while the drift tube was supported by a metal stem in a plane 180^{o} away. The effects of a stem located near the plane of symmetry between cells (i.e., in a position in the cavity where static theory is applicable) should have a purely local effect. The check was made by comparing the bypass currents in the supporting metal stem and another stem at 180°. No interacting effects were noted and the bypass current minimum occurred at the same position as determined with the lucite stem.

3. Frequency of Operation. (See UCRL-1173, Section XII.)

The frequency was measured by the beat frequency method of UCRL-1173.

$$f = 11.52 \pm .03 \text{ mc}$$

4. Q Measurement. (See UCRL-1173, Section VII.)

$$Q = 51{,}000 \pm 3\%$$

Further checks of the Q were made for several conditions, including:

(a) gap splitter inflated and deflated.

(b) drift tube end bells moved in both directions from design values.

No significant change was detected for these conditions.

5. Gap Splitter as a Tuning Element.

The effectiveness of the gap splitter as a tuning element was investigated by inflating the bladder in the hollow model of the gap splitter and measuring the frequency deviations caused by the resultant expansion. Figure 9 shows the variation of frequency with gap splitter thickness. The straight line portion is the region over which the expansion was essentially conical and the sudden drop occurs when the limit of longitudinal expansion is reached but the volume displaced continues to increase.

The frequency deviations measured were for $1\frac{1}{2}$ cells. Simple perturbation theory (as outlined in UCRL-1173, pages 27-29) shows that:

$$\frac{\Delta f}{f} = \frac{1}{2}\frac{\int_{\Delta v} B^2 dv}{\int_{v} B^2 dv} \qquad (1)$$

which can be extended to:

$$\frac{\Delta f}{f} = \frac{\epsilon_0}{4} \frac{\int_{\Delta v} B^2 dv}{U_s} \qquad (2)$$

But the energy stored in $1\frac{1}{2}$ cells is $1\frac{1}{2}$ times that stored in a single cell. If the taper of the tank and the geometry are taken into account the actual ratio (by volume, which is not exact) is 1.4.

The resultant perturbation coefficient is expressed in terms of unit changes of one foot for a single cell:

$$\frac{\Delta f}{f} = .07\%/\text{ft/cell}^* \qquad (3)$$

6. Drift Tube End Bells as Tuning Elements.

The effect on frequency of moving each of the two end bells in the full cell independently was investigated. Fig. 10 shows the perturbation curves for each end bell. The reason for the slight difference in slope is probably the presence of the entrance end wall which does not coincide with a surface of symmetry and would not be present if there were another cell on each side of the one used for measurement. Accepting the full drift tube end bell as the significant one:

$$\frac{\Delta f}{f} = 1.8\%/\text{ft/cell}^*$$

7. Drift Tube and Gap Splitter Bypass Current Variation with End Bell Movement.

Starting with the design geometry and the gap splitter suspended at the geometrical center of the gap the following bypass current perturbation coefficients were measured for various end bell movements:

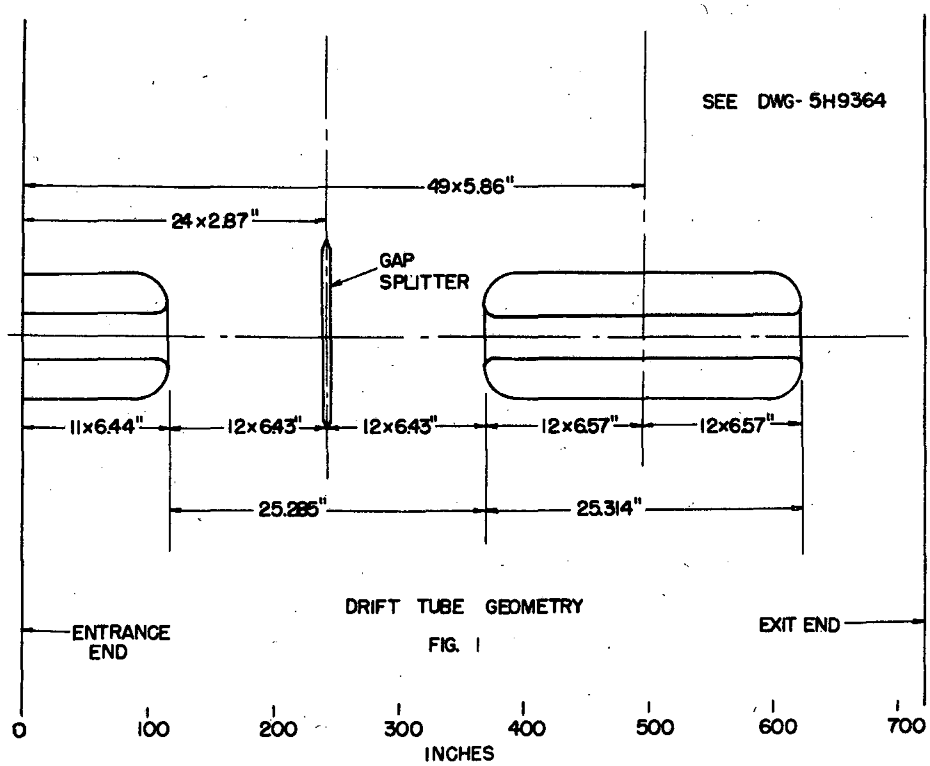
End Bell Moved	Bypass Coefficient (for 18,000 uuf) amp/inch	
	Gap Splitter	Full Drift Tube
Half Drift Tube	230	0
Full Drift Tube	230	316

