# The OSCILLOSCOPE Applied to Transmitter Checking

***With permission to return to the air, amateurs should recheck their transmitting equipment. The oscilloscope is an ideal instrument for this purpose. Follow the procedure outlined herein***

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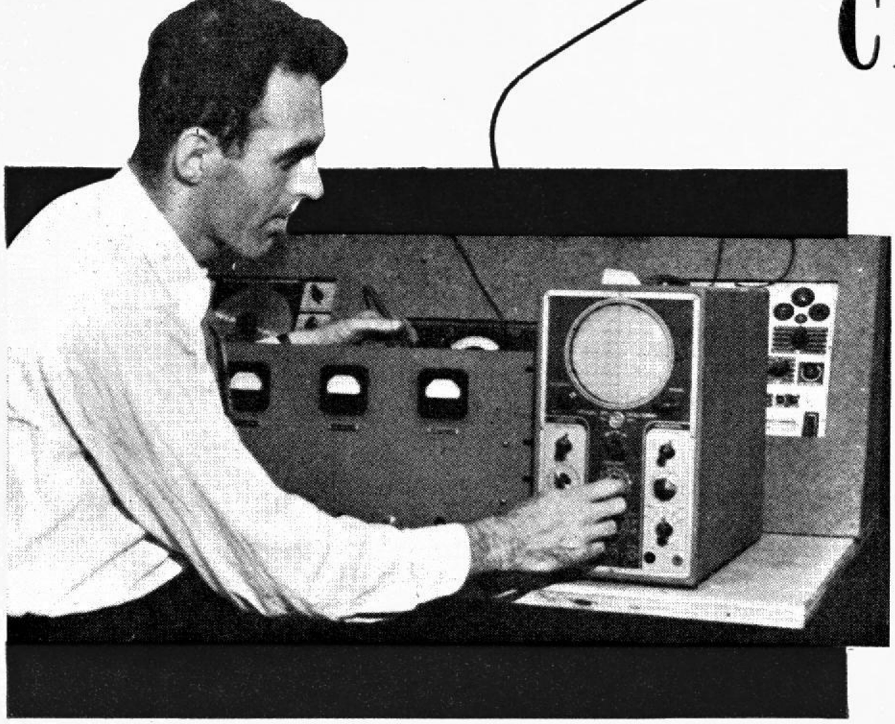


**Radio technician applying the oscilloscope in checking transmitter.**

IN A previous article, appearing in the September, 1944 issue of RADIO NEWS, we discussed the application of the oscilloscope to radio servicing. In this article, we will endeavor to demonstrate how the oscilloscope is used to check the operation of the transmitter.

The cathode-ray oscilloscope is the most valuable of all instruments in determining transmitter performance. It provides an instantaneous picture of what is actually happening inside the transmitter—thus, enabling the operator to determine the source of any possible defect in the apparatus. This versatile instrument is particularly suitable for r.f. or a.f. measurements, because it draws little or no power from the source. Where high speed analysis of performance is required, such as on the assembly line, the merits of the oscilloscope are once again realized.

The following are some of the uses to which the oscilloscope can be put for determining the operation and securing maximum results from your transmitter.

Since it is possible for one to observe r.f. with an oscilloscope, it can thus be readily used as a resonance indicator. Should plate current meters be included in the transmitter, the use of the oscilloscope is not necessary. If meters are not included, the oscilloscope can be used as a temporary expedient.

To use it as an indicator for determining resonance, connect a coil of one or more turns of wire to the vertical axis of the 'scope by means of a twisted pair line. Any sweep frequency can be utilized. Place the coil near the tank circuit of the stage being tested and a band should appear on the screen of the 'scope. The width of this band can be regulated by the number of turns of the coil and its distance from the tank. The load of the stage, such as the link coupling, grid coil of the next stage, or the antenna tuner is left on the resonant stage being tested, so that actual working conditions are observed. Your next step consists of rotating the tank condenser slowly, until maximum bandwidth is observed on the oscilloscope. When this condition is reached, the stage is at its desired resonance. Fig. 1 shows the necessary hookup.

