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AN F-M TEST SET FOR MICROWAVE OSCILLATORS

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AN F-M TEST SET FOR MICROWAVE OSCILLATORS

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September 27, 1948

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ABSTRACT

Previous methods of analyzing the low-frequency noise spectrum of microwave oscillators have employed the usual scanning type spectrum analyzer or an arrangement of fixed-tuned filters. The visual presentation of the spectrum analyzer makes high accuracy difficult, while a series of filters does not provide the necessary frequency discrimination. The present system makes use of a chart recorder to present noise level versus frequency as a continuous plot from 0 to 16,000 cycles.

PROBLEM STATUS

This is an interim report on problem R04-12D; work is continuing.

AUTHORIZATION

NRL Problem R04-12D (Bureau of Aeronautics project TED NRL AE-9110).

AN F-M TEST SET FOR MICROWAVE OSCILLATORS

INTRODUCTION

The recent revival of interest in continuous wave radar systems has greatly intensified the investigation of c-w oscillators. In the pulse-oscillator field the main emphasis has been on high peak power, long life, high efficiency, etc. The c-w oscillators on the other hand operate at relatively low power and, due to the impossibility of using transmit-receive devices in continuous operation, a duplexing device is used, in which case the matter of noise modulation is perhaps the greatest problem in need of solution. The noise consists of both amplitude and frequency modulation of the carrier caused by power supply ripple, microphonics, etc.

In connection with problem R04-12D (Development of Radio Ground-Speed Indicator) it was considered desirable to have a means of determining quantitatively the amount of spurious modulation in a given magnetron to permit selection of satisfactory tubes for flight tests and as an aid in isolating the sources of noise in the system.

It has been found in the past that one of the most serious problems in the Ground Speed and Drift Indicator is an f-m altimeter effect due to spurious frequency modulation on the magnetron. Although the test set herein described can be adapted for measurement of a-m modulation, its main use in the project has been as an f-m analyzer.

DESCRIPTION

Figure 1 is a block diagram of the analyzer as used for f-m analysis. The magnetron under test is fed by anode and filament supplies of high stability. The magnetron output is beat against a stable klystron of the 2K39 type in a crystal mixer, the mixer output being fed to an f-m receiver. The voltage developed across the discriminator of this receiver is proportional to the frequency deviation of the magnetron carrier. This information is then fed to a Hewlett-Packard, Model 300A, wave analyzer, which is coupled mechanically to a Sound Apparatus Company, Model FR-1, power-level recorder.

The chart paper in the recorder has a frequency scale which corresponds to that of the wave analyzer. The ordinate of the chart can be calibrated in frequency deviation and the abscissa in modulating frequency of the fm. The dynamic range of the instrument is approximately 60 db extending from 200 cycles to 200 kilocycles deviation.

Two sample charts are shown in Figure 2. Curve A was obtained with no mechanical excitation while Curve B was obtained while a knocker mechanically shocked the tube.

