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V-39, V-40 KLYSTRON OSCILLATORS DESIGN AND DEVELOPMENT PROGRAM

Progress Report for
Quarter Ending 30 November 1953

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V-39, V-40 KLYSTRON OSCILLATORS DESIGN AND DEVELOPMENT PROGRAM

Progress Report for
Quarter Ending 30 November 1953

Prepared for: Bureau of Ships
Navy Department

On: BuShips Contract No. NObsr-52105
Index No. NE-110244

By: Robert G. Rockwell

Approved: S F Varian
Sigurd F. Varian
Vice-President for Engineering

PURPOSE

The purpose of the program engaged under BuShips Contract No. NObsr-52105 is to design and develop two wide-range klystron oscillators, V-39 and V-40, which will comply with the specifications outlined in this contract.

The two oscillators will cover the frequency band from 10 to 21 kmc. One tube will tune over the lower half of the band from 10 to 15.5 kmc, and the other will cover the band from 15 to 21 kmc. Preliminary design tubes of each type, complete with electrical test and characteristic data, will be furnished. In addition, five tubes embodying the final design of each type will be supplied, along with electrical characteristics and test data, final proposed specifications, and manufacturing drawings.

GENERAL FACTUAL DATA

Several V-39 and V-40 tubes of standard design were completed in this quarter. The V-39 tubes employed waveguide mode suppressors which extended perpendicularly from the main tuning cavity.

The V-39 tubes tested fell off in power at about 10 kmc; otherwise, both the V-39 and the V-40 tubes operated satisfactorily in accordance with the present specifications.

It has been decided to change the design of the V-40 tube in order to reduce the amount of distortion of the cavity caused by the excessive pretuning required. This new design also should eliminate the need for shorting screws to the tube body. In the new V-39, scaled up from the new V-40, an attempt will be made to reduce the number of mode suppressors, position the suppressors alongside the main cavity, and increase the power at the 10 kmc end of the tuning range.

A V-40 of the new design was assembled toward the end of this quarter. Pretuning data will be taken and a tuning curve drawn to compare this design with the previous one.

DETAILED FACTUAL DATA

A prototype cavity for the V-39 tube was completed early in this quarter. The tube was found to operate satisfactorily in this cavity.

Two other cavities for the V-39 also were completed. When the tubes were operated in these cavities, it was evidenced that the half-wave cavity mode interfered with the desired full-wave mode, especially around 14 kmc. By switching reflector voltage modes and the polarity of the reflector pulse voltage at this frequency, however, no trouble was anticipated in tuning the tube over its full range, that is, from 10 to 15.5 kmc.

It was found in this quarter that all of the waveguide mode suppressors would function properly if they were extended perpendicularly from the main tuning cavity, instead of being positioned alongside the main tuning cavity as in previous designs. When the suppressors are positioned alongside the main tuning cavity, a structure is formed that resonates several kmc below the cut-off frequency of the mode suppressor. In the case of the V-39 the resonant frequencies of these structures were falling within the desired tuning range, causing the tube to stop oscillating. (This trouble has not been experienced with the V-40.) The V-39 mode suppressors, hence, were built straight outward from the main cavity. These new suppressors have worked satisfactorily.

Figures 1 and 2 show the final V-39 tube and cavity assembled and disassembled. The position of the mode suppressors and the terminations used to load the undesired cavity modes are shown. Figures 3 and 4 show the final V-40 tube and cavity assembled and disassembled.

During this quarter, one V-40 tube (tube No. 54) was tested and passed contract specifications. In addition four V-39 tubes (tubes No. 14, 18, 20, and 21) were tested and performed satisfactorily except for low power output at about 10 kmc. The performance data for the V-40 tube are given in Table I. Table II shows typical data for the V-39, as exemplified by V-39 tube No. 20. Figures 5 and 6 are tuning curves for V-40 tube No. 54 and V-39 tube No. 20, respectively. Measurements of all five tubes tested this month were witnessed by the local Inspector of Naval Material.

