(2) Theory. - The electron beam moves in accordance with the resultant of the sine and sawtooth signals. The effect is shown in Figure 3-6 where the sine and sawtooth waves are graphically represented on time and voltage axes. Points on the two waves that occur simultaneously are numbered similarly. For example, 2 on the sine and 2 on the sawtooth waves occur at the same instant. Therefore, the position of the beam at instant 2 is the resultant of the voltages on the horizontal and vertical deflection plates at instant 2. Referring to Figure 3-6, by projecting lines from point 2, the position of the electron beam at instant 2 can be located. If projections were drawn from every other instantaneous position of each wave to intersect on the circle representing the tube

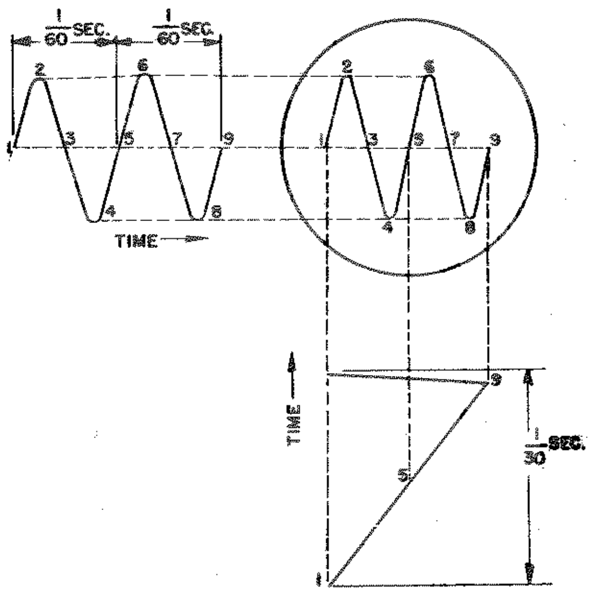


Figure 3 - 7

Projection drawing showing the resultant pattern when the frequency of the saw tooth is one-half of that employed in Figure 3-6.

screen, the intersections of similarly timed projections would trace out a sine wave.

(3) Conclusion. - In summation, Figure 3-6 illustrates the principles involved in producing a sine wave trace on the screen of a cathode-ray tube. Each intersection of similarly timed projections represents the position of the electron beam acting under the influence of the varying voltage waveforms on each pair of deflection plates. Figure 3-7 shows the effect on the pattern of decreasing the frequency of the sawtooth wave. Any recurrent waveform plotted against time can be displayed and analyzed by the same procedure as used in these two examples.

(4) Other Patterns. - The sine wave example just illustrated is typical of the method that any wave form can be displayed on the screen of the cathode-ray tube. Such wave

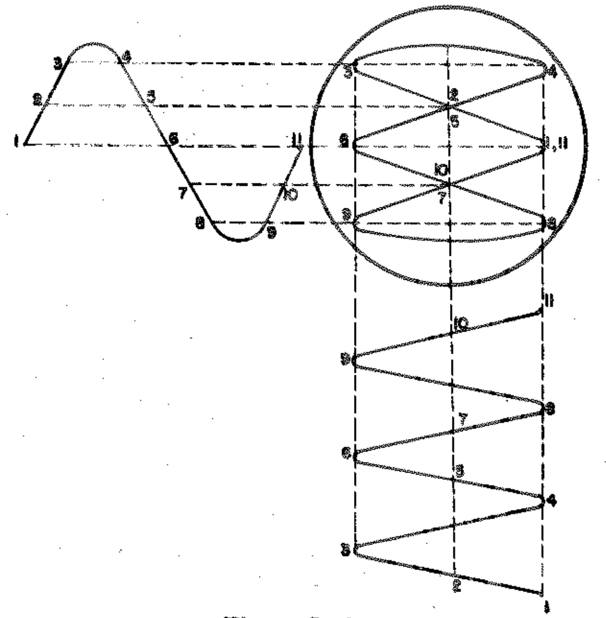


Figure 3 - 8

Projection drawing showing the resultant Lissajous pattern when a sine-wave applied to the horizontal axis is three times that applied to the veritcal axis.

forms as square wave, sawtooth wave, and many other more irregular recurrent wave forms can be observed by the same method explained in the preceding paragraphs.