*Note: These values are correct only for this particular cell and not for any other part of the machine.

8. Gap Splitter Stem Positioning.

The original design called for the gap splitter to be placed at the geometrical center between drift tubes with a straight stem. This could not be done and at the same time use an existing liner nozzle so the following investigation was made to determine optimum gap splitter position for a given stem angle.

The gap splitter with a hinged stem (shown in Fig. 8) was mounted with a bypass capacitor. For several longitudinal gap splitter positions the optimum stem angle was determined (by minimizing bypass capacitor voltage). The results are plotted on Fig. 11 in terms of the offset (at the top of the nozzle) from the gap splitter.



DRIFT TUBE GEOMETRY

FIG. 1

MU 1951

FIG. 2- 1/10 SCALE MODEL GEOMETRY (WITH LUCITE STEM)

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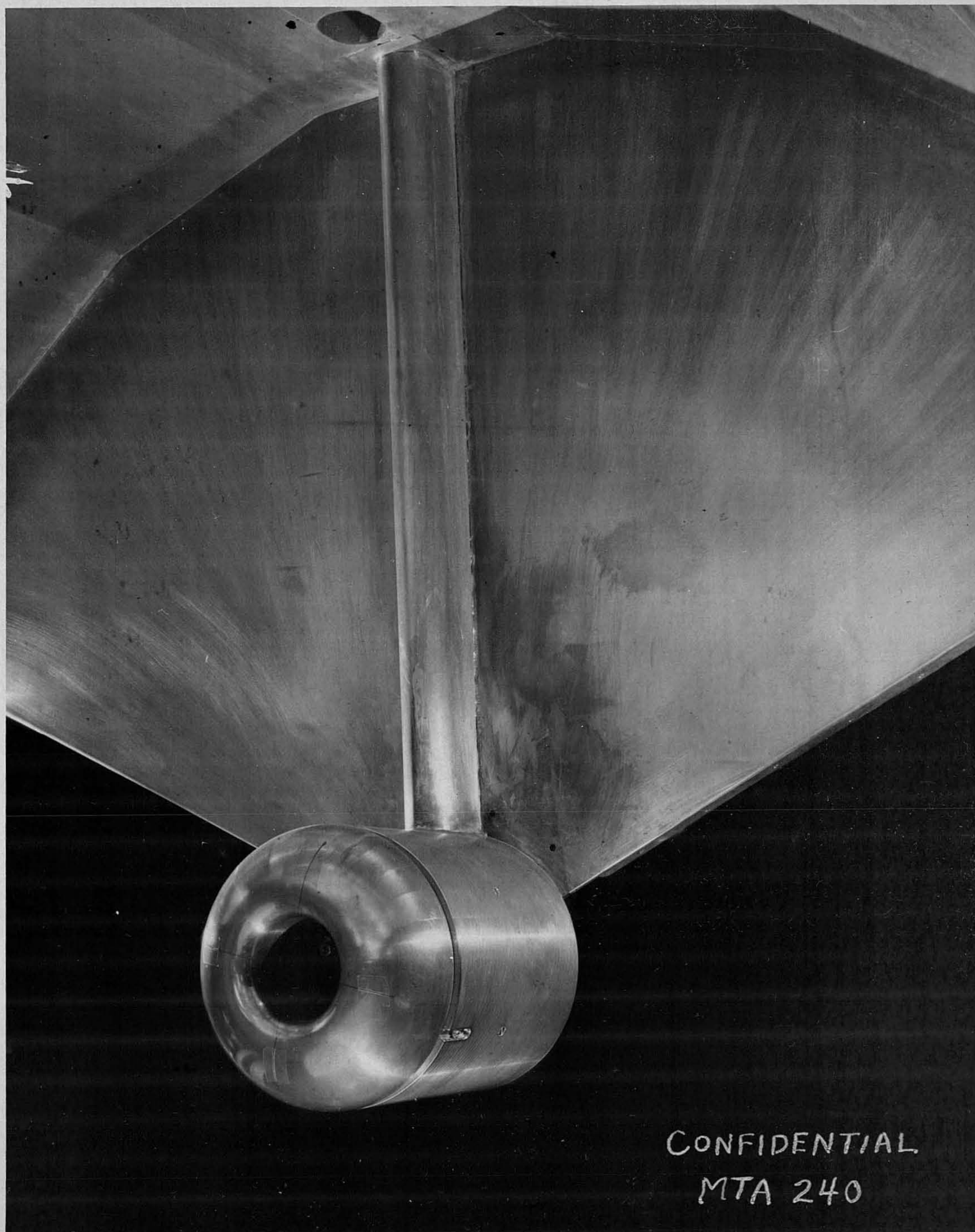