TABLE I

Performance Data of V-40 Tube No. 54

Heater Voltage = 6.3 v
Heater Current = 1.2 a

Frequency (kmc)	Beam Voltage (vdc)	Beam Current (madc)	Reflector Voltage (vdc)	Power Output Matched Load (mw)	Power Output Optimum Load (mw)	Tuning Resetability (%)
21.0	750	32	-300	71	115	0.020
20.5	750	35	-285	94	144	0.020
20.0	750	36	-260	83	167	0.008
20.0	750	35	-530	91	111	0.020
19.0	750	34	-460	120	157	0.008
18.0	750	35	-400	137	181	0.020
17.0[1]	750	36	-340	132	255	0.040
17.0[2]	750	36	-340	105	170	0.040
16.0	750	36	-270	116	240	0.010
15.0	750	36	-240	111	200	0.010

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1 K-Band Waveguide

2 K_u-Band Waveguide

TABLE II

Performance Data of V-39 Tube No. 20

Heater Voltage = 6.3 v
Heater Current = 1.2 a

Frequency (kmc)	Beam Voltage (vdc)	Beam Current (madc)	Reflector Voltage (vdc)	Power Output Matched Load (mw)	Power Output Optimum Load (mw)	Tuning Resetability (%)
15.5	750	33	-315	58.5	155	0.006
15.0	750	33	-300	176	210	0.030
14.0	750	32	-250	109	128	0.000
14.0	750	35	-450	292	292	0.000
13.0	750	35	-380	187	243	0.020
12.0	750	35	-300	160	239	0.005
11.0	750	35	-240	76	181	0.005
10.0	750	31	-170	25	110	0.000

An improved technique was introduced in this interval to measure tube noise. This method consisted essentially of utilizing a Pound Microwave Discriminator, as shown in Figure 7. The technique resulted in much greater sensitivity than obtained heretofore. It was found that the FM beam noise of the V-39, measured with battery voltages applied to all electrodes of the tube, was of the order of 3 kc; the measured noise was approximately doubled when ac was applied to the heater of the tube.

The modulation sensitivity of the V-39 tubes, measured at 12 kmc, was approximately 0.18 mc/volt.

Two of the V-39 tubes required shorting screws to the tube body since the ring spacing was at the extreme limits of tolerance.

At this time it was decided to make a change in the design of the V-40 tube which should reduce the amount of pretuning required. Pretuning, with the existing design, has resulted in a bowed reflector header causing special, undesired trimming of the mica windows. Another change should eliminate the need for shorting screws to the tube body, and hence relax the close tolerances needed for the ring spacing. After successful operation of this new V-40, a V-39 will be designed by scaling from the V-40 in an attempt to: (1) reduce the number of mode suppressors, (2) bring the suppressors alongside the main cavity, and (3) increase the power at the 10 kmc end of the tuning range.

Toward the end of this quarter a V-40 of the new design was assembled sufficiently to enable pretuning data to be taken. Since the internal cavity dimensions have been altered to reduce the bowing of the reflector header during pretuning, a tuning curve will be made to compare the old standard V-40 with the new design.

CONCLUSIONS

The design of the V-40 tube has been changed to reduce the amount of distortion of the cavity caused by the excessive pretuning required and to eliminate the need for shorting screws to the tube body. Pretuning data will be taken from this tube and the results used to compare this design with the previous one.

If the new V-40 is successful, the design will be scaled up for the V-39. The purpose of the new V-39 will be to reduce the number of mode suppressors now in use, to position the suppressors alongside the main cavity, and to increase the power at the 10 kmc end of the tuning range.

PROGRAM FOR NEXT INTERVAL

Work will continue on the new design of the V-40 tube. Data will be taken from this new design and a tuning curve drawn to compare this design with the previous one.