b. LISSAJOUS FIGURES

(1) Preliminary. - Another fundamental pattern is the Lissajous figure, named after the 19th century French scientist. This type of pattern is of particular use in determining the frequency ratio between two sine wave signals. If one of these signals is known, the other can be quickly calculated from the

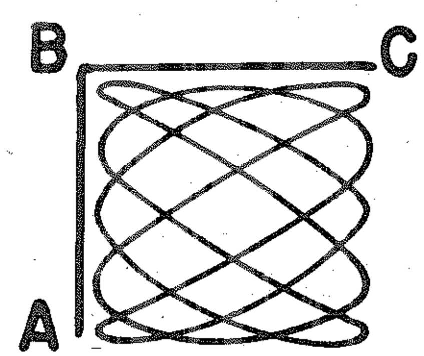


Figure 3 - 9

Method of calculating frequency ratio of Lissajous figures.

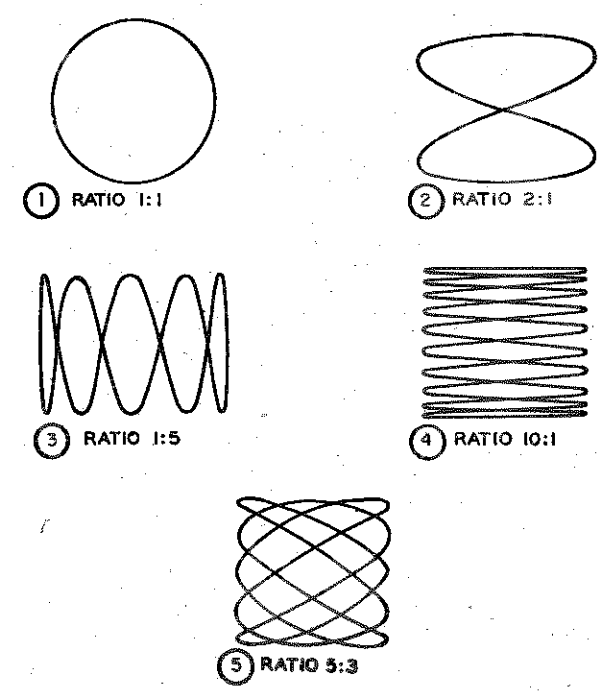


Figure 3 - 10

Other Lissajous patterns

ratio. Common practice is to connect the known signal to the horizontal channel and the unknown to the vertical channel. The amplifiers may or may not be used depending upon the voltage of the signals and their frequencies.

(2) Theory. - The presentation of Lissajous figures can be analyzed by the same method as previously used for sine wave presentation. A simple example is illustrated in Figure 3-8. The frequency ratio of the signal on the horizontal axis to that on the vertical axis is 3 to 1. If the known signal on the horizontal axis is 60 cycles per second, the signal on the vertical axis is 20 cycles.

The Lissajous pattern is traced by joining intersections of projections from like numbered points on the signals. The frequency relationship, determined by the ratio of the number loops touching two mutually perpendicular sides, is calculated most readily when the two signals are out of phase. For example, Figure 3-9 shows a complex Lissajous figure. The vertical line, AB is touched by 5 loops and the horizontal line BC is touched by 3 loops. The ratio of the frequency on the horizontal axis is to the frequency on the vertical axis as the number of loops which intersect line AB is to the number of loops which intersect line BC.

Algebraically:

$$\frac{\text{Frequency on horizontal Axis}}{\text{Frequency on vertical Axis}} = \frac{\text{Number of loops intersecting AB}}{\text{Number of loops intersecting BC}}$$

(3) Obtaining a Lissajous Pattern on the screen

Preliminary Settings:

COARSE FREQUENCY—HOR INPUT AMP

VERTICAL INPUT switch —AMP

Step 1. Connect a wire from the TEST SIGNAL terminal to the HORIZONTAL INPUT terminal.

Step 2. Place an audio oscillator conveniently near the oscillograph, and connect its output and ground terminals to the VERTICAL INPUT and GROUND terminals of the Type 274 oscillograph.

Step 3. Switch the oscillograph and the audio oscillator into operation.

