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NRL REPORT 3738

FR-3738

A 1,000-MC WOBBULATOR

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Date: 26 JAN 2017
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NRL REPORT 3738

A 1,000-MC WOBBULATOR

R. M. Gran

September 6, 1950

Approved by:

Mr. H. O. Lorenzen, Head, Radio Countermeasures Branch
Mr. L. A. Gebhard, Superintendent, Radio Division II

DEPARTMENT OF THE NAVY ★ OFFICE OF NAVAL RESEARCH

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ABSTRACT

A 1,000-Mc wobbulator has been developed primarily for use in a system that gives a visual presentation of amplitude response curves for a 1,000-Mc amplifier. A tuned-plate, tuned-cathode coaxial cavity with the necessary controls is employed as a 1,000-Mc sweep generator. It has an amplitude output constant to ±0.3 db over the frequency range of 950-1050 Mc.

PROBLEM STATUS

This is an interim report; work on this problem is continuing.

AUTHORIZATION

NRL Problem R06-07R
NE 071-211

A 1,000-MC WOBBULATOR

INTRODUCTION

As part of a program for the development of microwave intercept receivers the feasibility of using 1,000-Mc grounded-grid coaxial amplifiers[1] is being investigated. To accelerate progress, a frequency-sweeping oscillator system was devised that gives a rapid visual indication of amplitude vs. frequency response. This system consists of a 1,000-Mc wobbulator (frequency-modulated signal generator), the 1,000-Mc amplifier under test, a broadband crystal detector, a d-c amplifier, and an oscilloscope.

A block diagram of a typical equipment setup for testing amplifiers is shown in Figure 1. The amplifier output is rectified by a broadband crystal detector,[2] amplified by a d-c amplifier, and fed directly to the vertical plates of an oscilloscope with provision for intensity modulation.

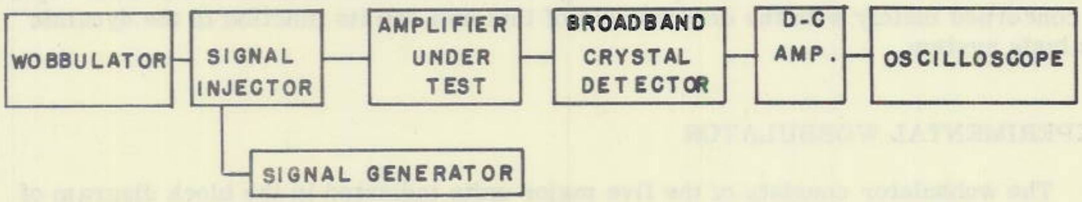

Figure 1 - Block diagram for dynamic analysis of band pass characteristics

The signal generator injects a CW signal into the wobbulator output by means of a capacity probe as shown in Figure 2. This signal provides frequency calibration for the horizontal sweep of the oscilloscope whereby determination of bandwidth, gain, and selectivity characteristics of the amplifier can be made.

The necessary requirement for the 1,000-Mc wobbulator was that it have an essentially constant amplitude output over a 100-Mc sweep. No equipment meeting this requirement

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[1] Weedman, W. F., "Development of a 1,000-Mc Intermediate Frequency Amplifier," NRL Report R-3531, September 19, 1949 (Confidential)

[2] Gran, R. M., "Development of a 1,000-Mc Broadband Crystal Detector," NRL Report 3620, January 26, 1950 (Confidential)

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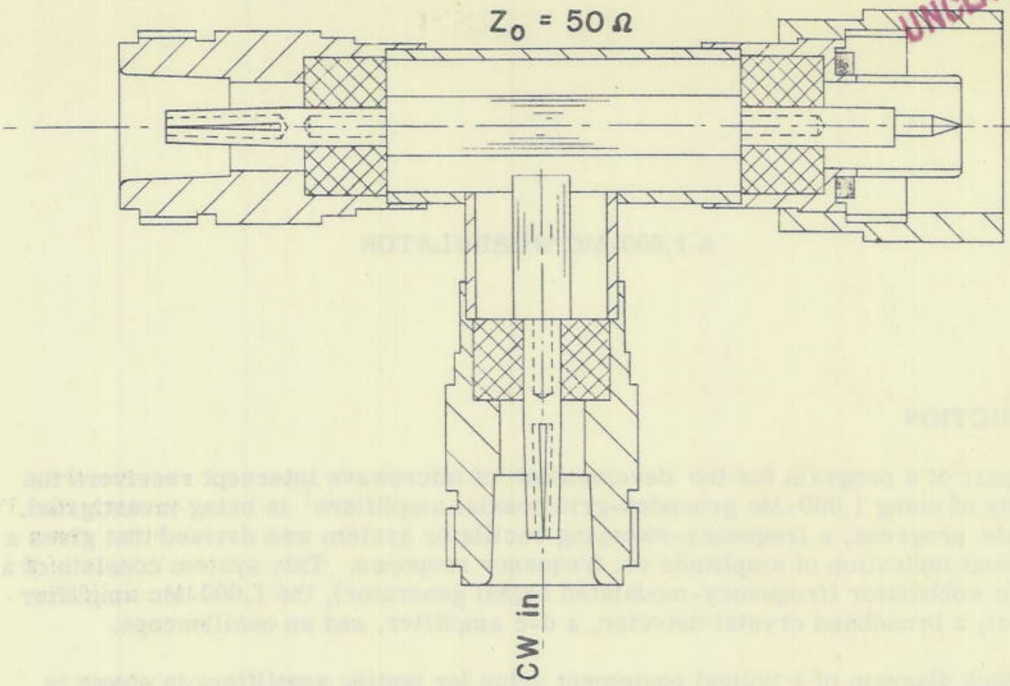

Figure 2 - Cross-section, signal injector (capacity probe)

was available, so it was necessary to design and construct a suitable unit. This report is concerned mainly with the development of this unit and its function in the dynamic analysis system.