In the above manner, all stages of

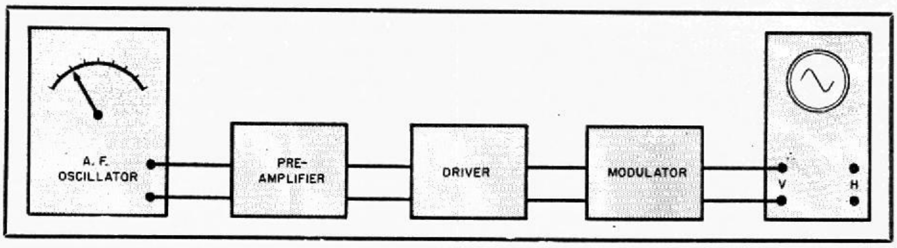
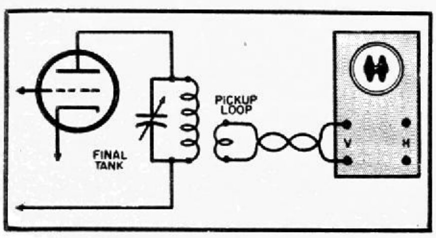
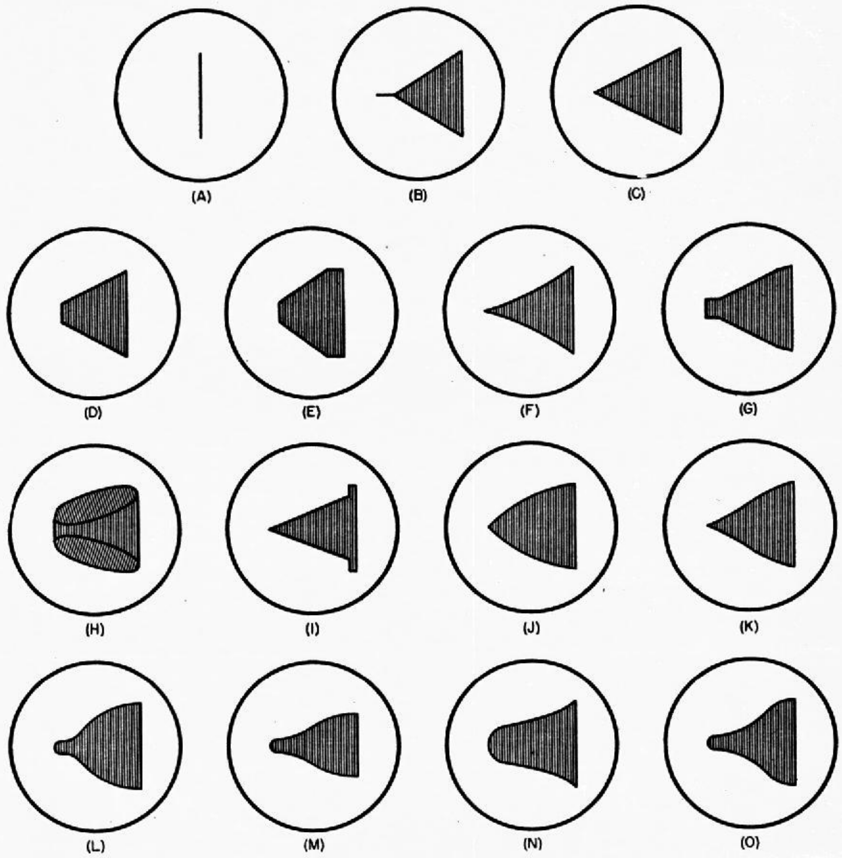



**Fig. 2. Any defects in the speech-amplifier equipment can be easily checked by employing, along with the oscilloscope, an audio frequency oscillator, connected as shown**

**Fig. 1. When applying the oscilloscope to determine resonance of the tube circuit, the 'scope is loosely coupled as shown.**



