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V-52 KLYSTRON OSCILLATOR
DEVELOPMENT PROGRAM

Progress Report for
Quarter Ending 31 January 1954



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5413-55825

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Engineering Report
No. 101-26

Copy No. 5

V-52 KLYSTRON OSCILLATOR
DEVELOPMENT PROGRAM
Progress Report for
Quarter Ending 31 January 1954

Prepared for: Bureau of Ships
Navy Department

On: BuShips Contract NObsr-52503
Index No. NE-110420

By: Peter H. Kafitz

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

U. S. MILITARY ORGANIZATION

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PURPOSE

The original purpose of the program covered by BuShips Contract No. NObsr-52503 was to develop a rugged local oscillator to comply with the Bureau of Ships Contract Specification SHIPS-O-419, dated 15 March 1951, which was subsequently modified at a conference held at the Bureau of Ordnance, Washington, D.C. on 20-21 May 1952 and later at a conference held at Varian Associates on 29-30 September 1952. The tube was to be a reflex klystron operating in the frequency range from approximately 8.5 to 9.6 kmc, and its performance was to be similar to the 2K25 except for severe restrictions on frequency drift with temperature, frequency change due to shock, and FM noise due to vibration.

An amendment to Contract No. NObsr-52503 executed on 10 July 1953 changed the scope of this contract to incorporate additional development work, as follows:

- I. Additional design work in connection with the prototype tube meeting the "1000-Tube Production Refinement Order Specification."
- II. Long-range extended development including:
 - A. Broadband matching to load: Elimination of the matching screw in the output iris to simplify the use of the tube.
 - B. Conduct an investigation to improve repeller or modulation sensitivity and reduce sensitivity variations over the frequency range and from tube to tube.
 - C. Elimination of undesirable modes.
 - D. Increase mechanical tuning range from 8.8 - 9.6 kmc to 8.5 - 9.6 kmc.

The product of the extended development program will be designated the VA-158, to differentiate it from the V-52 developed on the original contract.



GENERAL FACTUAL DATA

Since this contract has only one additional month to run, the progress described in this report is essentially the extent of the work to be covered in this program. The remaining time in the program will be devoted to completing unfinished business and to building a few sample tubes for delivery.

All of the objectives listed in the Purpose section of this report, with the exception of increasing the modulation sensitivity, have been attained. Specifically, the extended tuning range of 8.5 to 9.6 kmc has been realized. A good match has been obtained over this tuning range without necessitating adjustment. All of the r-f characteristics of the tube, including the modulation sensitivity, have been made more uniform over the range.

In addition, repositioning of the mode suppressing screws in conjunction with a cavity redesign and the use of the broadband output tuner have greatly lessened the moding problem. On the basis of the few tubes built to date, it appears possible to eliminate the unwanted modes completely without adjusting the mode suppressors.

In addition to the objectives outlined above, the mechanical design of the VA-158 is such that this tube should be easier and less expensive to produce than the V-52. The tuning screw, which is the only remaining adjustment, has been redesigned to eliminate the need for the lock nut.

No major improvements have been made in temperature compensation. The VA-158 is more repetitive than the V-52, that is, repeated tests on the same tube give the same frequency drift; however, the random variation from tube to tube does not appear to be improved.



DETAILED FACTUAL DATA

Introduction

The problems of wide tuning range, uniform r-f characteristics, broadband matching, and mode suppression are all physically interrelated, and it is difficult to separate them for the purposes of this report. However, an attempt has been made to cover them in the order in which they were encountered.

A summary of the data gathered from the VA-158 tubes completed is included as Table I of the report.

TABLE I
SUMMARY OF VA-158 TUBE DATA

Federal Mode = 350v beam voltage
Convair Mode = 300v beam voltage

Tube No.	Mode	Power Output		Bandwidth		Modulation Sensitivity		10-Minute Warm-up Drift	
		Min (mw)	Max (mw)	Min (mw)	Max (mw)	Min (mc/v)	Max (mc/v)	Min (mc)	Max (mc)
10	Federal	98	172	32	82	1.2	2.0		
11	Federal	88	158	20	72	0.7	1.3		
12	Federal	79	138	38	74	1.1	1.8		
13	Federal	106	162	50	100	1.3	2.5		
14	Federal	78	100	43	63	1.2	1.9	- 5.8	- 13.0
	Convair	26	39	49	60	1.9	2.4		
15	Federal	106	123	41	65	1.2	1.8	- 0.2	- 2.8
	Convair	35	55	44	74	2.0	3.2		
16	Federal	112	131	42	52	1.1	1.7	0.0	- 3.0
	Convair	49	59	46	60	1.9	3.1		
17	Federal	99	123	36	41	1.2	1.6	+ 0.8	- 2.0
	Convair	41	53	36	47	2.2	3.3		
18	Federal	105	154	46	65	1.5	1.9	+ 0.6	- 2.0
	Convair	44	71	49	56	2.4	3.0		
19	Federal	110	136	41	44	1.2	1.6	+ 2.7	0.0
	Convair	50	65	42	49	2.0	3.3		