FIG. 3 - HALF DRIFT TUBE AND STEM SHIELD
(1/10 SCALE MODEL)

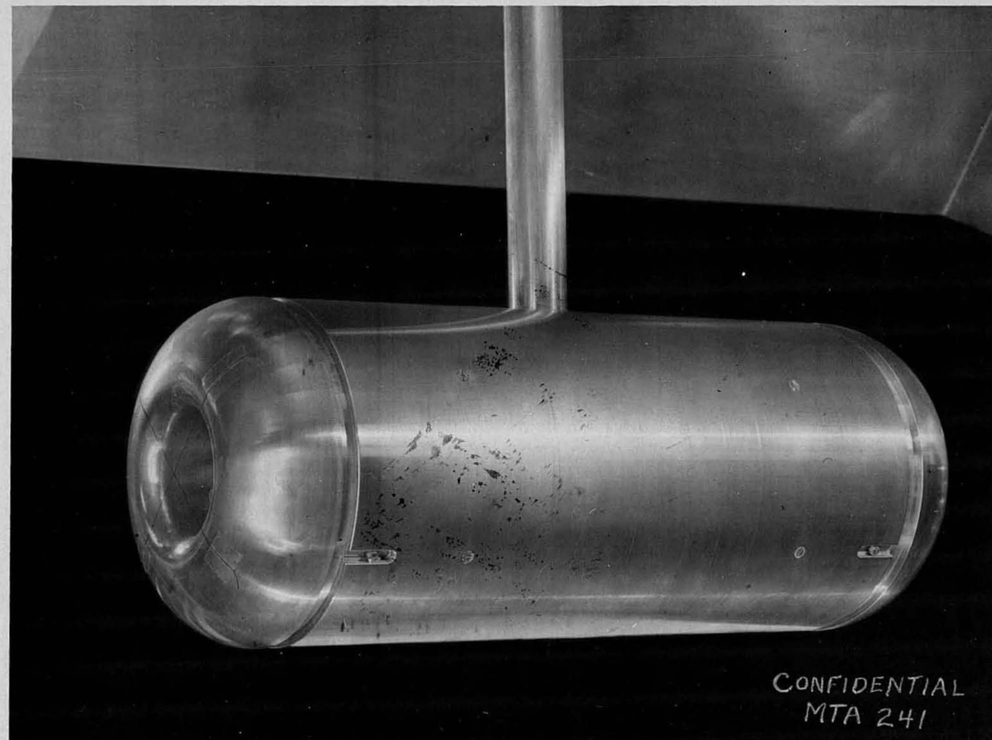

FIG. 4 - FULL DRIFT TUBE WITH METAL STEM
(1/10 SCALE MODEL)

