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# ANALYSIS OF FM DEGRADATION BY MULTIPATH




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Project Apollo

# ANALYSIS OF FM DEGRADATION BY MULTIPATH


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# FM DEGRADATION BY MULTIPATH

This report investigates the effects of multipath in an enclosed chamber, such as the orbital workshop. At VHF frequencies, (400 MHz in this test), it was believed that multipath, through sideband cancellation, could cause distortion of a transmitted signal in the orbital workshop. The RF Communications Section of the Electromagnetic Systems Branch (Instrumentation and Electronic Systems Division) has conducted the following tests in order to determine what degradation, if any, there is of signal due to multipath at these frequencies.

Laboratory results are presented here which show spectrum distortion due to multipath and the resulting transmitted signal (utilizing square wave modulation). The test was conducted in the RF Communications Laboratory in Building 14. Existing facilities were made available and used throughout.

When a transmitted signal is received via two or more paths (multipath) at a receiver, the multiple of signals may add or subtract depending on their relative phases. The relative phases of the signals depend on their relative path lengths between the transmitter and the receiver.

A preliminary test, simulating actual conditions expected in the orbital workshop, was conducted by the RF Communications Section in Building 14. An enclosed cylindrical tunnel (Laser Experimental Tunnel of IESD) 13 feet in diameter and 280 feet in length was utilized in order to simulate the enclosed chamber. There were several random objects, extruding and intruding, within the enclosure such as one might expect to exist in the workshop.

The necessary equipment in this test included a Standard Signal Generator for transmitting the desired FM signal, a Spectrum Analyzer for receiving and displaying the transmitted signal, and a camera for recording the various spectrums. Portable antennas were also used at both the signal generator and the spectrum analyzer. Figure 1 shows the equipment set up. The test consisted of photographing the various spectral displays generated by multipath as the antennas were positioned at numerous sites within the chamber. It was concluded after a considerable number of trials that there was no place within the tunnel that multipath would completely cancel out the transmitted signal. This condition could in no manner be forced on the system during the test.

In order to reproduce these spectrums in the laboratory, the transmitted signal was hard lined through two separate paths between the transmitter and receiver. The lab test configuration is shown in Figure 2. An adjustable line was utilized in order to produce phase variations in the two paths. Throughout the test, the transmitter was frequency modulated with a square wave at a repetition rate of 4.2 KHz. A constant deviation of 500 KHz was maintained. The test procedure was as follows:

a. Initially, the carrier was applied only. Attenuators and an adjustable line were adjusted so that the carrier was nulled (zero amplitude) on the spectrum analyzer. It was evident from this procedure that the attenuation over the two paths was equal, and one path was an integral number of wavelengths plus 180° longer than the other.

b. The carrier was modulated (utilizing a square wave) and the spectrum adjusted for the waveforms illustrated in Figures 3 and 4.

c. The spectrum was made symetrical about the center frequency by adjusting the line. Photographs were recorded of the spectral display and the output signal (see Figure 3D and 4D).

d. Several multipath conditions, such that portions of the spectrum sidebands were attenuated, were displayed on the analyzer. The conditions were chosen so as to represent the possible phase shifts that might be encountered at the receiver. These spectral displays and the resulting output signals were photographed and are illustrated in Figures 3A through 3G and Figures 4A through 4G respectively.

As indicated, this part of the test was performed in order to reproduce a periodic sampling of multipath conditions which were recorded in the preliminary test of this report. Figure 3D is the resulting spectrum when the spectral sidebands are equal in magnitude that is, there is no phase difference in the two signals at the receiver. A comparison of this received signal (Figure 4D) with the received signals for the various multipath conditions when sidebands are unequal in magnitude show a minimum of distortion. There was no loss of signal whatsoever.

It is concluded from these tests that VHF frequencies are useable in the orbital workshop regardless of multipath. In summary, it may be stated that at any single point within the enclosed chamber there exists an infinite number of transmitted signals which may add or subtract as described herein. Since this is true, it becomes practically impossible as proven in the test, to force cancellations of the transmitted signal due to multipath conditions.