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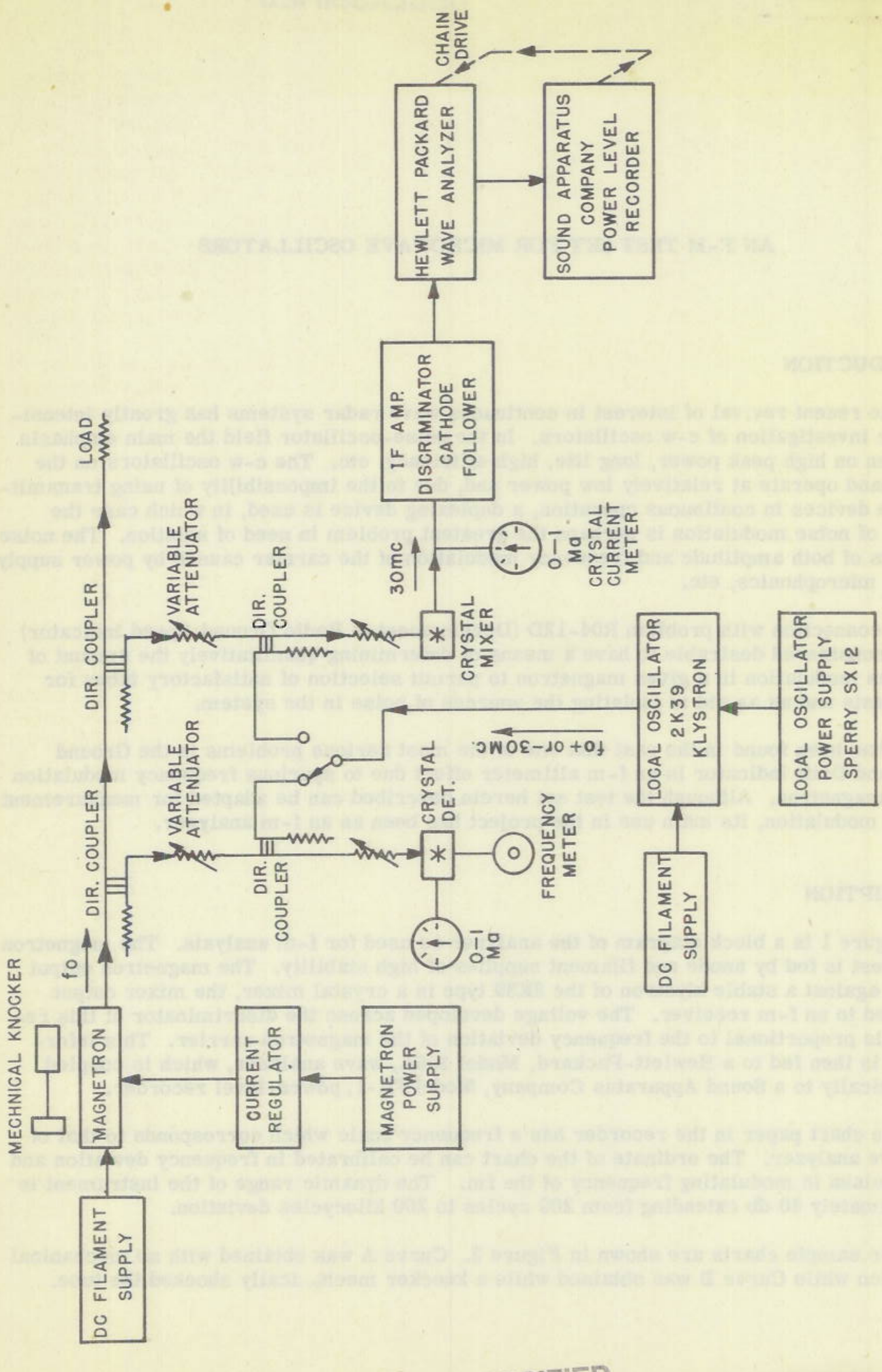

Fig. 1 - Block diagram of test set

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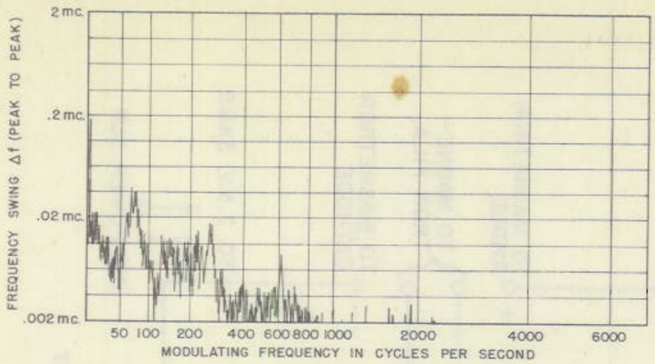
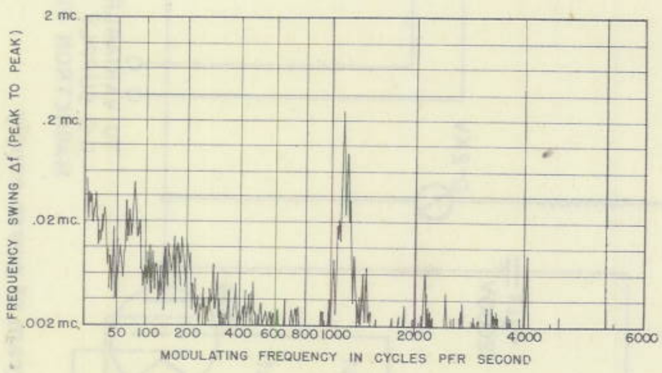


Curve A



Curve B

Fig. 2 - Sample chart

POWER SUPPLIES

The magnetron power supplies are essentially the same as employed in the equipment installed for flight test. The anode supply is of the current-regulated type employing an 804 pentode. The filament supply consists of a dry-disk rectifier and LC filter combination with provision for adjusting the filament current for proper operation. Figure 3 is a diagram of the regulated power supply.