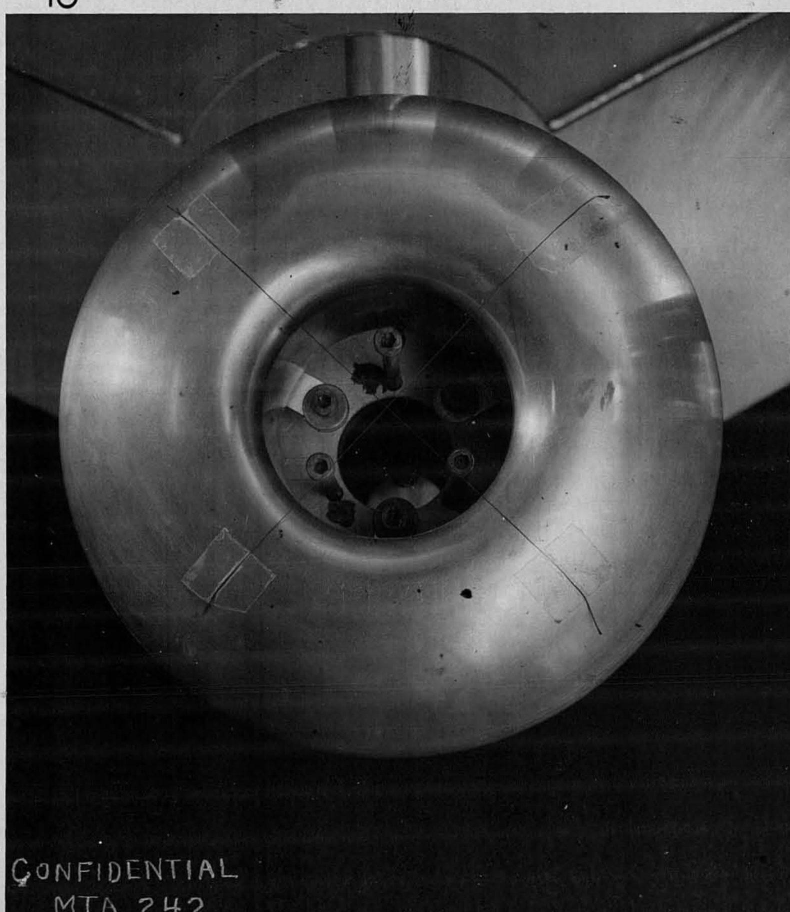

FIG. 5 - FULL DRIFT TUBE END VIEW SHOWING
END BELL ADJUSTMENT SCREWS (1/10 SCALE MODEL)

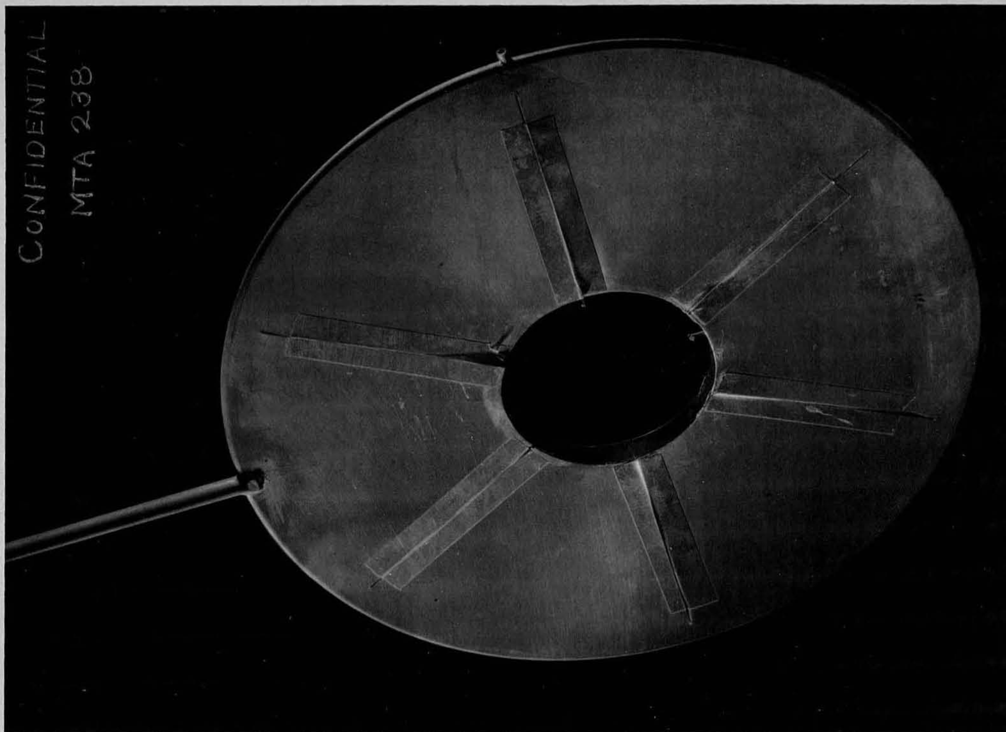

FIG. 6- EXPANDABLE GAP SPLITTER (MOD. I)