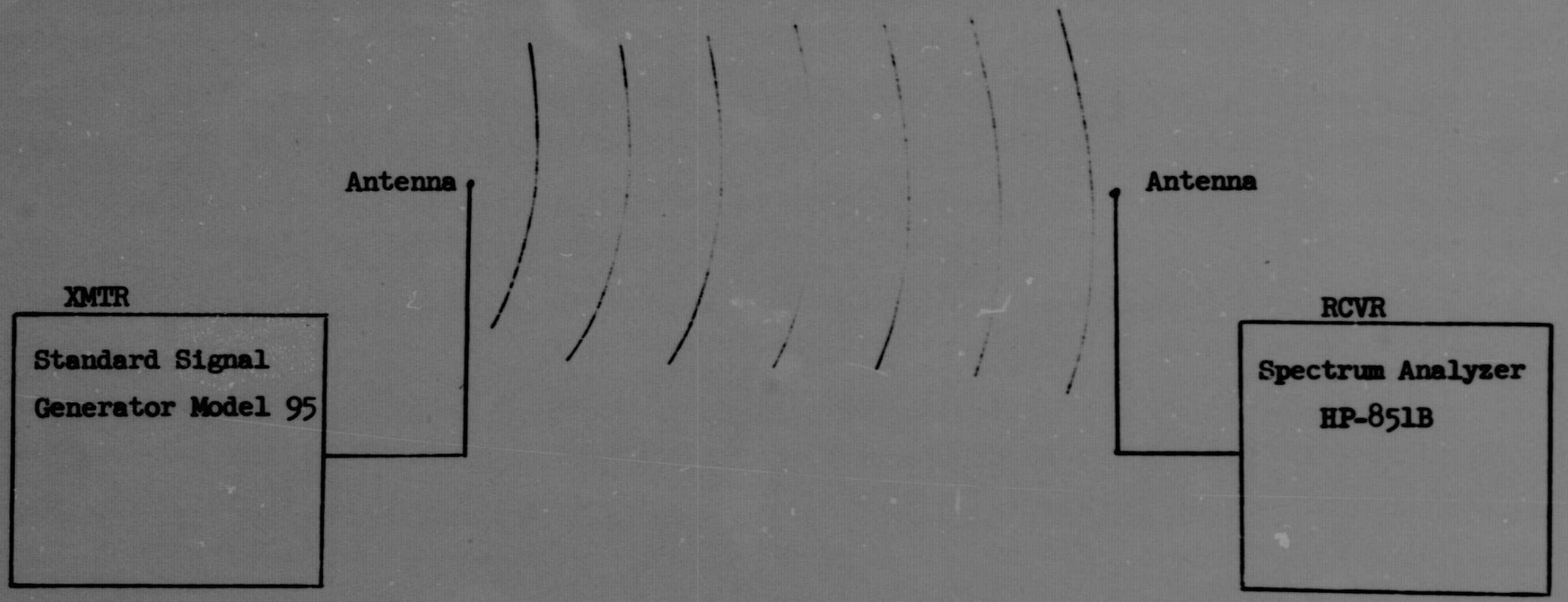
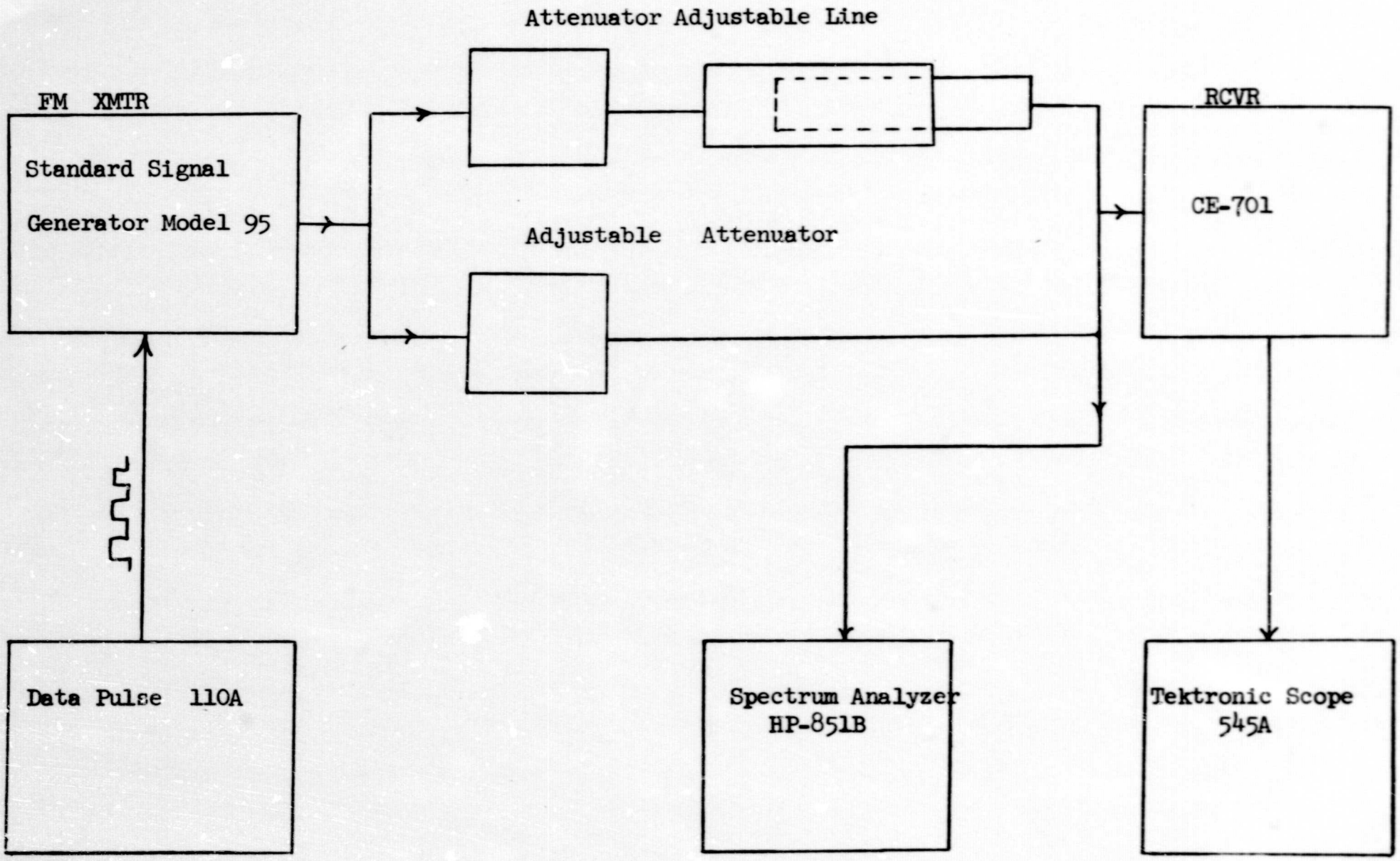