## TYPICAL TRAPEZOIDAL PATTERNS SHOWING TRANSMITTER OPERATION




**(A) Unmodulated carrier. (B) Over 100% modulation—distortionless wave. (C) Illustrating distortionless 100% modulated wave—ideal pattern. (D) Less than 100% modulation—wave contains no distortion. (E) Pattern illustrates two possible troubles. Insufficient r.f. grid excitation to modulated amplifier or lack of sufficient filament emission. (F) Pattern illustrates regeneration in class "C" stage, which is due to too much bias or improper neutralization. Note curved sides of pattern. (G) This trace is due to mismatched class "B" modulator to the class "C" load. (H) In this pattern we have a condition of phase shift. This is due to the fact that the audio voltages were not taken directly from the output of the modulator. (I) This pattern shows that parasitics are present on the positive modulation peaks in the modulated amplifier. (J) Insufficient excitation or bias applied to a triode (plate modulated zero bias) will cause this trace. (K) Approximately 100% modulated (grid or cathode) wave. (L) Approximately 100% suppressor modulated wave. It uses separate r.f. driver. (M) This trace shows a poorly regulated r.f. driver or it can also be the result of excessive excitation. (N) Diagram of a grid modulated phone wave. It is not properly neutralized and also lacks proper reactive load. (O) A suppressor modulated wave. Circuit uses an 802 or 804 and has a crystal in the grid circuit.**

the transmitter can be aligned and faults existing in a stage of a transmitter can be traced to that particular stage.

### Neutralization Indicator

Because of the property of the oscilloscope of not drawing any appreciable power from a circuit, it makes a fairly sensitive neutralization indicator. In cases of emergency, it can be substituted for the regular indicating device.

To determine whether or not a stage is properly neutralized, turn on the filament of the chosen stage and apply excitation from the previous r.f. amplifier to its grid circuit. Be certain that the plate voltage is turned off. Use the same coil and twisted wire line as shown in Fig. 1. Hold this coil near the plate tank coil of the stage under test. Next, tune the condenser through resonance and, at resonance, no r.f. waves should appear on the screen, provided the stage is properly neutralized. If r.f. is present, adjust the neutralizing condenser with an insulated screwdriver until there is no r.f. remaining on the screen of the scope.

In push-pull circuits, both neutralizing condensers are adjusted simultaneously, i.e., step by step, until there is no r.f. present.

### Checking Modulation Equipment

Any defects in the speech amplifier equipment can be determined with the use of the oscilloscope. Faults indiscernible to the human ear are made apparent with this instrument.

First, connect an audio oscillator to the input of the speech amplifier equipment in place of the microphone. Take the output off the final stage of the modulator. Next, synchronize the sweep oscillator of the 'scope with the audio frequency. Refer to Fig. 2 for the diagram.

By comparing the original waveform of the a.f. oscillator with that of the output of the final stage, you can determine the quality of your modulating equipment. If distortion is present, it can be traced down to the individual stage causing this condition.

To localize the distortion to the stage causing it, proceed as follows:

Connect an a.f. oscillator to the input terminals of the speech amplifier. Then, connect the oscilloscope successively to the output stage of each of the tubes in the amplifier, starting with the preamplifier stage, and working toward the output stage.

As we proceed in this manner, the gain of the amplifier will increase. To compensate for this, decrease the amplifier gain control of the oscilloscope. This is necessary in order to prevent overloading the oscilloscope. Once the faulty stage is located, it should be serviced accordingly.

Another trouble frequently encountered by the operator is phase distortion. This condition occurs when the phase relationship of two or more factors in the amplifier circuit is altered. This condition can be usually rectified by changing the circuit constant (RC values).

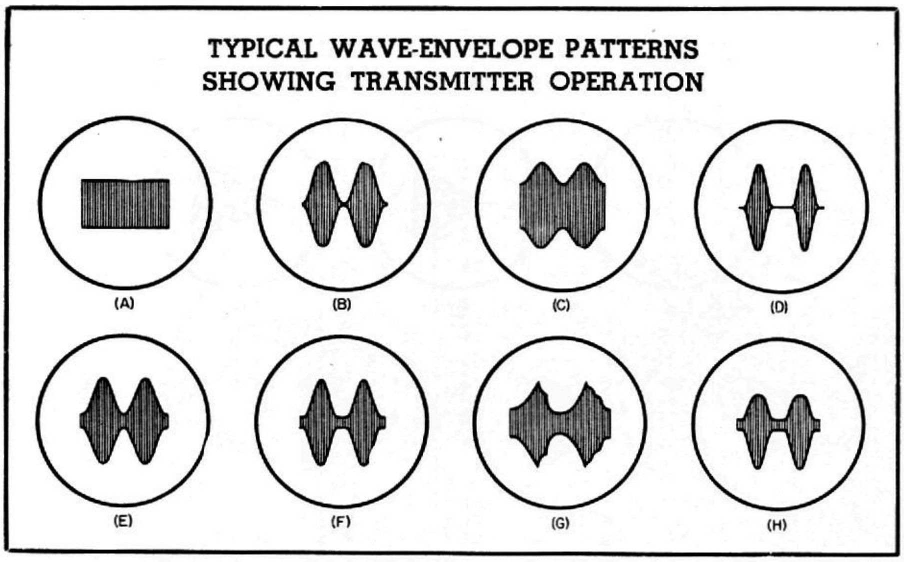
By using the above procedure, audio distortion, improper operation due to incorrect bias, phase distortion, etc., are readily detected. If desired, the over-all frequency response of the amplifier can be approximated by varying the audio oscillator frequency and noting the changes, if any, in the amplitude of the trace. It is essential that the output of the a.f. oscillator used be kept constant. For those wishing more accurate knowledge of the frequency response of the audio apparatus, a graph thereof should be made.