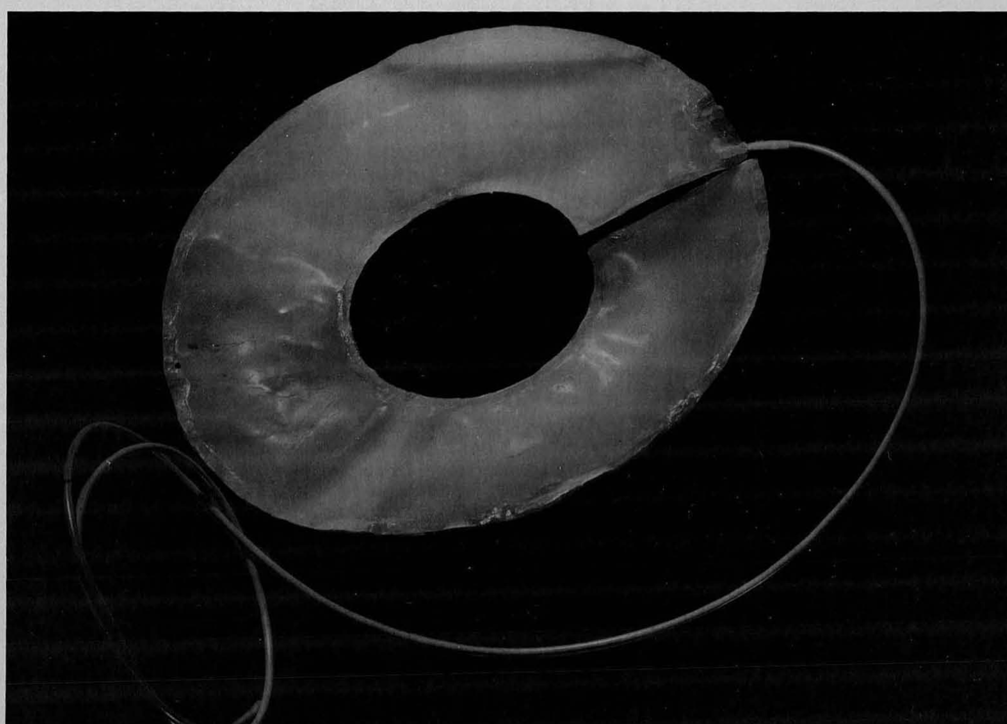

FIG. 7- GAP SPLITTER BLADDER

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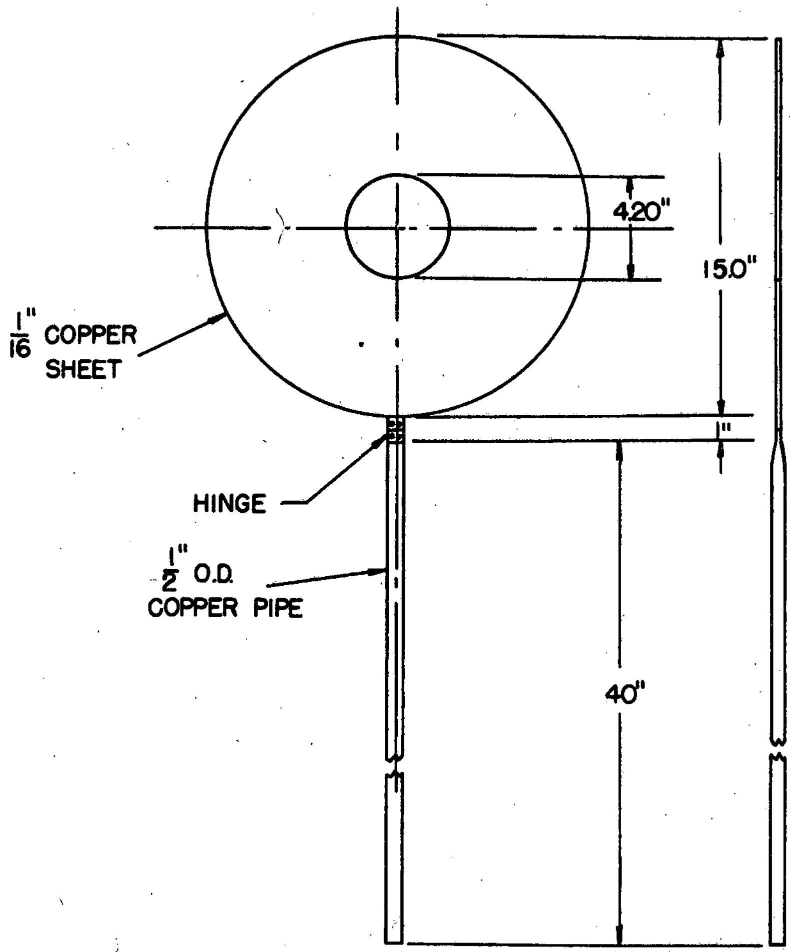