Antenna
Antenna
XMTR
Standard Signal
Generator Model 95
RCVR
Spectrum Analyzer
HP-851B

FIGURE 1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FM XMTR
Standard Signal
Generator Model 95
Adjustable Attenuator
RCVR
CE-701
Data Pulse 110A
Spectrum Analyzer
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Tektronic Scope
545A

FIGURE 2

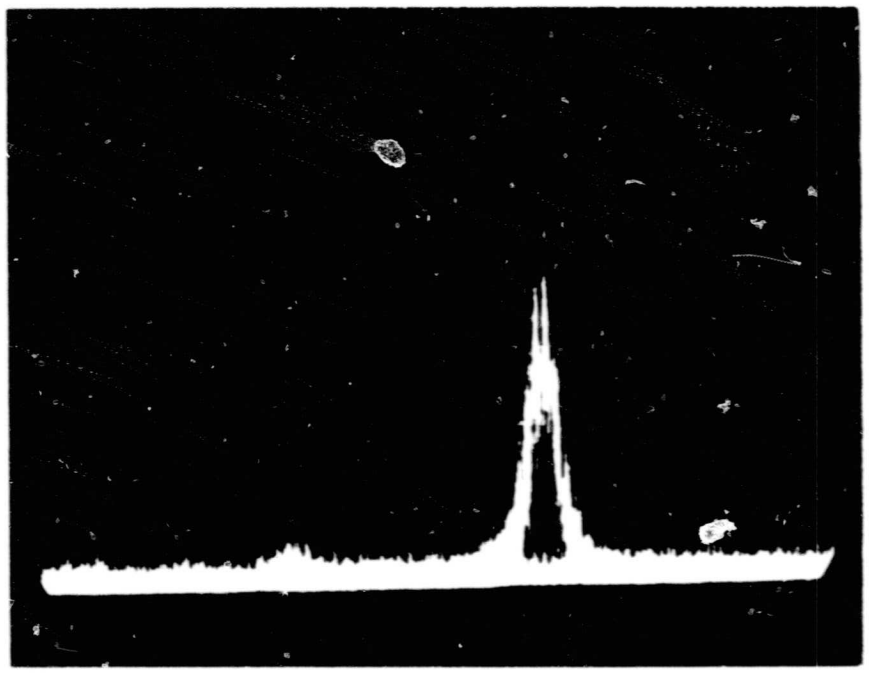


Figure 3A

Figure 4A

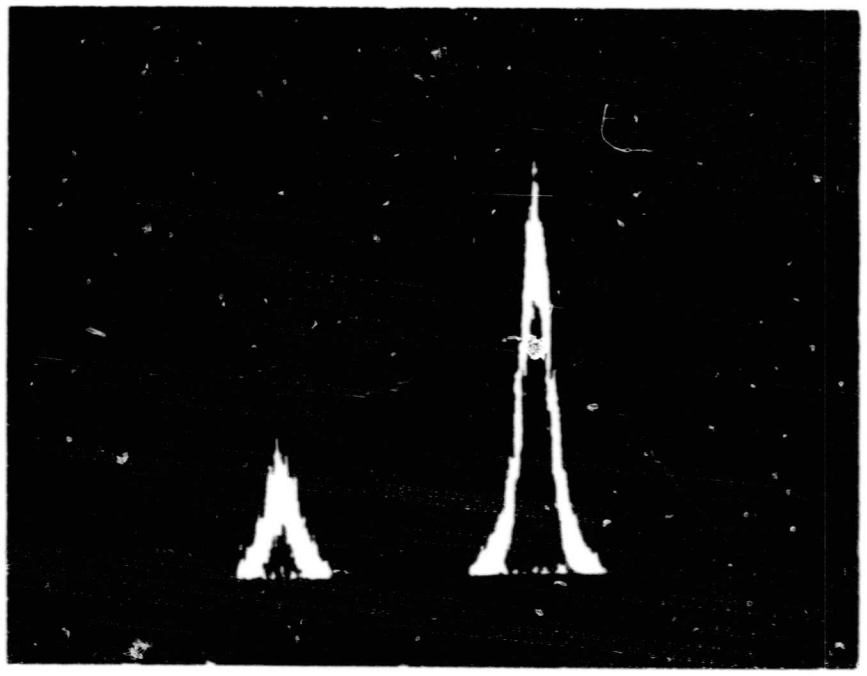


Figure 3B