The klystron local oscillator is powered by a Sperry SX-121 power supply. Heater power is supplied by storage battery.

RECEIVER

The receiver consists of a four-stage stagger-tuned i-f amplifier centered at 30 Mc, followed by a discriminator and cathode follower. It was found necessary to use d-c power for the heaters of the discriminator and cathode follower to maintain a 60-db dynamic range.

ANALYZER AND RECORDER

The analyzer and recorder are stock items. The recorder operates on an a-c signal; consequently it was necessary to obtain a 20,000-cycle signal from the analyzer band-pass amplifier to actuate the recorder. A 20,000-cycle band-pass filter was placed in the circuit between the analyzer and recorder to improve the signal-to-noise ratio. The 6SJ7-type tubes used in the analyzer were replaced with RCA "red type" equivalents, which proved to have lower microphonics.

CALIBRATION

The first step in calibration was the determination of the noise level in the klystron local oscillator. This was measured by beating the local oscillator against a completely battery-operated 723A/B klystron. The local-oscillator noise level was found to be below 200 cycles deviation except at 60 and 120 cycles, where it was approximately 600 cycles.

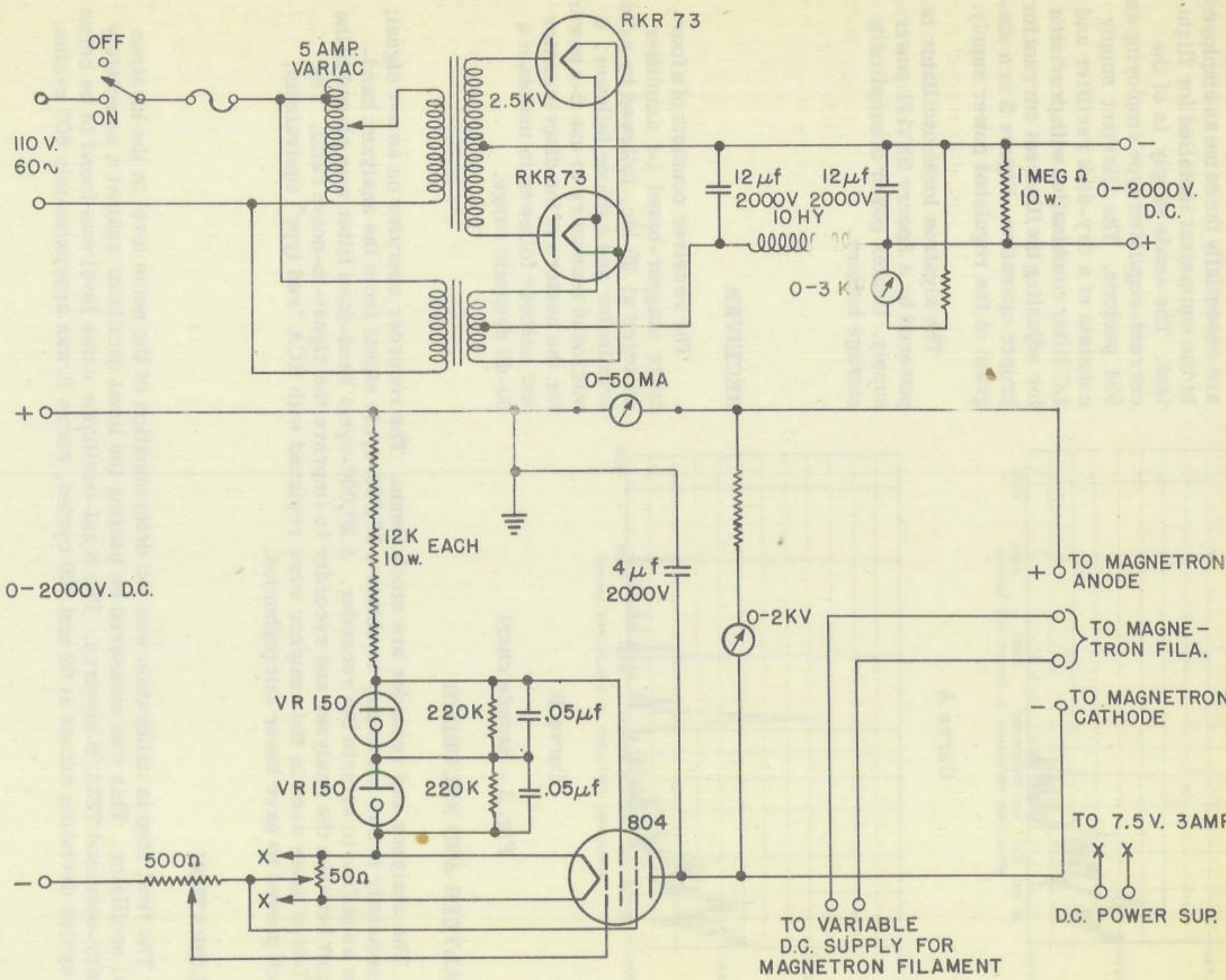


Fig. 3 - Diagram of power supply

The actual calibration was done by means of a wobbulated oscillator and signal generator, which were applied directly to the i-f amplifier of the receiver. Since the output of the wobbulator was not a sine wave, it was necessary to analyze the waveform of the discriminator output to permit setting the gain of the level recorder to obtain the proper deflection on the chart corresponding to the fundamental or one of the harmonics.

UTILIZATION