EXPERIMENTAL WOBBULATOR

The wobbulator consists of the five major units indicated in the block diagram of Figure 3.

A 1,000-Mc oscillator was designed for operation with a 2C40 microwave triode. The assembled unit is shown in Figure 4 and the component parts in Figure 5. The plate

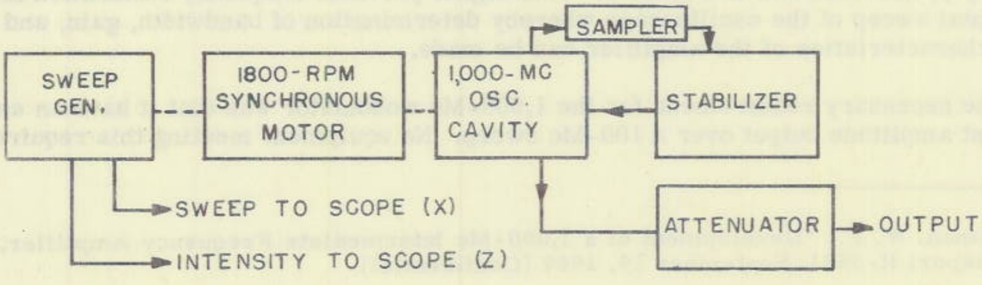

Figure 3 - Block diagram of wobbulator components

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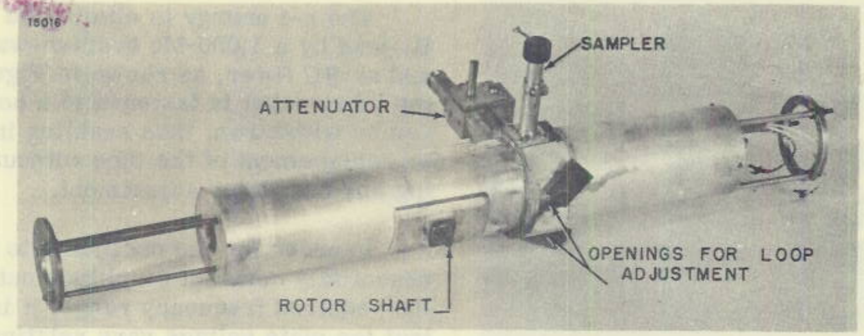


Figure 4 - 1,000-Mc experimental wobbulator

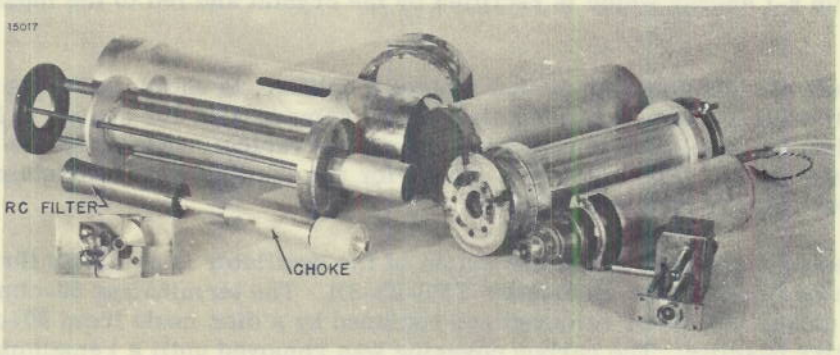
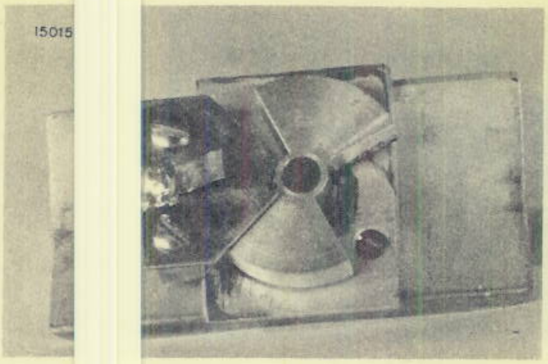


Figure 5 - 1,000-Mc experimental wobbulator, unassembled

and cathode cavities, located at opposite ends of the tube, are tuned by fingered shorting plungers that are moved by three equally spaced rods. In the plate cavity plunger, one of the rods is a length of 1/4-inch ID telescopic tubing that permits the entrance of a small pickup loop into the cavity. The loop was used in conjunction with a panoramic receiver during initial tests to determine the frequency range of the oscillator.