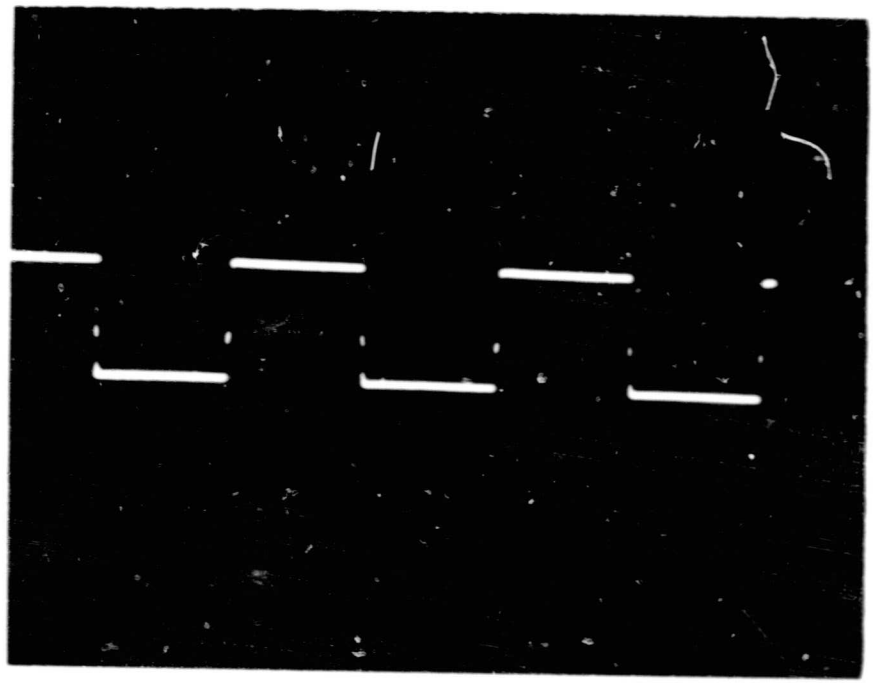


Figure 4B

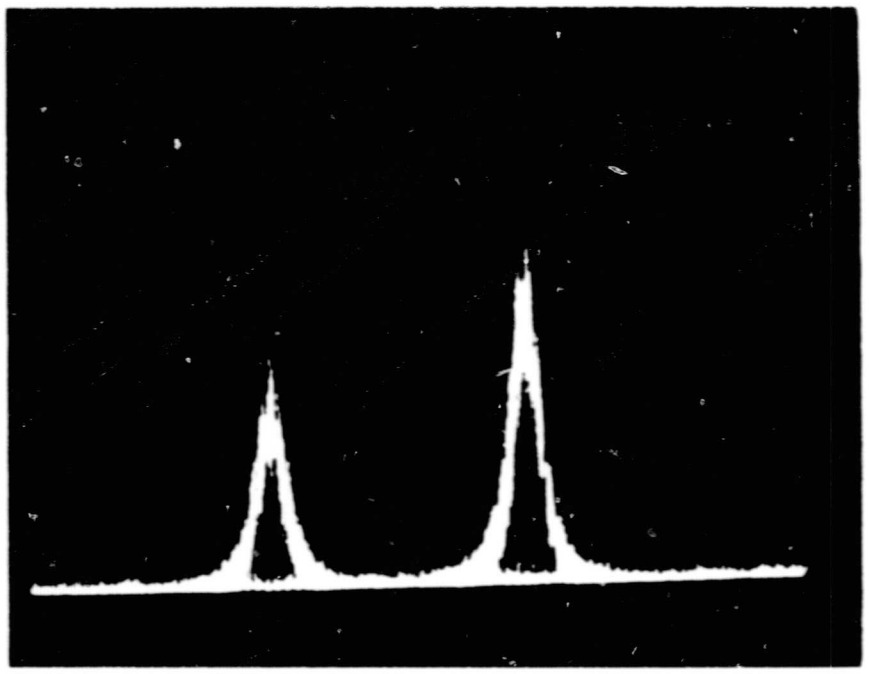


Figure 3C

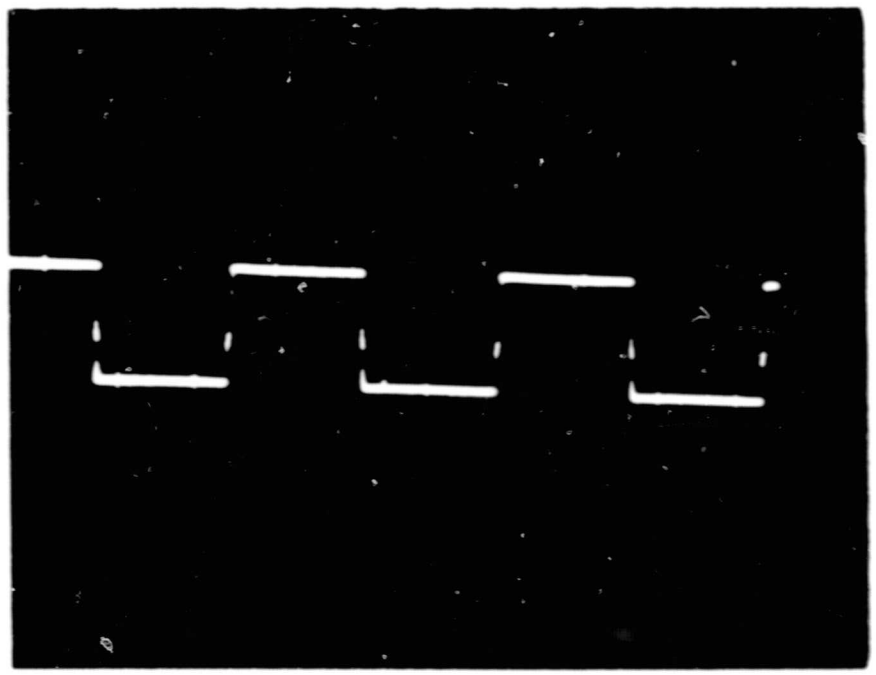


Figure 4C

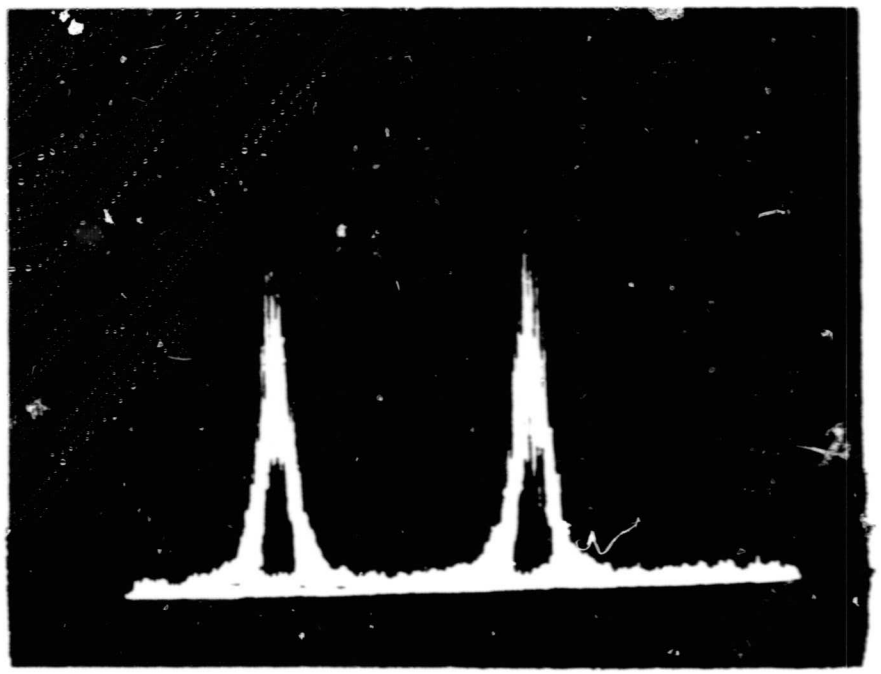
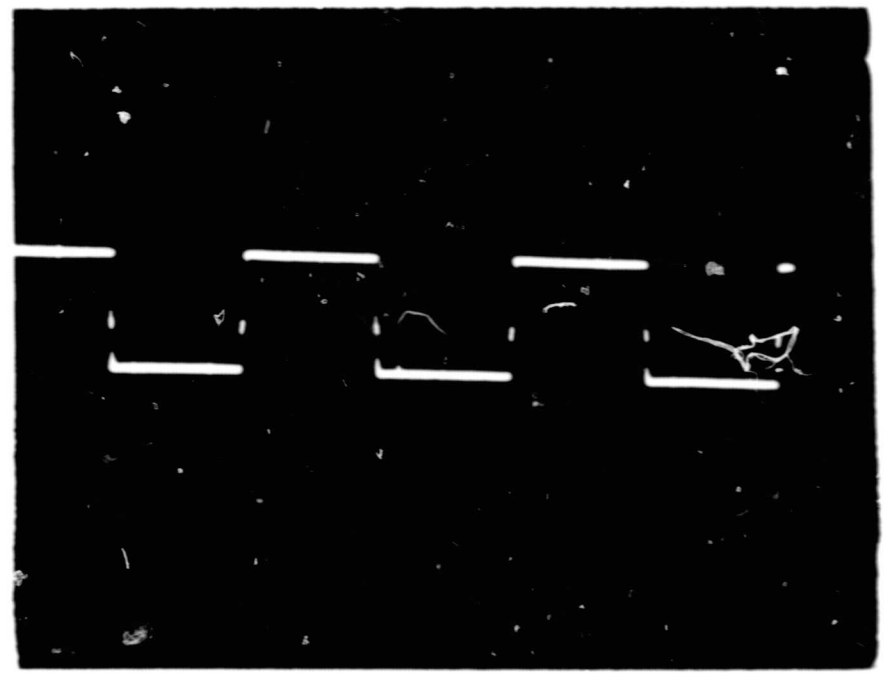