Estimated expenditures during November 1953: $1080.00

Estimated man-hours during November 1953: 98

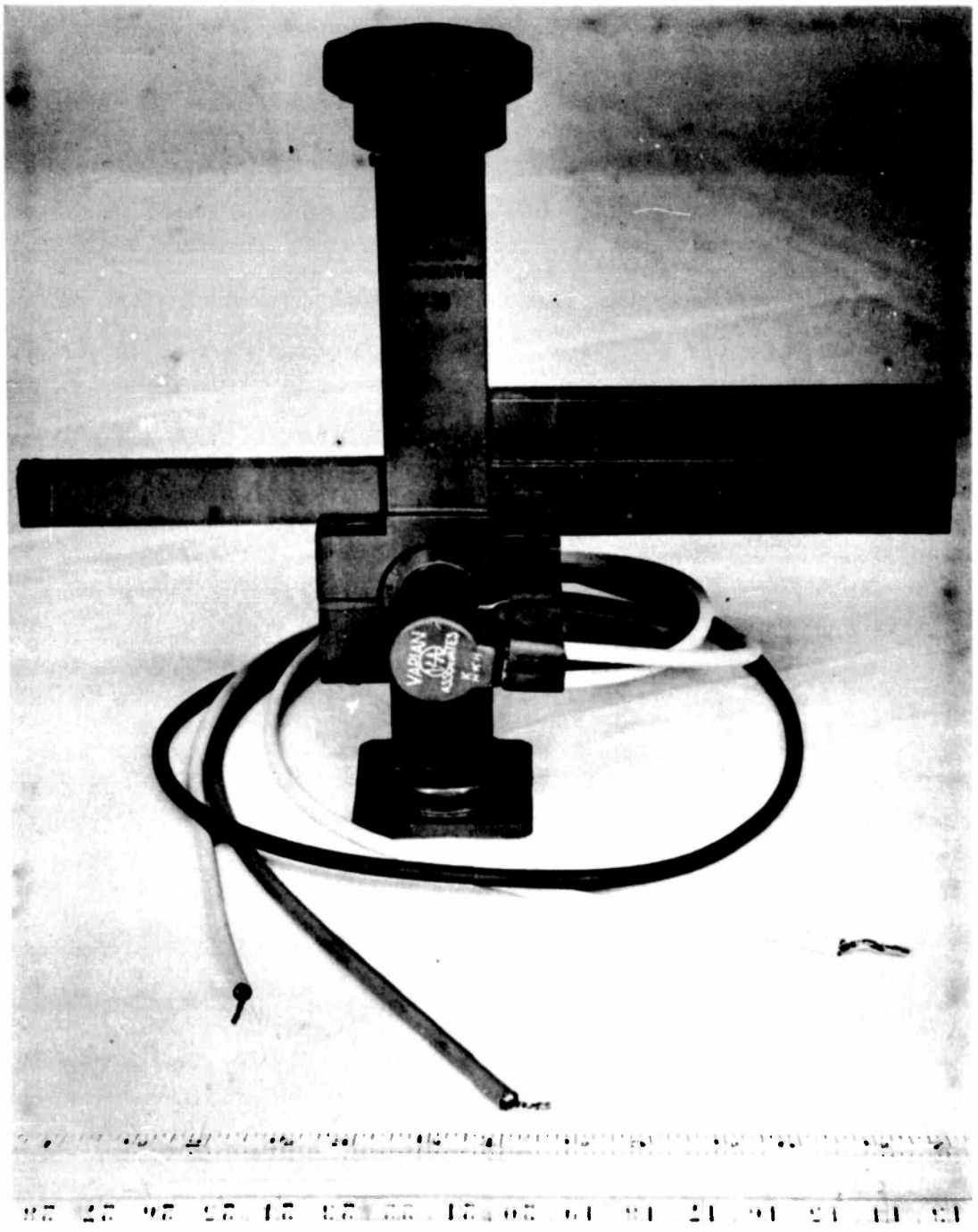


FIGURE 1

ASSEMBLED V-39 TUBE AND CAVITY

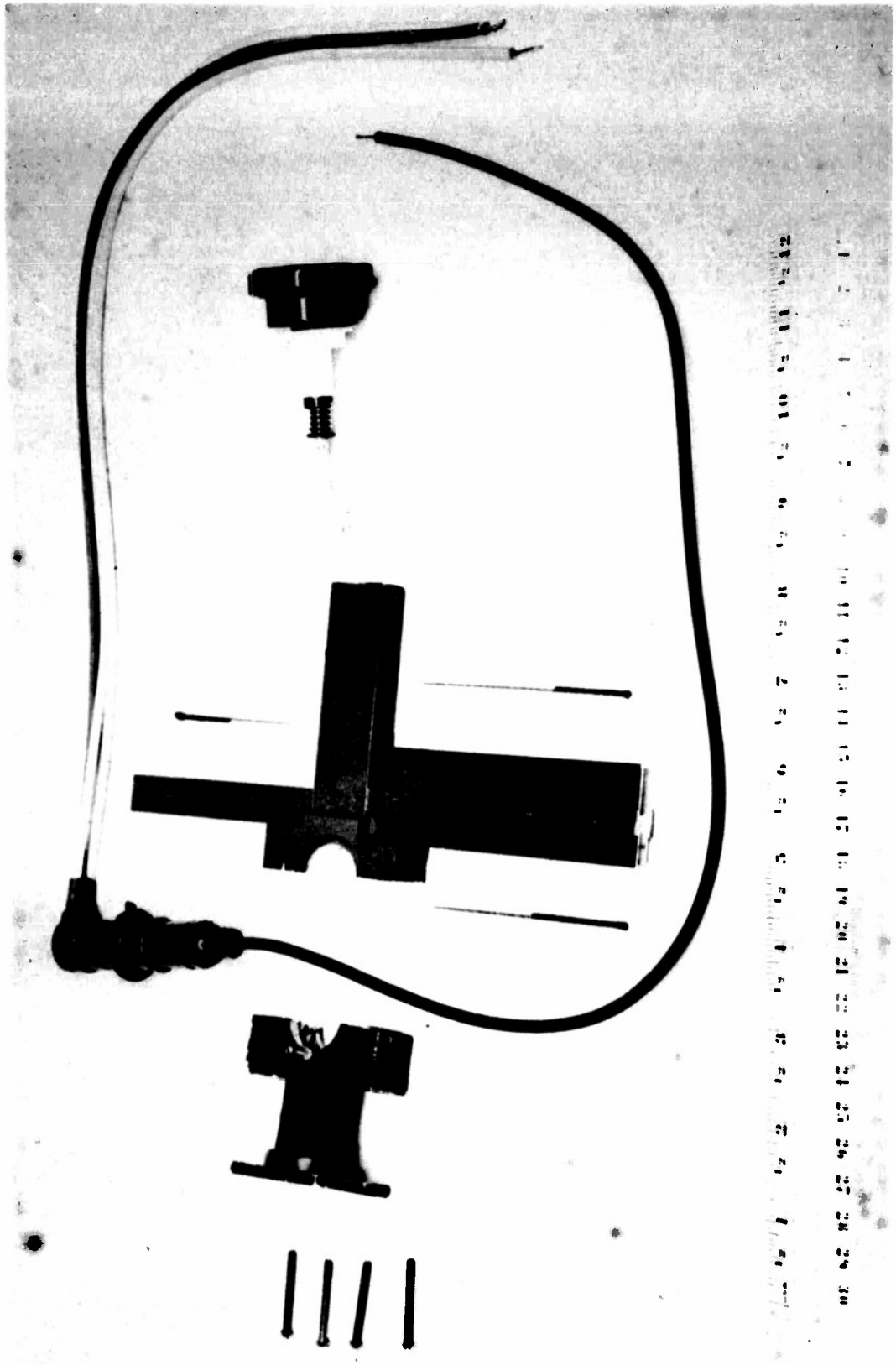