A rotor type variable capacitor (Figure 6) was designed to allow axial movement in the plate cavity for optimum positioning. A strip of 15-mil beryllium copper 1/8 inch wide was soldered to the bottom plate of the condenser for the purpose of making a sliding contact with the center conductor of the oscillator. The maximum size of the rotor assembly was limited by the available space. Semi-circular rotors made from various materials having high dielectric constants (such as "Textolite" and "Resinox") gave a maximum variation of 30 Mc. A semi-circular rotor of aluminum produced over 200-Mc frequency variation. As a result, an aluminum butterfly-type rotor was designed, the rotor having the advantage of mechanical balance. It provided a 100-Mc frequency variation.

The type and dimensions of the feedback loops were determined by experimentation. Each of the two final loops, radially spaced at 90 degrees, has one end connected to the center conductor of the cathode cavity, and the other end is looped into the plate cavity and fastened to the grid plane. They were adjusted through openings as shown in Figure 4.



Figu - Rotating capacitor assembly

The r-f energy is eliminated from the B+ lead by a 1,000-Mc quarter-wave choke and an RC filter, as shown in Figure 5, and the tube socket is fastened to a holder that can be withdrawn, thus enabling inspection or replacement of the tube without disturbing any oscillator adjustment.

In order for the oscillator to have an essentially constant amplitude output over the required frequency range, it is necessary that the plate voltage vary relative to the oscillator frequency. This is accomplished electronically by a sampler and stabilizer. The sampler, shown in Figure 4, is an attenuator with a crystal incorporated in the unit. A loop s up r-f energy which is rectified by the crystal and fed to the input grid of the stabili

T rcuit of the stabilizer, or d-c control amplifier, is shown in Figure 7. It has a regu B+ voltage and a balancing circuit that compensates for change of heater temperatu When the stabilizer is operating, the output varies inversely as the r-f power in the lator cavity. This control of the B+ for the oscillator tube maintains the oscillator r wer output constant to ±0.3 db.

Tl sentially constant amplitude output of the oscillator is available through a modifi andard microwave attenuator TPS-23-SH. The terminating 50-ohm disc resistanc d pickup loop were removed and replaced by a disc made from 50-ohms-per-square stive bakelite. The carbon covering was removed until a remaining radial strip, n in Figure 8, measured 50 ohms d-c resistance. This strip acts simultaneously as a 5 n termination and as a pickup loop with a minimum of inductance.

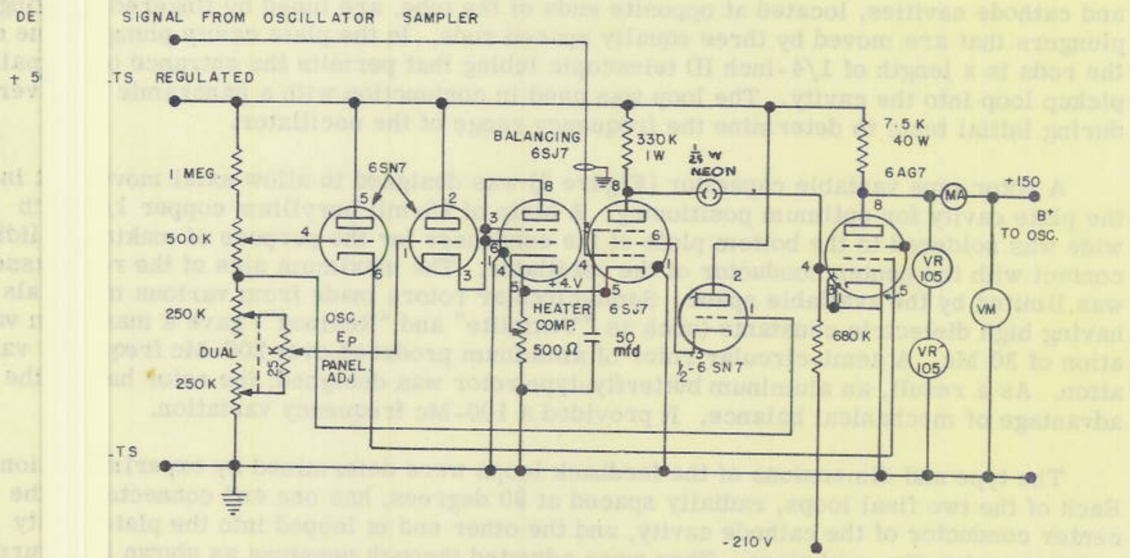


Figure 7 - Stabilizer circuit diagram

The horizontal sweep voltage for the oscilloscope is produced by a generator, the circuit of which is shown in Figure 9. The pulse that initiates the sweep is generated in the earphone coils when an iron disc is moved past the magnets. The iron is supported in a thick brass disc mounted on the shaft of the synchronous motor that rotates the condenser rotor (Figure 10). By a mechanical shift in the coupling to the motor, the synchronization of the horizontal time base for the oscilloscope can be phase-shifted relative to the frequency sweep of the oscillator.

There are four sweeps of frequency for each complete revolution of the variable capacitor. A choice of any one of the sweeps is procured by intensity modulation from the sweep generator and a mechanical shift in the coupling of the capacitor rotor.