Figure 3D



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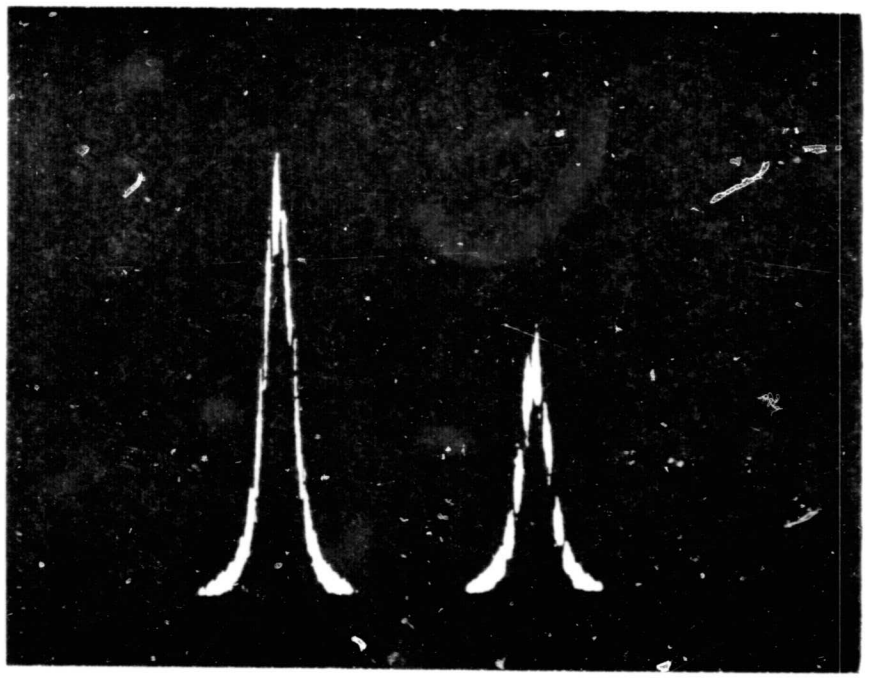