FIGURE 2

EXPLODED VIEW OF V-30 TUBE AND CAVITY

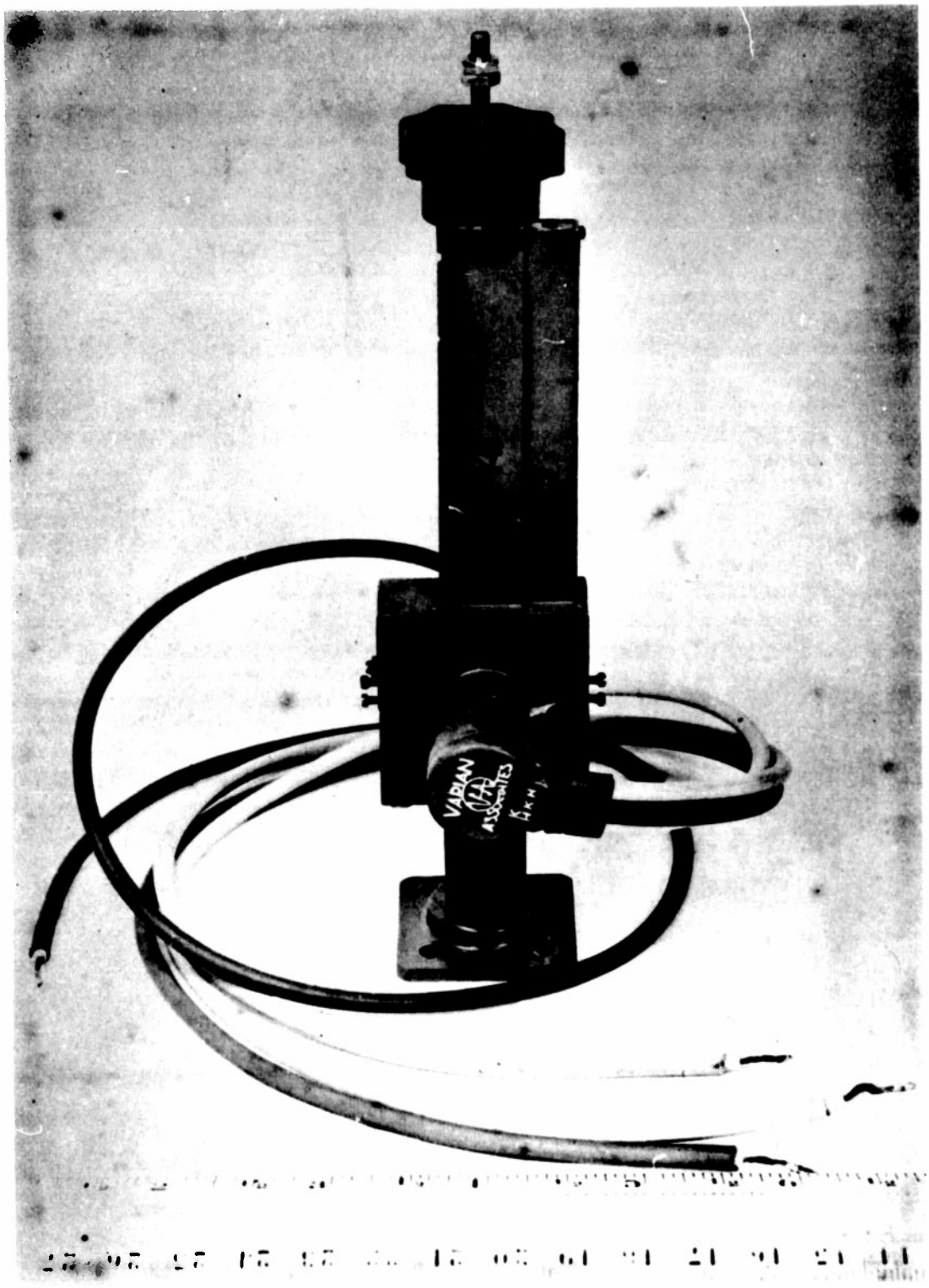


FIGURE 3