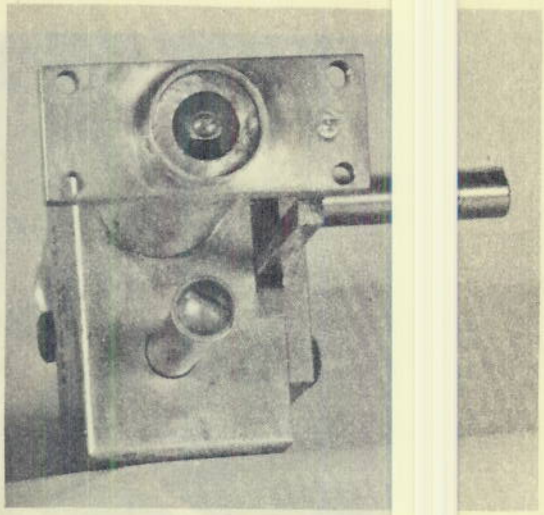


Figure 8 - Modified atte ır

The results obtained with this wobbulator unit were satisfactory in that a ı ɔ greater than 100 Mc was obtained with fairly flat output response. However, i ve- ments were needed because the unit was difficult to adjust and very unstable a ɜs. Spurious responses appeared on the sweep, and adjustments made to eliminate ı created other spurious responses. There was, moreover, insufficient output f ɜt purposes.

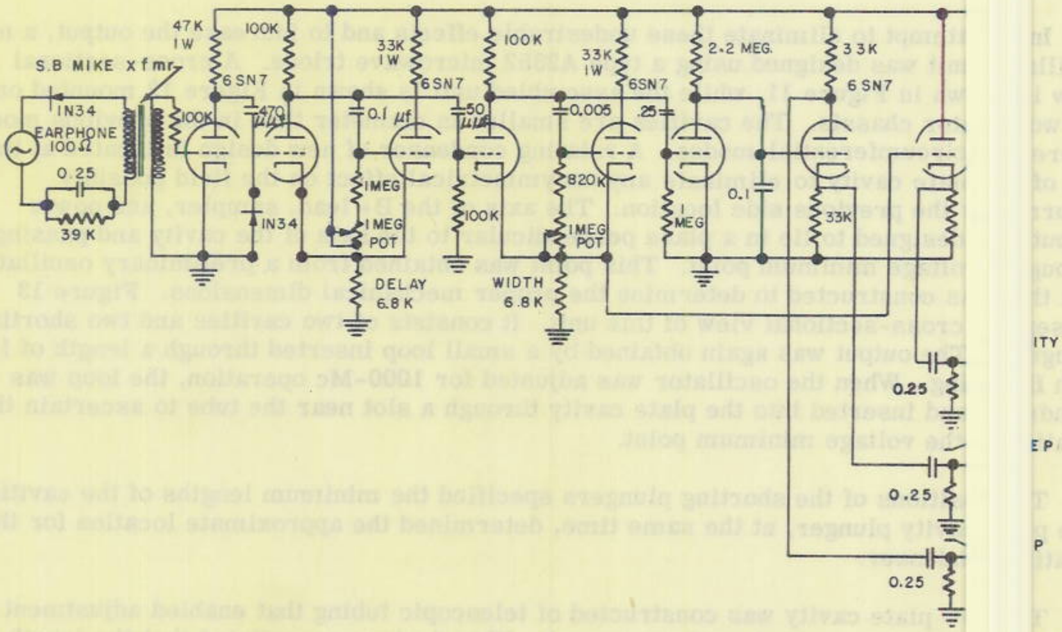


Figure 9 - Sweep generator circuit diagram

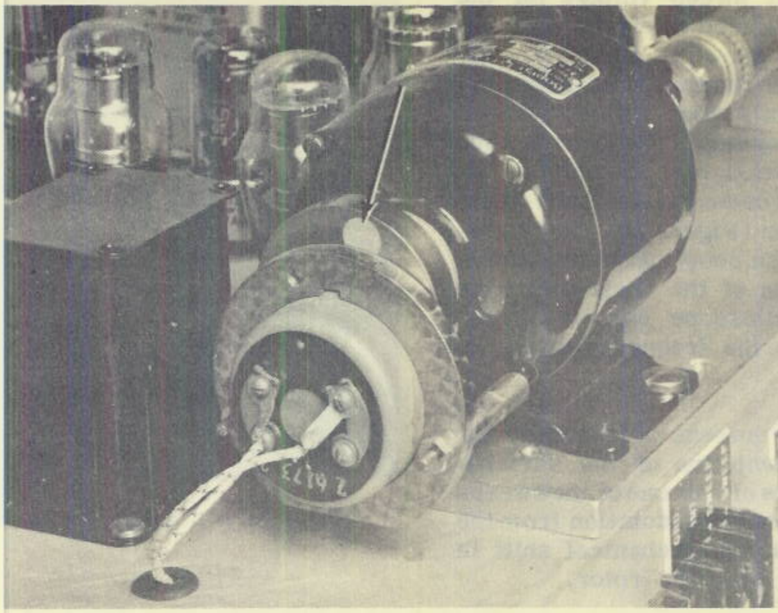


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Figure 10 - Iron disc

SECO ODEL OF WOBBULATOR

I ttempt to eliminate these undesirable effects and to increase the output, a new oscill nit was designed using a type A2352 microwave triode. A cross-sectional view i wn in Figure 11, while the assembled unit is shown in Figure 12 mounted on the wo ator chassis. The cavities are smaller in diameter than in the previous model to pre circumferential modes. A rotating condenser of new design is located at the end of plate cavity to eliminate any unsymmetrical effect on the field possibly incur the previous side location. The axis of the B+ lead, sampler, and power output designed to lie in a plane perpendicular to the axis of the cavity and passing throu oltage minimum point. This point was obtained from a preliminary oscillator unit t s constructed to determine the proper mechanical dimensions. Figure 13 prese cross-sectional view of this unit. It consists of two cavities and two shorting plung The output was again obtained by a small loop inserted through a length of 1/4-inch ing. When the oscillator was adjusted for 1000-Mc operation, the loop was withd and inserted into the plate cavity through a slot near the tube to ascertain the locati the voltage minimum point.