### Modulation in Radiotelephone Transmitter

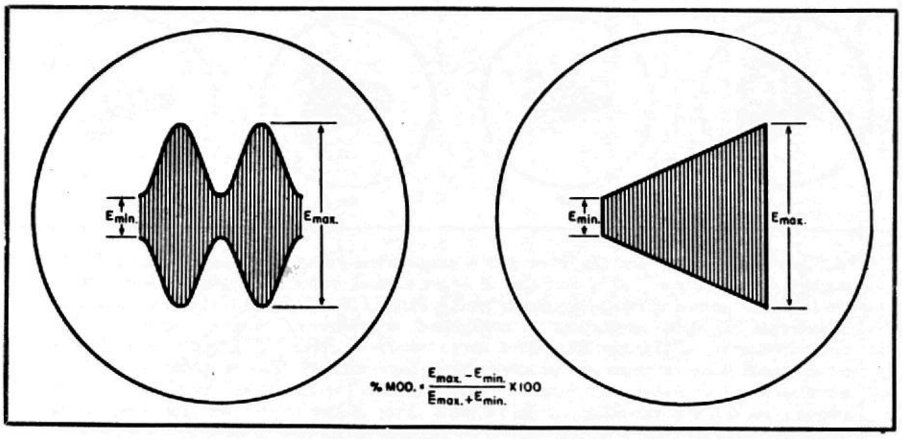
Perhaps the most frequent use of the oscilloscope is for observing modulation characteristics in radiotelephone transmitters. The oscilloscope can be utilized to disclose the modulation percentage, linearity, and power output available from the audio-modulator—without distortion.

Two types of patterns are regularly employed for checking the performance of radiotelephone transmitters. These are the wave-envelope and trapezoidal patterns. Each pattern tells much about the operation of the transmitter. For ordinary purposes, either one may be used. However, for a more exacting determination of performance, both types of patterns should be employed, thus getting a better delineation of the transmitter capabilities.

The wave-envelope pattern is the easiest to hook up and gives an over-

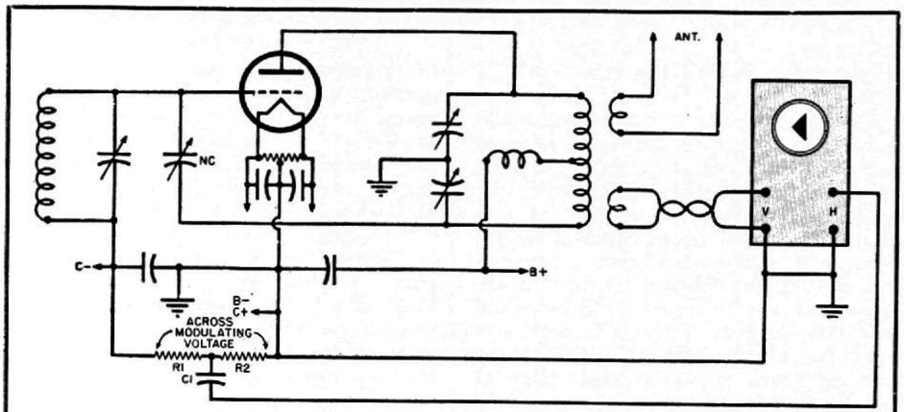



**(A) Unmodulated carrier wave. (B) 100% modulation—ideal pattern to get. (C) Less than 100% wave. (D) Greater than 100% modulation (overmodulation). (E) This type of pattern is due to insufficient grid excitation to the final modulation stage. (F) This is a condition of overmodulaton (greater than 100%) with the addition of audio distortion. (G) When the plate circuit of the modulated amplifier is not at the proper resonance, the trace, as shown, will be the result. (H) This type of pattern is due to overloading or rectification in the oscilloscope's amplifier.**