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Tuning Range and Uniform R-F Characteristics

After making the basic mechanical transition from the V-52 to the VA-158, the first developmental problem was to attain the required r-f performance over the extended tuning range of 8.5 to 9.6 kmc. To increase the tuning range of an externally tuned tube such as the VA-158, it is necessary to increase the coupling between the internal and external cavities. This was first done by increasing the loading at the output window of the tube without changing the size or position of the window. The results obtained were at least partially satisfactory in that close to the minimum required power output could be obtained over the extended tuning range (see data for tubes No. 10 to 13 in Table I); however, all the r-f characteristics showed about a 2:1 variation over the range.

It was believed that this variation could be eliminated by optimizing the various cavity parameters; however, tests on the VA-116 (Johns Hopkins University P.O. No. 44424) showed that a very significant improvement could be achieved by increasing the size of the coupling window. A somewhat oversimplified explanation of this method is as follows: By building a larger window less loading of the tube is required for the same degree of coupling. Because it is less loaded, the tube is operating farther from resonance, and hence, the coupling varies less with frequency. Since the coupling varies less, the power, bandwidth, and modulation sensitivity, which are functions of the coupling, are more uniform over the tuning range.

Six tubes with windows larger by a factor of 1.4 have been completed. The results obtained (see data for tubes No. 14 to 19 in Table I) are very encouraging. The overall performance has been improved, the variation with frequency has been decreased, and, perhaps most important, all the r-f characteristics reach a maximum at the center of the tuning range rather than at the high end. Based on these data, it has been decided to standardize on a window of this size.

The larger window does not appear to be more difficult to seal to the body than the one previously used. In general, because of the new

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construction in which the window is loaded by a screw, the wide window is considerably easier to install. After the tube body is complete, the window-loading screw is adjusted and soldered in place.

Broadband Matching

As was stated in the previous quarterly report¹, the broadband matching problem was attacked by first measuring the output characteristics of a number of tubes. Several possible matching devices were indicated by these data; however, because the output characteristics are dependent on the other parameters of the tubes, no final decision could be made until these parameters were fixed. For the first half of the present quarter, the output problem was investigated in a general way. With the decision to use the large window and to freeze the design of the other cavity parameters, it was possible to design two suitable matching devices.

The first broadband output tuner consists of the usual external cavity and output iris, with the addition of a second larger iris placed a short distance down the output waveguide. The cavity and two irises are built as a single unit which is only 0.4 inch longer than a tuner without the matching device. With proper initial adjustment of both irises, it is possible to obtain matched powers of at least 90 per cent optimum power over the tuning range.

The second matching device is an outgrowth of the first. It consists of a short section of narrow waveguide connecting the external cavity with the output waveguide. This section is loaded capacitively at its center, forming a low-Q resonant iris which is tuned below the operating range of the tube. In this way, the coupling increases rapidly with decreasing frequency. At high frequencies the width of the iris or guide is such that it approaches cutoff and the coupling increases. This combination of effects gives the U-shaped coupling curve needed to give a uniform match over the range.

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The second matching section adds only 0.35 inch to the overall length of the tube and tuner. With proper adjustment, the first broadband tuner gives a more uniform match; however, adjustment of the second is simpler and less critical. For this reason the latter will be used.

Spurious Mode Suppression

With the fixing of the window size and cavity parameters and the use of the broadband output tuner, attention was then turned to the problem of suppressing spurious modes. Three factors have greatly improved the moding problem of the VA-158 over that of the V-52. First, the increased coupling between internal and external cavities by the adoption of the larger window has increased the frequency separation between modes. That is, the one-half wavelength mode has been reduced in frequency and the three-halves wavelength mode has been increased. Second, the use of the broadband output with its increased coupling at low and high frequencies loads the unwanted modes more than the desired mode. And third, the change in mechanical construction permits the mode screws to be placed in more effective positions.

All of the above factors combined to solve the moding problem without any further development work. Based on the six tubes built to date, both of the unwanted modes can be eliminated with a fixed setting of two mode screws. There is about a five per cent loss in power of the main mode at either end of the tuning range.

Mechanical Development

The external tuner of the VA-158 has been modified slightly to permit its fabrication of punched or drawn parts. This modification is in the form of full radii on the ends of the tuner cavity. It is doubtful that there will be time actually to make a cavity of such parts.