T sitions of the shorting plungers specified the minimum lengths of the cavities. The p avity plunger, at the same time, determined the approximate location for the rotati ndenser.

T w plate cavity was constructed of telescopic tubing that enabled adjustment of cavity th and amount of condenser mesh. This design necessitated that the length of the ca determined by the preliminary unit, be increased by one-half wavelength.

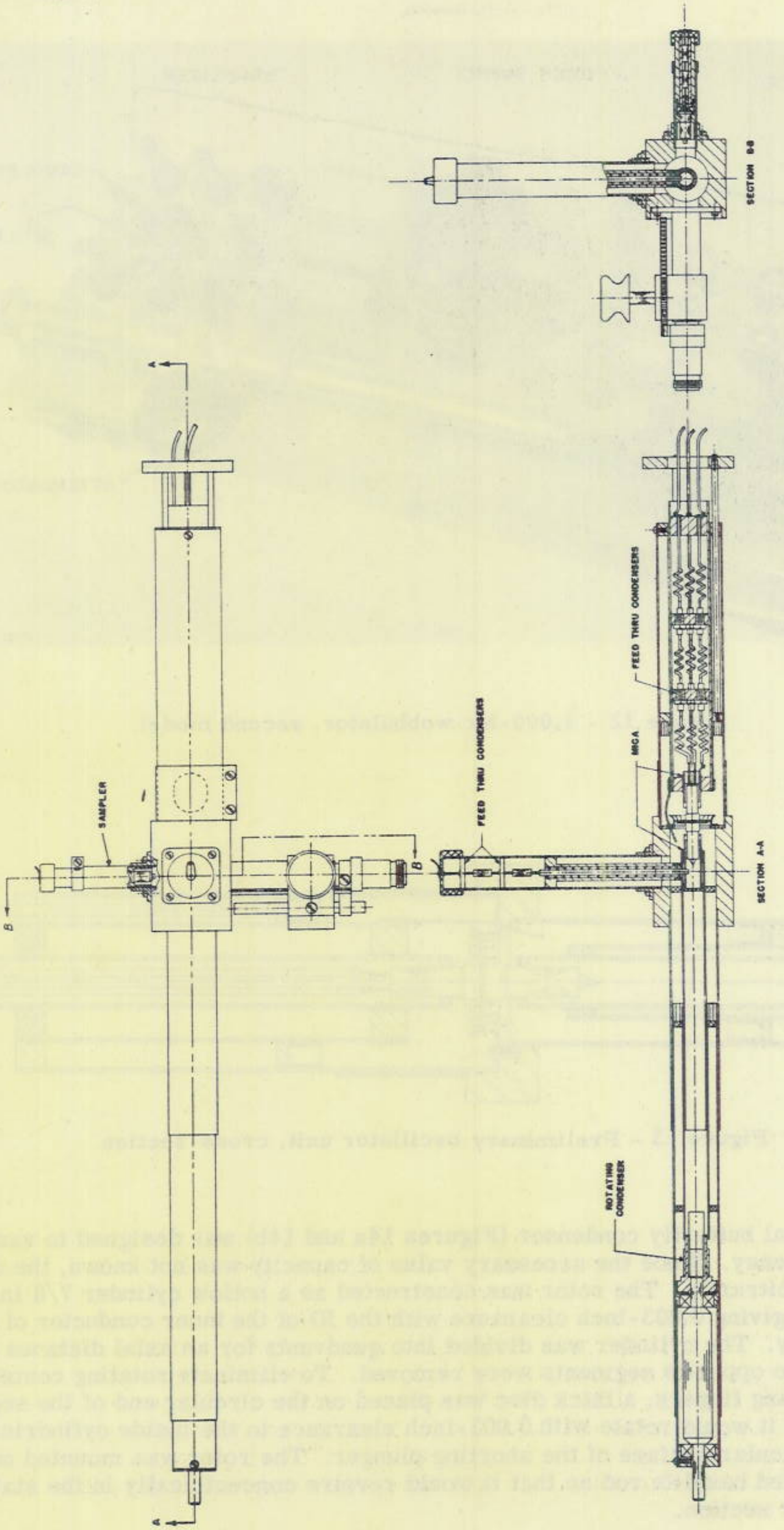


Figure 11 - Cavity assembly, cross-section

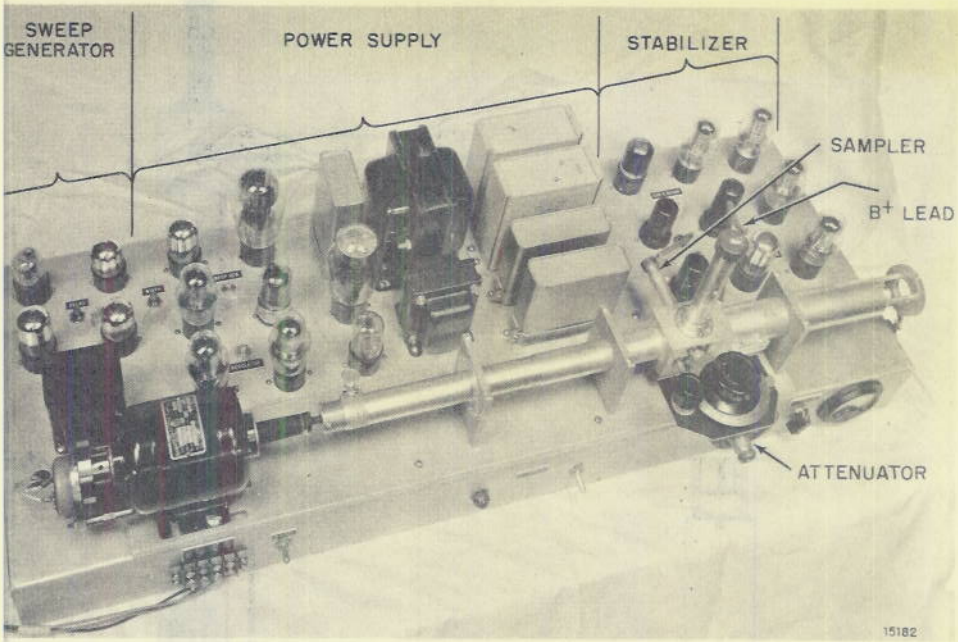


Figure 12 - 1,000-Mc wobbulator, second model

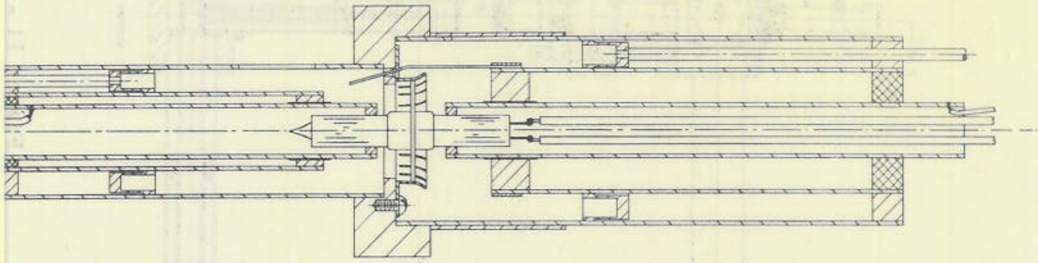


Figure 13 - Preliminary oscillator unit, cross-section

lindrical butterfly condenser (Figures 14a and 14b) was designed to vary the
osc r frequency. Since the necessary value of capacity was not known, the dimensions
wer sen arbitrarily. The rotor was constructed as a hollow cylinder 7/8 inch long
and an OD giving 0.003-inch clearance with the ID of the inner conductor of the
osc r cavity. The cylinder was divided into quadrants for an axial distance of 5/8
inch the two opposite segments were removed. To eliminate rotating contacts with
the y shorting fingers, a thick disc was placed on the circular end of the segmented
cyli so that it would rotate with 0.003-inch clearance to the inside cylindrical wall
and ack circular surface of the shorting plunger. The rotor was mounted on a
bea supported bakelite rod so that it would revolve concentrically in the stator part
of th ndenser section.