ASSEMBLED V-40 TUBE AND CAVITY

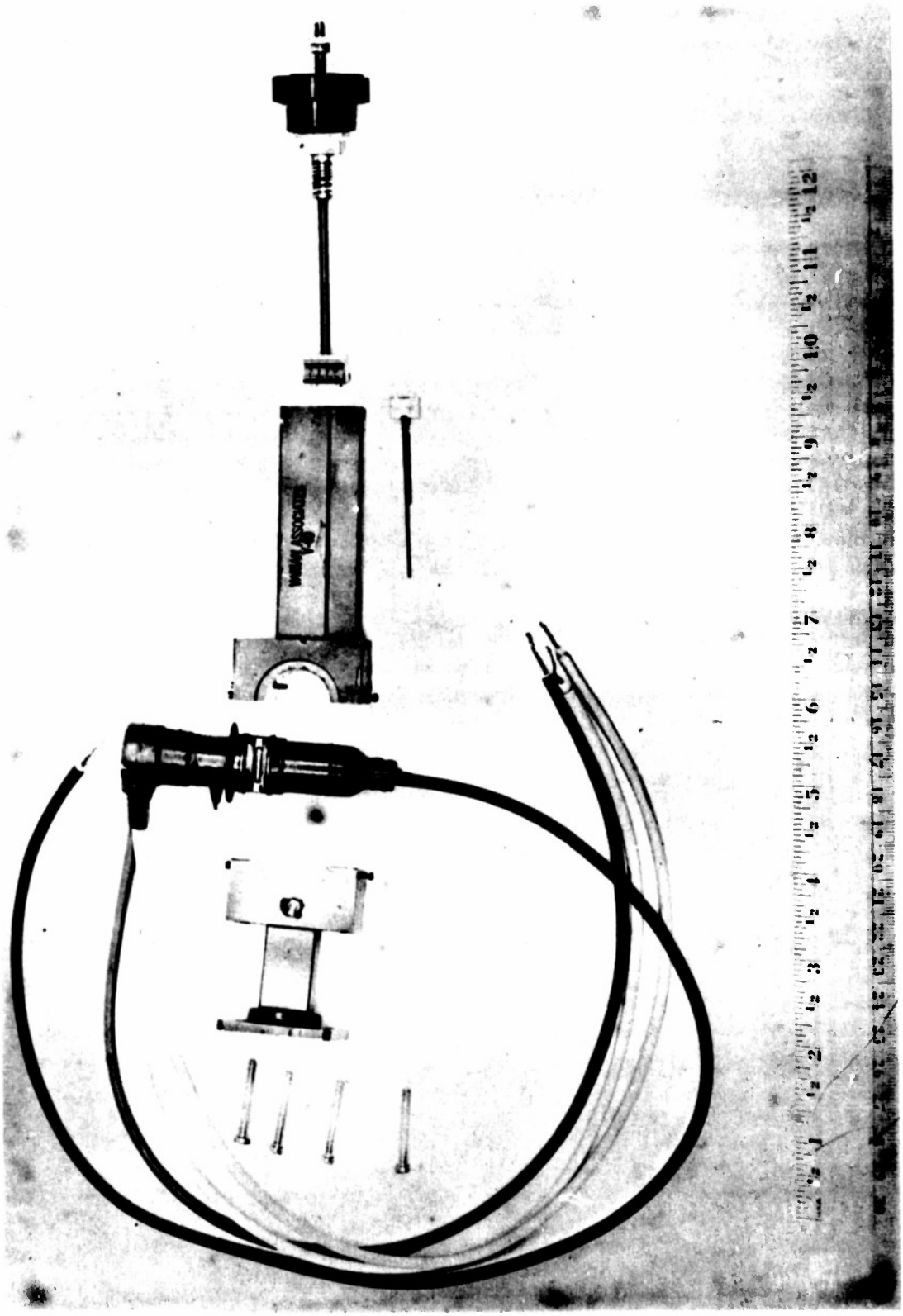
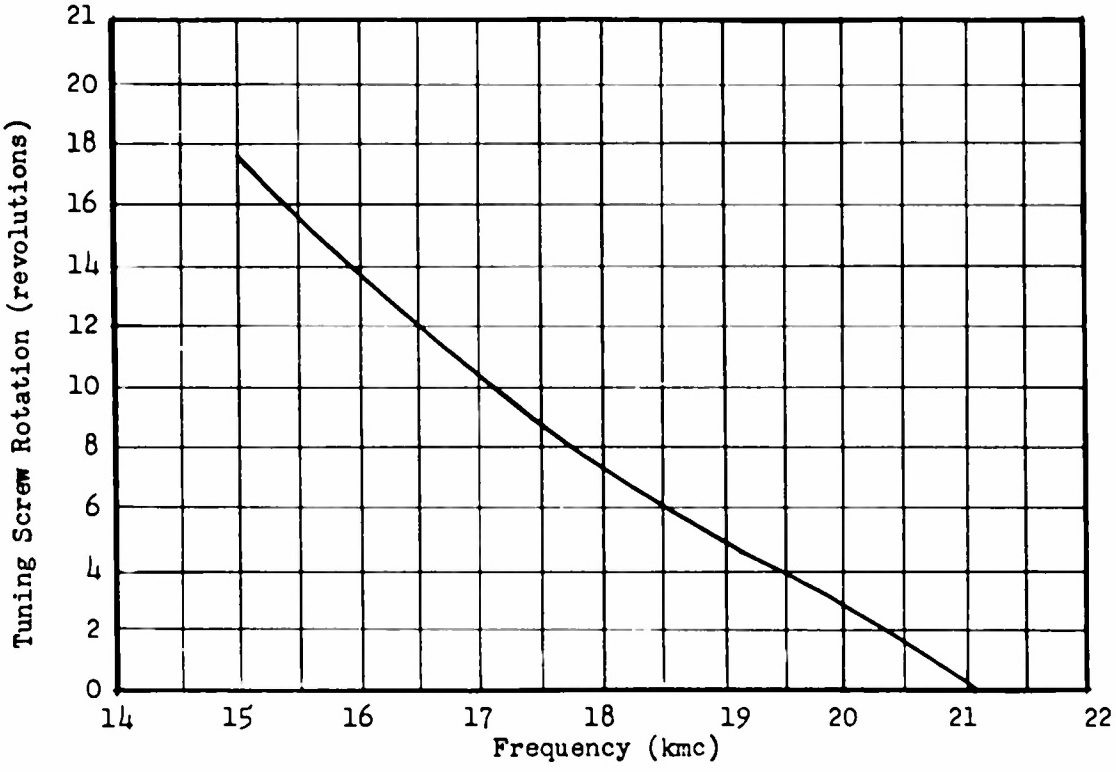