HINGED GAP SPLITTER
(MOD. II)
FIG. 8

MU 1952

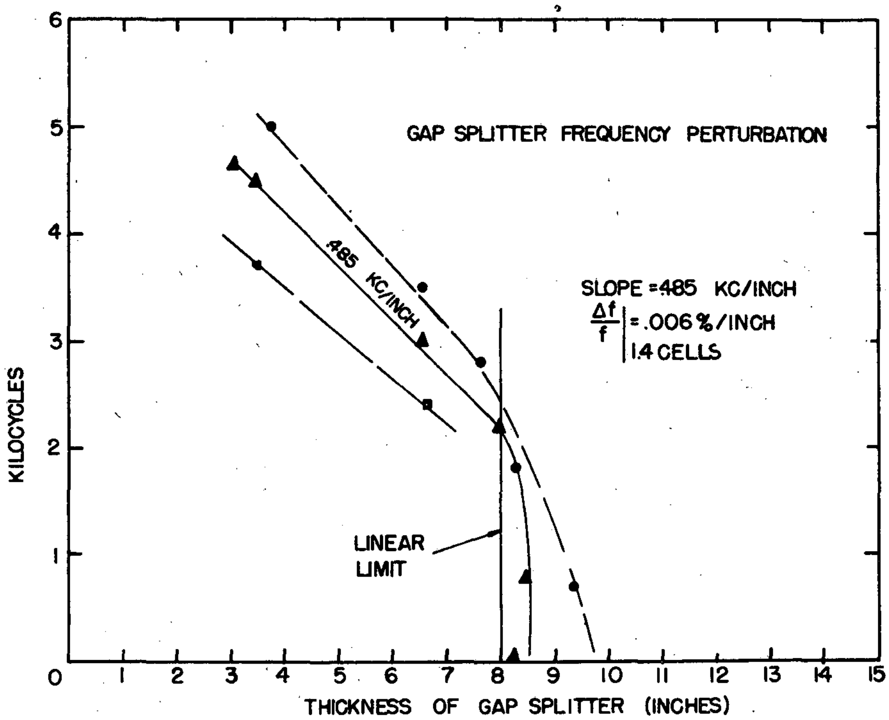
GAP SPLITTER FREQUENCY PERTURBATION
SLOPE = 485 KC/INCH
Δf/f | = .006 %/INCH
1.4 CELLS
485 KC/INCH
LINEAR LIMIT
KILOCYCLES
THICKNESS OF GAP SPLITTER (INCHES)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 9