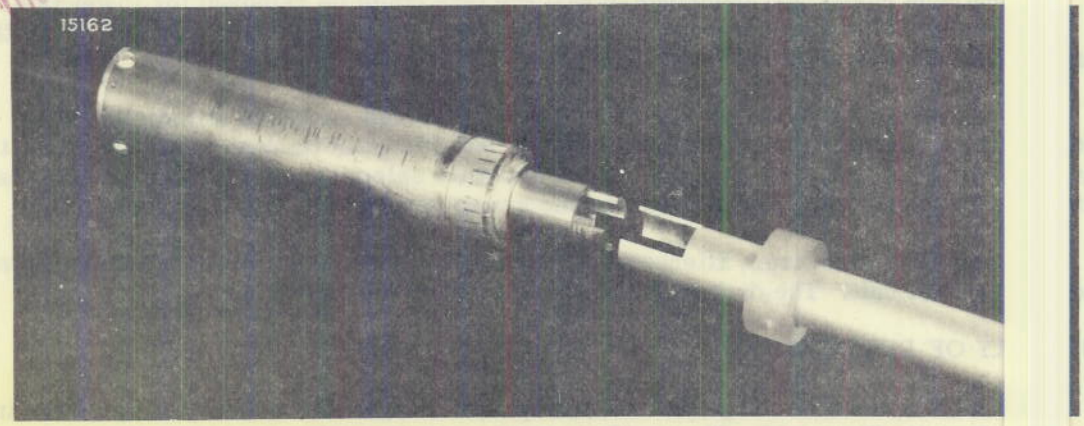


Figure 14a - Rotating condenser mounting

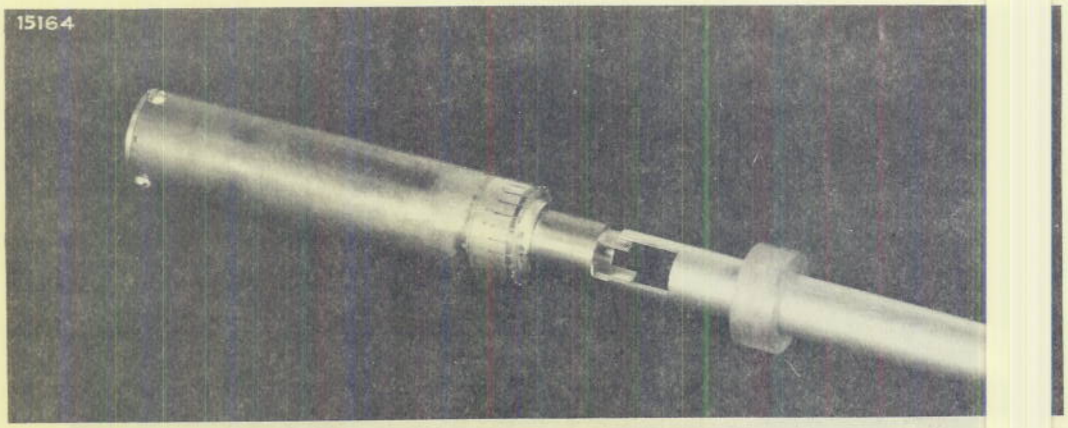


Figure 14b - Rotating condenser, partial mesh

When the rotor was operated at the position of maximum axial overlap, the f ency range of oscillation exceeded 100 Mc. A uniform decrease in the amount of ove resulted in a slow increase of range to a maximum and then a rapid decrease to at the position of no overlap. The amount of axial overlap required for 100-Mc ency range is approximately 1/16 inch. It was necessary to vary the cavity length si neously with condenser overlap in order to maintain 1,000-Mc operation. The sle n the rotor had no electrical effect but was left for rigidity.

The B+ connection to the plate of the tube was designed to have a minimum e on the oscillator. The B+ supply passes through an RC filter and then through the e of the center conductor of a coaxial line. This section is shorted at one-quarter w ngth from the center of the inner conductor of the oscillator cavity.

The feedback loops were again determined experimentally, optimum results g obtained with an insulated wire. One end was capacity-coupled to the inner conc r of the cathode cavity, and the other end protruded about 1/2 inch into the plate c .

cathode cavity was designed so that the tube could be removed for inspection or r :ement without disturbing cavity or feedback adjustments. R-F filters for both filaı and cathode leads were incorporated in the removable unit.

ing or the selection of one of the four sweeps can easily be accomplished by rota of the movable part of the plate cavity, but this must be done with care so that the y length will not be changed. More accurate selection can be obtained with the aid delay and width adjustments on the sweep generator.

sampler, stabilizer, attenuator, and sweep generator are identical to the ones usec he first unit. The dial on the attenuator reads directly in db.

SUM Y OF PERFORMANCE

re 15 is the test setup for the development study of the wobbulator as shown in the form in Figure 16. Figure 17 shows the output vs. frequency curve of the wob or as presented on the oscilloscope, after detection and amplification (2500 tim The injected signal for calibration appears at 1000 Mc.

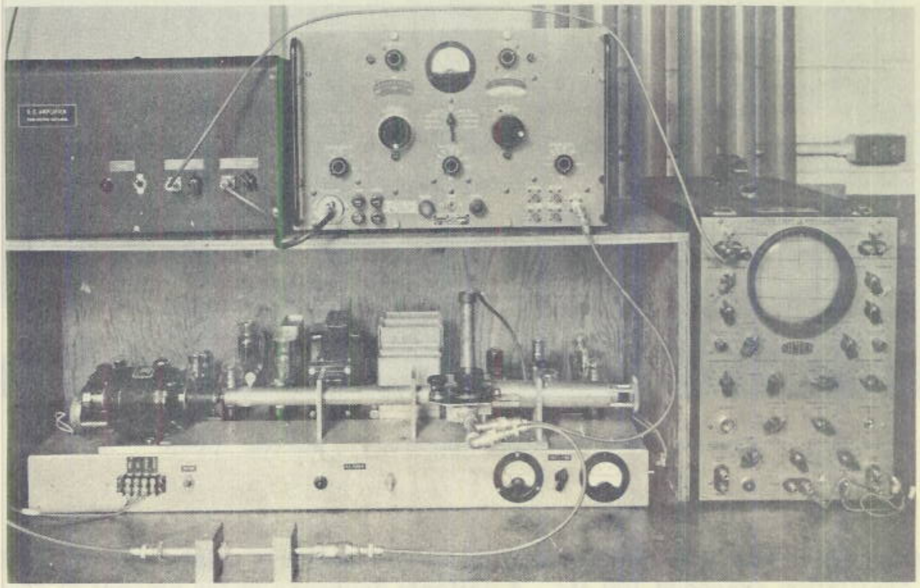
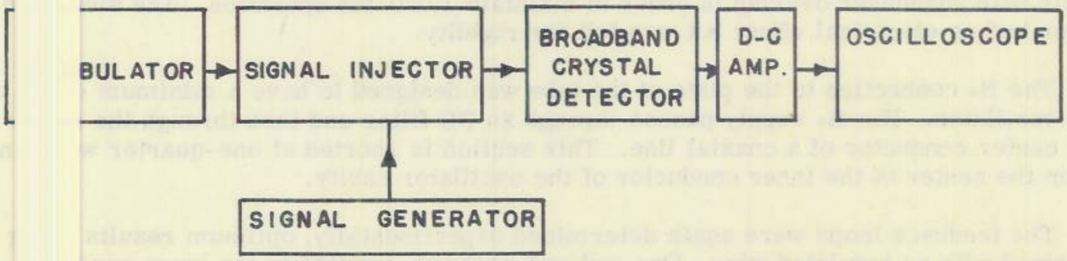