The altitude to which a continuous-wave doppler-type ground velocity indicator* will work is limited mainly by the amount of frequency modulation which exists on the magnetron transmitter. This modulation gives rise to a beat note similar to the f-m altimeter, which appears as a frequency modulation of the true doppler note. Theoretically if an axis-crossing-type frequency meter is employed, no error results until the beat frequency due to fm exceeds the frequency due to doppler. This sets an upper limit for the beat note due to fm, which is equal to the lowest doppler frequency to be encountered. The note due to fm at any given altitude, however, is proportional to the modulating frequency of the unwanted f-m side bands and to the frequency deviation. These two factors taken together constitute the rate of change of frequency of the transmitter. For any given modulating frequency, doppler note, and altitude there exists a limiting frequency deviation beyond which errors will be incurred. Thus it is possible to make an overlay such as shown in Figure 4 for any given minimum doppler frequency. When this is placed over the recording obtained for a given magnetron it will show the maximum altitude to be expected. This assumes that the fm produced by mechanical vibration in the test set is the same as that produced by vibration in the plane. It appears that above a certain intensity of mechanical excitation the fm remains practically unchanged. This is probably due to the fact that the internal structure is partially constrained and has a maximum amplitude of vibration.

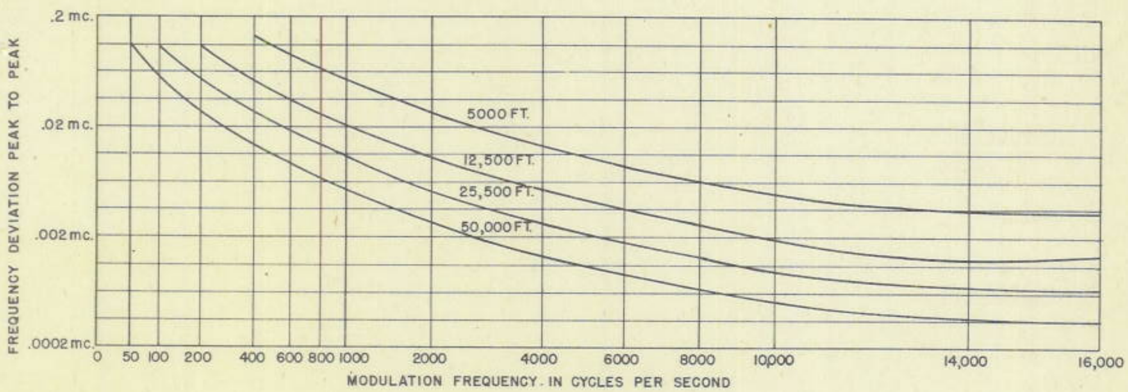


Fig. 4 - Overlay chart

This test set has proven satisfactory and has made it possible to select at the Laboratory magnetrons which give good performance in flight.

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* This is described in NRL ltr report C-1390-106/47 (1392/wd) to BuAer dated 14 July 1947.

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