FIGURE 4

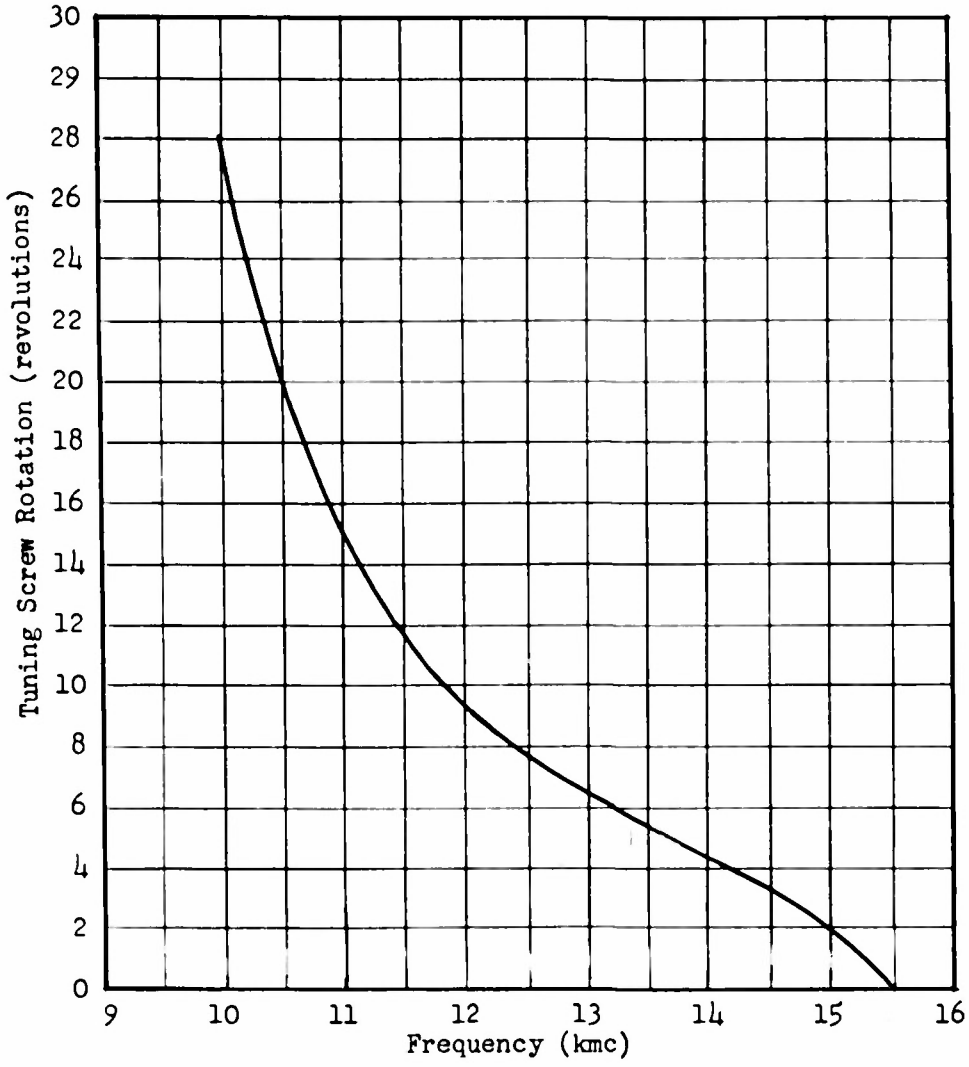
EXPLODED VIEW OF V-40 TUBE AND CAVITY



Reflector Mod. Sens. = 0.19 mc/volt @ 17 kmc
FM Noise (battery voltage on tube) ≈ 2 kc
FM Noise (a-c voltage on heater) = 30 kc