A second change has been the development of a locking device for the tuning screw which eliminates the need for the lock nut. This device provides a friction load which prevents the screw from moving during vibration

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or shock but which allows the screw to be turned easily with a screw driver.

Figure 1 shows a complete VA-158 with broadband tuner, with the mode screws and output screw soldered in place. The overall dimensions are a length of 2.0 inches and a width of 1.7 inches. Future tubes will be shortened to 1.9 inches by moving the pumpout tubulation from the rear of the tube.



PROGRAM FOR NEXT INTERVAL

During the next interval, several more VA-158 tubes will be completed. All available tubes of the most advanced design will be shipped as sample tubes as soon as possible.

Estimated expenditures during January 1954: \$6,675.00

Estimated man-hours during January 1954: 671

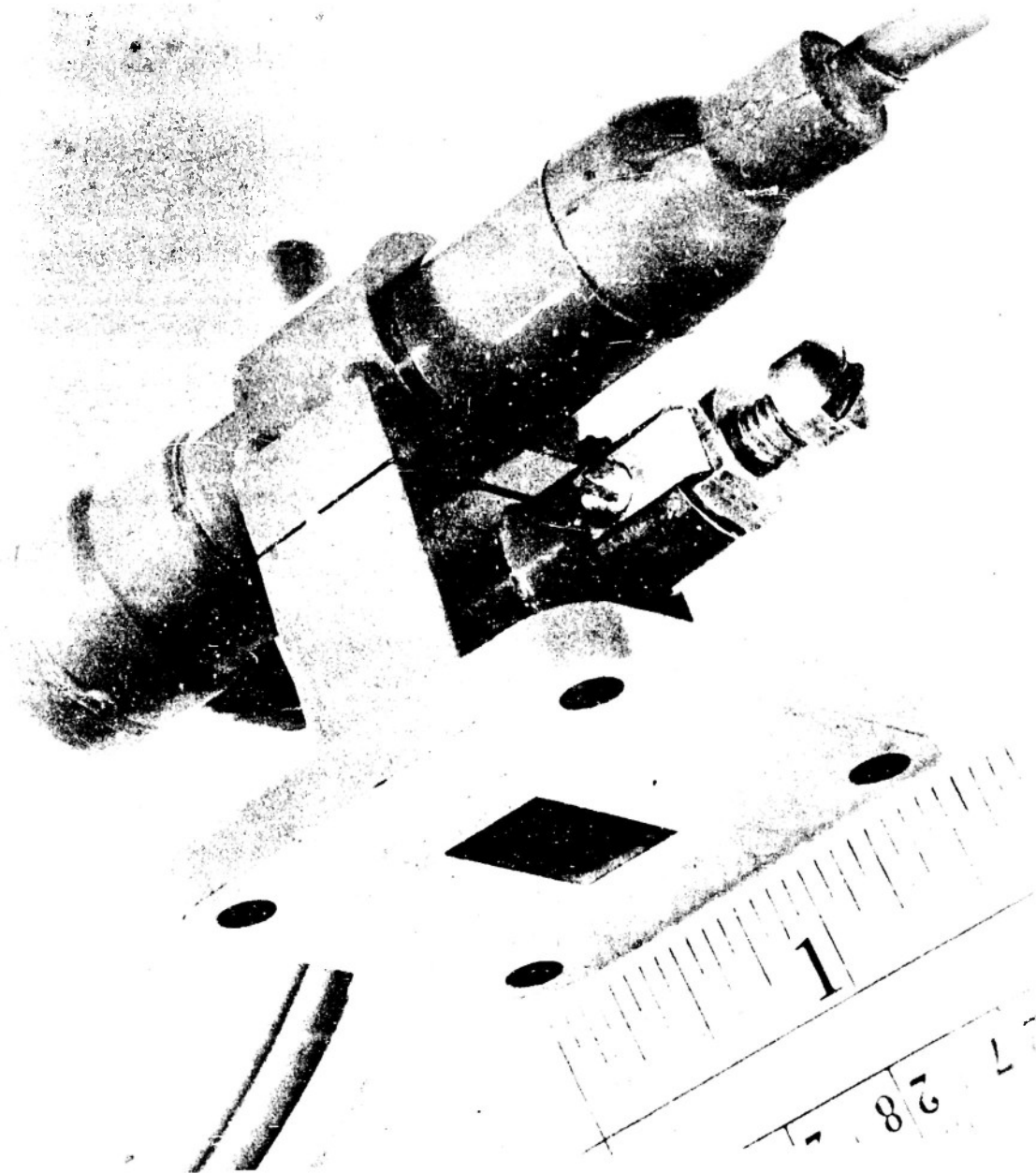


FIGURE 1
VA-158 WITH BROADBAND TUNER

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