**Method of determining modulation percentage of trapezoidal or wave-envelope patterns.**

**Fig. 3. Diagram showing oscilloscope connections for obtaining trapezoidal patterns when checking grid, suppressor, or screen modulated type transmitters.**




*Values for voltage divider should be determined by trial, as they depend on the oscilloscope used.*
*Usual values are:*
*$R_1$—.5 megohm, 1 w. res.*
*$R_2$—50,000 ohm, 1 w. res. (low power)*
*$R_2$—10,000 ohm, 1 w. res. (high power)*

*For direct connection, $R_2$ is a potentiometer with $C_1$ attached to moving arm.*
*$R_2$—.2 megohm pot. (high power)*
*$R_2$—.5 megohm pot. (medium power)*
*$R_2$—.5 megohm pot. (low power)*
*($R_1$ should be shorted when used on low power)*

all picture of the audio amplifier, modulator, and modulated amplifier. Any change in the waveform of the speech amplifier will produce a corresponding change in the wave pattern.

The waveform should be sinusoidal if the modulator is functioning correctly. A change in the audio frequency of the oscillator will necessitate a corresponding change in the sweep circuit.

In contrast, when observing a trapezoidal pattern, changes in audio frequency or waveform of the audio oscillator will not produce a change in the general shape of the pattern, provided the modulation percentage is constant. Thus, the trapezoidal pattern indicates only modulation percentage and linearity of the modulated r.f. amplifier.

Typical wave-form and trapezoidal patterns illustrating different modulating conditions, etc., are included. These should be referred to and studied. For critical examination, the proportions as shown on the typical characteristic sheets should correspond closely with the waveforms and trapezoidal patterns appearing on the screen.

The great advantage of the trapezoidal pattern over the wave-envelope pattern is that a microphone can be substituted for the audio oscillator and the effect of the operator's voice will be noted. The figure expands and contracts horizontally as the operator talks, completing the triangle as one hundred per-cent modulation is approached. Overmodulation is indicated by a dashed horizontal line extending from the vertex of the triangle.

If the same process as outlined above is carried out with the wave-envelope pattern, a meaningless jumble appears across the screen, because the sweep circuit is not synchronized with the speech. This effect can be counteracted to some extent by the following method. Apply a strong synchronizing voltage, taken from the pre-amplifier stage, to the synchronizing jacks of the sweep oscillator. This measure should make the trace more constant. Individual waveforms separated by short, bright dashes indicate overmodulation.

To determine the 60 or 120 cycle hum level of the transmitter in question, using the wave-envelope pattern, proceed as follows:

No a.f. signal is fed to the speech amplifier so that the figure appearing across the screen is a band (like an un-modulated carrier). Then, adjust the sweep circuit to a submultiple of the power line frequency, such as 20 or 30 c.p.s. If ripples or humps appear across the screen, extraneous modulation due to the power line is occurring. On the other hand, the trapezoidal pattern indicates immediately whether there is appreciable hum or noise modulation of the carrier.

### Methods of Connection

The connections for the wave-en-

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## Transmitter Checking

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velope pattern, as stated above, are much simpler than those of the trapezoidal pattern. The method consists of feeding some of the output of the modulated amplifier to the vertical axis. This is done with a coil of one or more turns of wire fed to the input terminals by means of a twisted pair. On high frequencies (100 kc. and above) direct connection should be made to the vertical deflector plates of the scope. This measure is necessary because the amplifier contained in the instrument is not capable of handling high frequencies.

The sweep circuit is synchronized with the audio oscillator that is fed to the input of the speech amplifier equipment. To do this, feed the audio output from the oscillator to the synchronization terminals through a .01 μfd. condenser. The height of the pattern is varied by changing the number of turns of the coil or its distance from the output tank. The load, antenna, or antenna tuner is left connected to observe performance under actual working conditions. With the sweep circuit properly synchronized and at a multiple of the audio oscillator frequency, an image appears with several sine waves. By increasing the audio oscillator output, the percentage of modulation is correspondingly increased. By this method, all types of modulation may be observed including plate, grid, screen, and suppressor modulation. Fig. 1 shows the necessary hookup.