Figure 15 - Equipment setup for wobbulator development



igure 16 - Block diagram of equipment setup for wobbulator development

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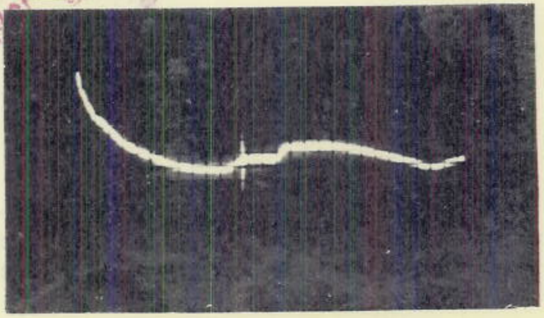
Figure 17 - Wobbulator output vs. frequency. Frequency marker at 1,000 Mc

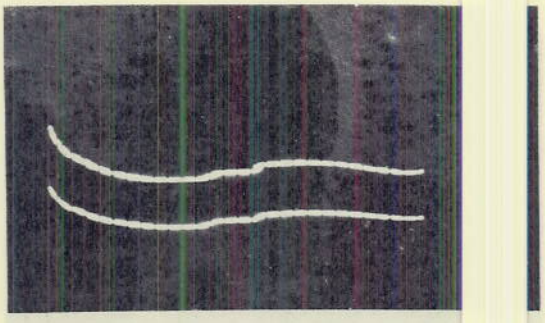
Figure 18 - Wobbulator output two different levels to determi linearity

Figure 18 is a double exposure of the wobbulator output at two different powe - put levels. The first exposure, or the upper trace, was the output of the wobbula hen the attenuator was set at a predetermined level. The output was then attenuated the upper limit of the sweep reached the reference line determined by the lower of the first exposure. The amount of attenuation required for this condition was), which indicated that the over-all linearity of the wobbulator output is ± 0.3 db.

Figure 19 presents the equipment arrangement for testing a 1,000-Mc coaxi amplifier. Figure 20 is a typical amplitude vs. frequency response curve of a 10 Ic amplifier obtained by this system. The injected CW signal that provides freque calibration for determination of bandwidth, gain, and selectivity characteristics visible at 990 Mc.

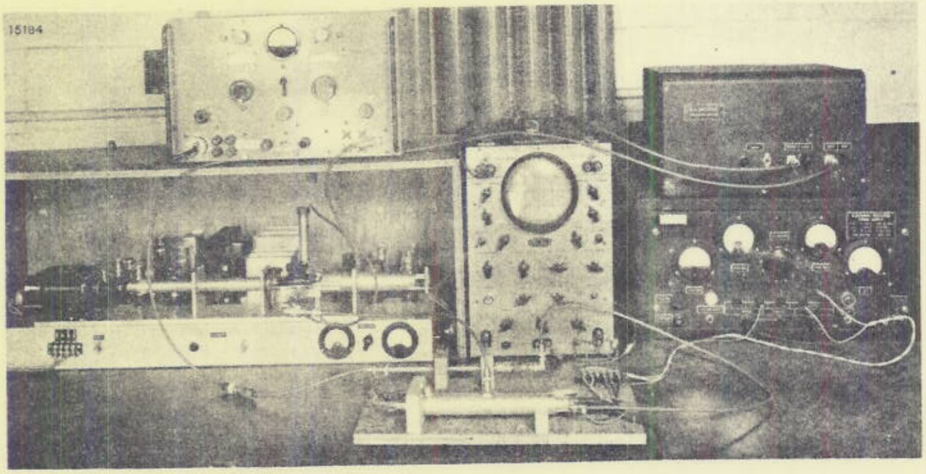

Figure 19 - Equipment setup for testing a 1,000-Mc amplifier

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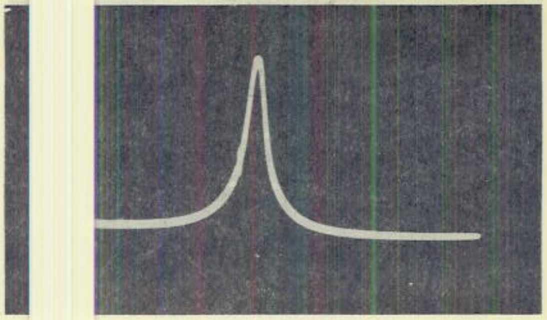

Figure 20 - Typical amplitude vs. frequency response curve of a 1000-Mc amplifier. Frequency marker at 990 Mc

CO JSIONS

new wobbulator developed has proven to be very satisfactory. It has been used con usly for a period of over two months in determining the characteristics of several gro l-grid coaxial amplifiers. By the use of this method data have been acquired in a s fraction of the time required by the point-by-point method previously necessary for -Mc amplifier investigations.

ACI VLEDGMENT

author wishes to express his appreciation to Henry K. Weidemann of the Counter-mea s Branch, NRL, for his aid and guidance in this project.

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