MU 1953

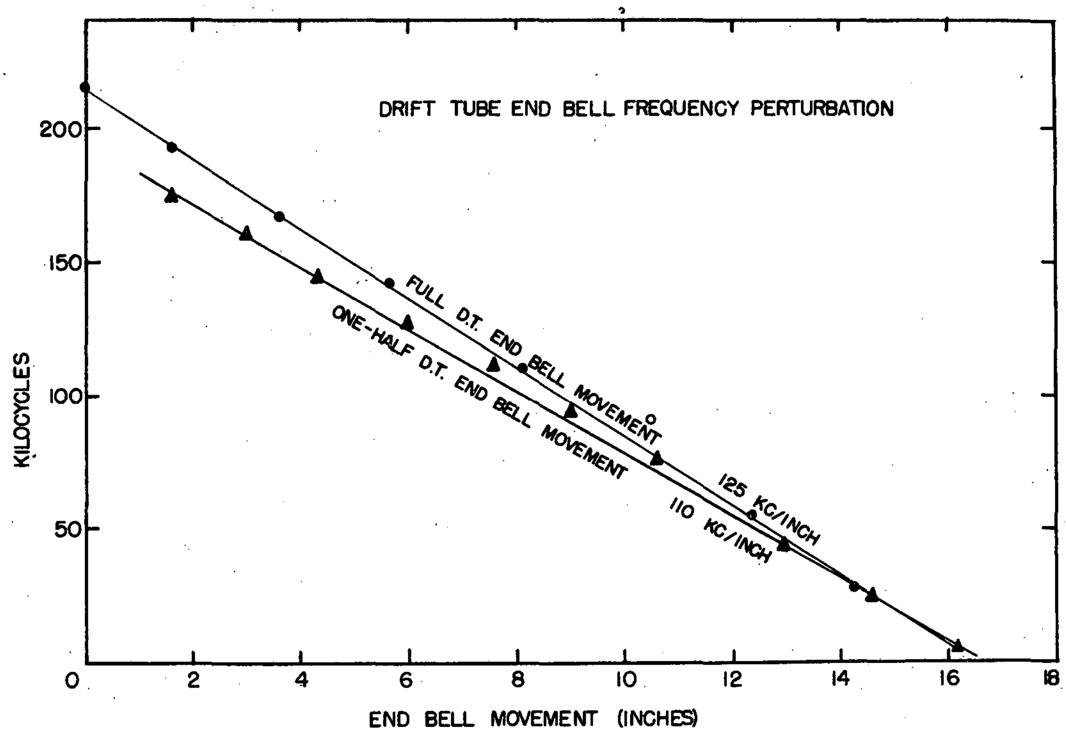

FIG. 10

MU 1954

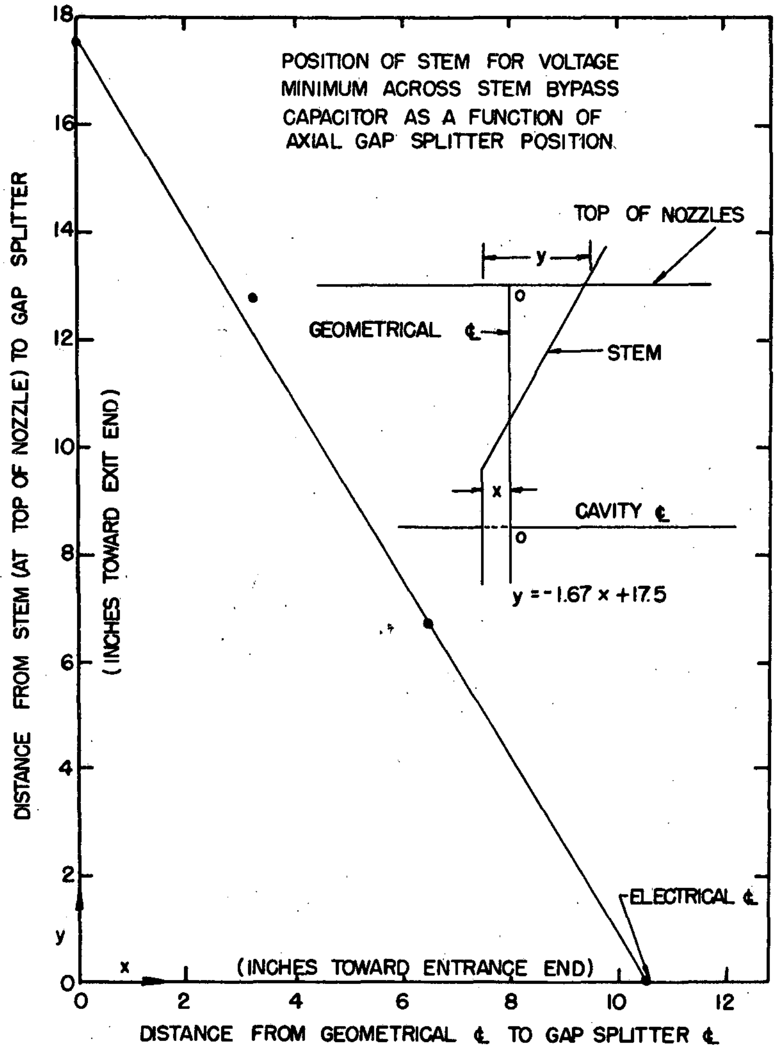

FIG. 11

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