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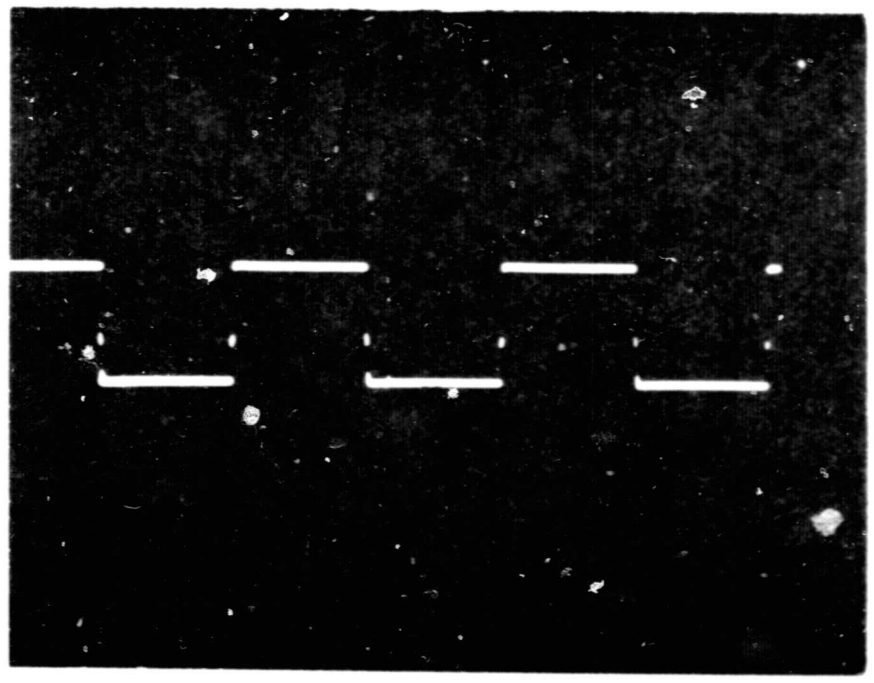