FIGURE 5

TUNING CURVE FOR V-40 TUBE NO. 54



Reflector Mod. Sens. = 0.17 mc/volt @ 12 kmc
FM Noise (battery voltage on tube) < 1 kc
FM Noise (a-c voltage on heater) < 2 kc

FIGURE 6

TUNING CURVE FOR V-39 TUBE NO. 20

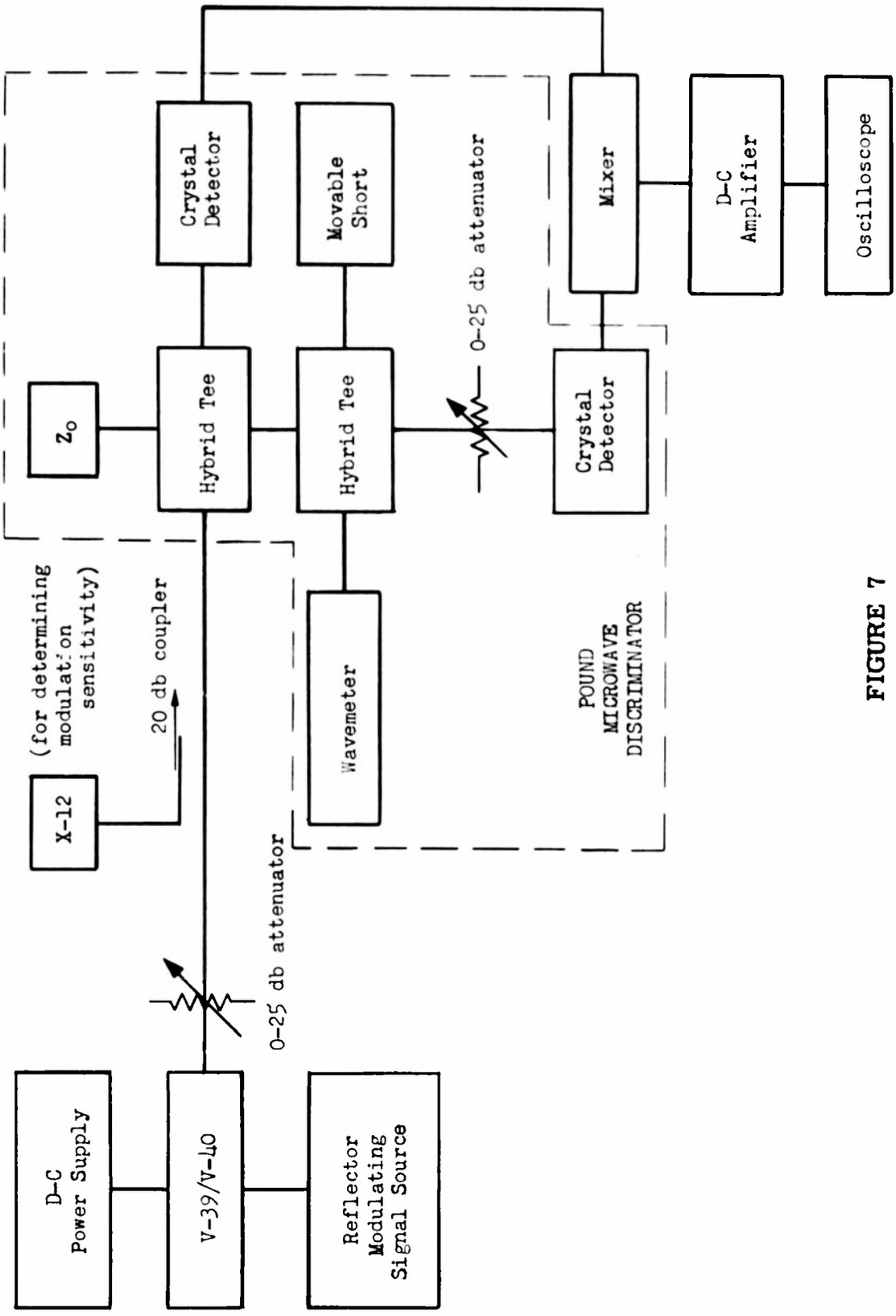


FIGURE 7

NOISE MEASURING SET-UP USING POUND MICROWAVE DISCRIMINATOR, BLOCK DIAGRAM