Figure 4E

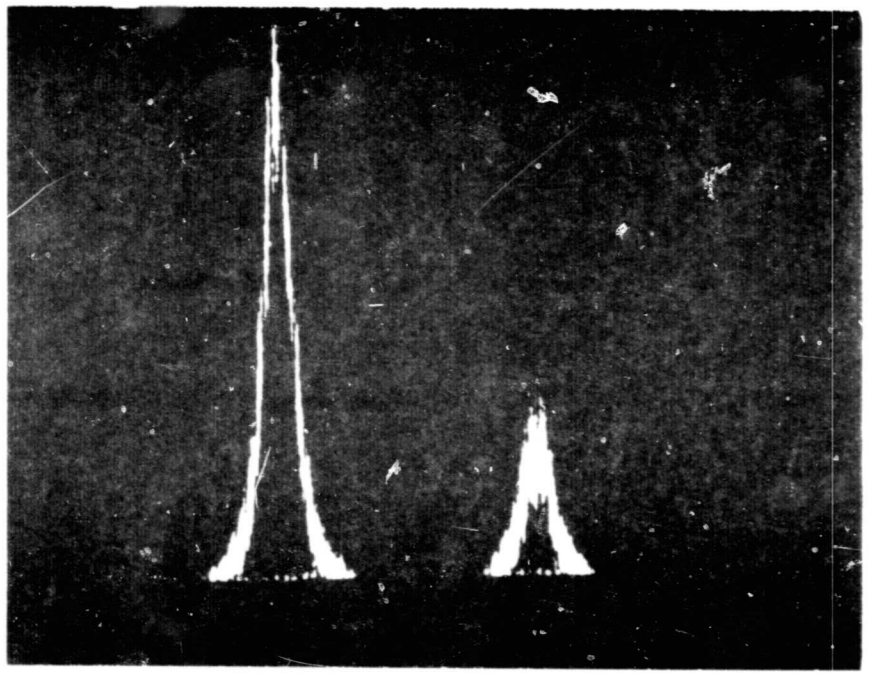

Figure 3F

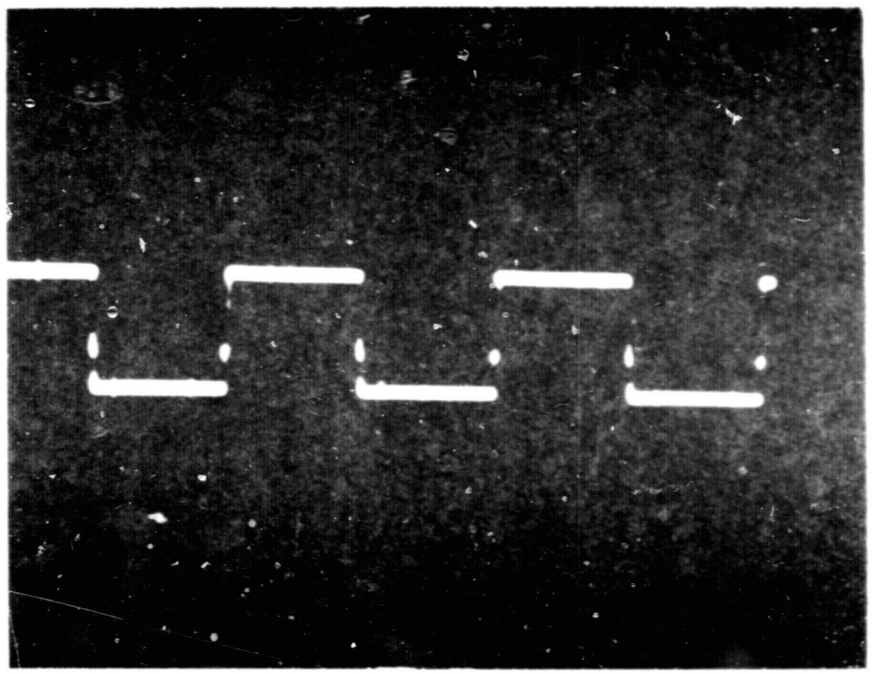

Figure 4F

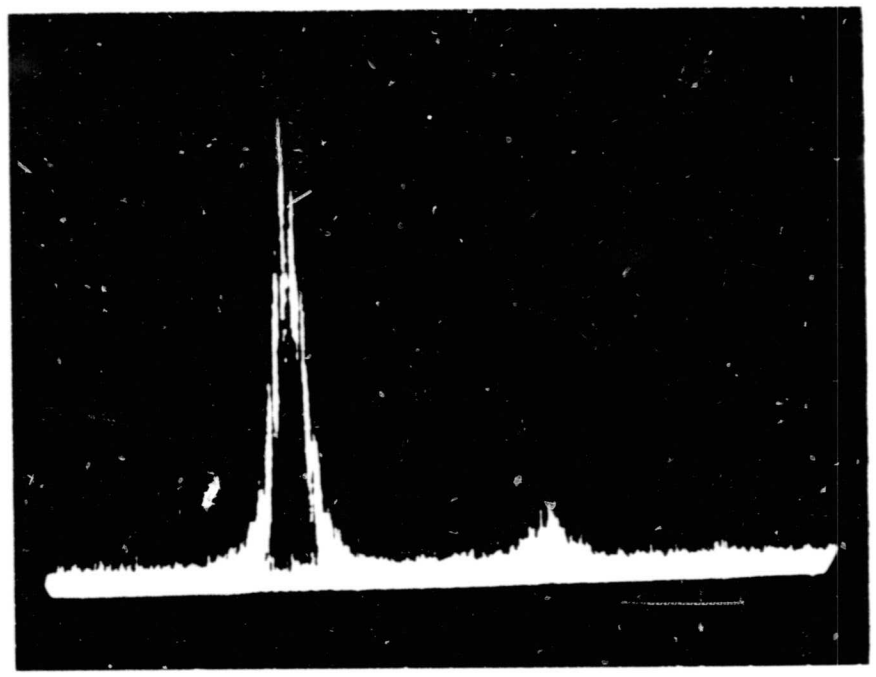

Figure 3G

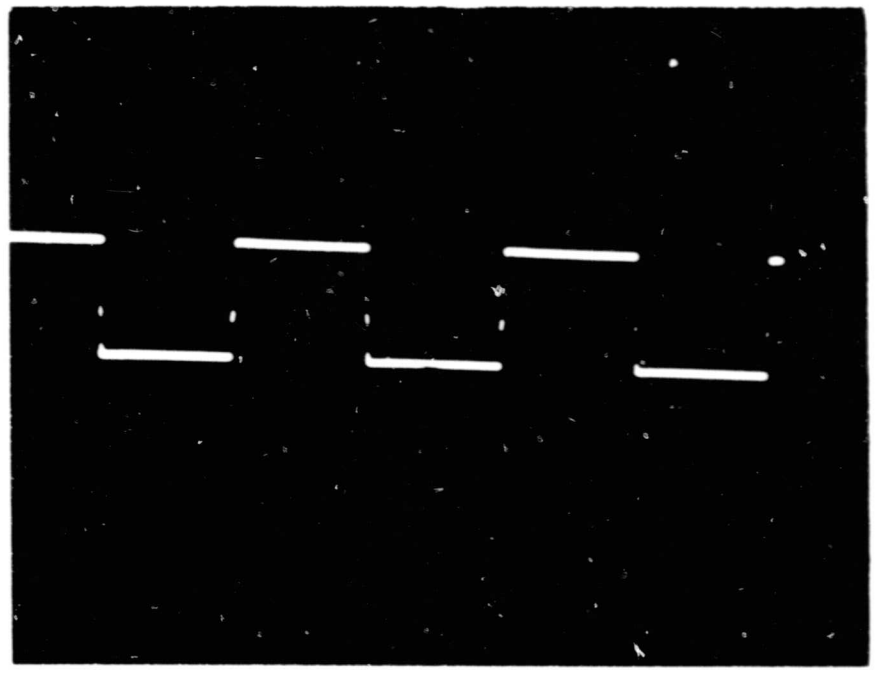

Figure 4G