Step 4. Locate a pattern of convenient size in the center of the screen by adjusting

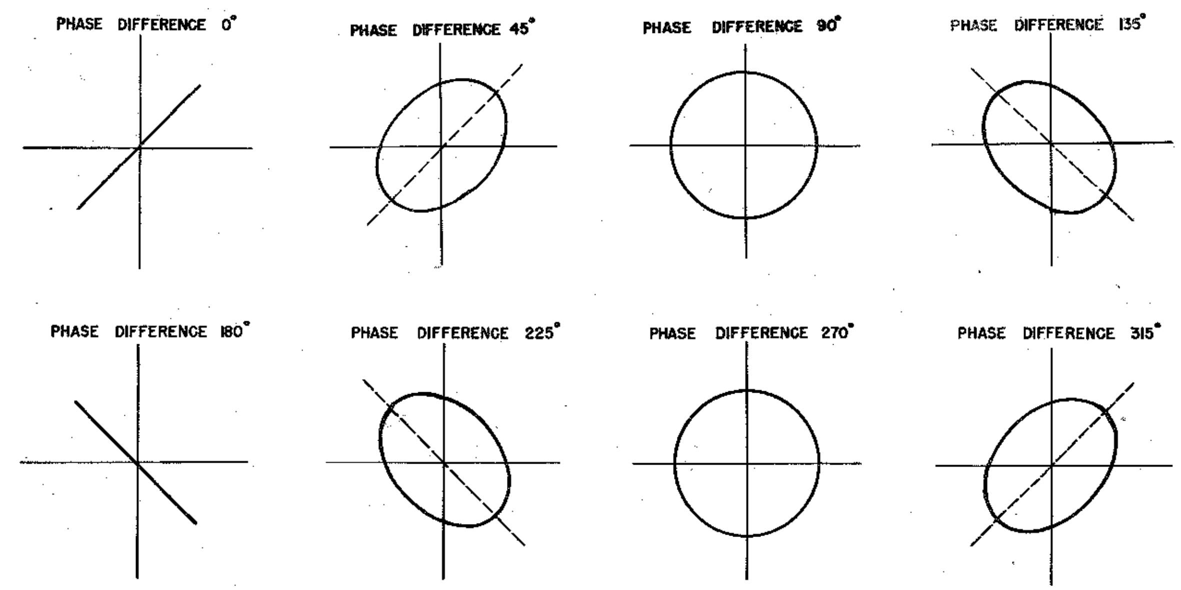


Figure 3 - 11

Lissajous patterns obtained from the major phase difference angles

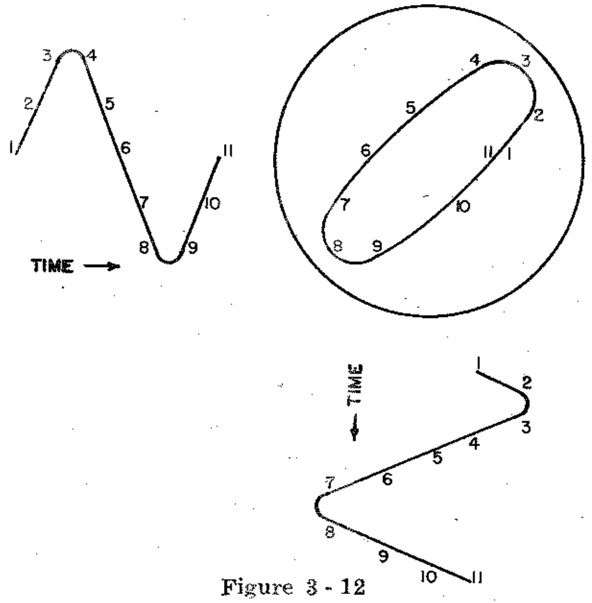


Figure 3 - 12

Projection drawing showing the resultant phase difference pattern of two sinewaves 45° out of phase.

the positioning and amplitude controls.

Step 5. By adjusting the frequency of the audio oscillator obtain a pattern that is nearly stationary. It is not necessary to stop the pattern, but merely to slow it up enough to count the loops at the sides of the pattern.

Step 6. Count the number of loops which intersect an imaginary vertical line AB and the number of loops which intersect the imaginary horizontal line BC as in Figure 3-9. The ratio of the number of loops which intersect AB is to the number of loops which intersect BC as the frequency of the horizontal signal is to the frequency of the vertical signal.

(4) More examples of Lissajous Patterns. - Figure 3-10 shows other examples of Lissajous figures. In each case the frequency ratio shown is the frequency ratio of the signal on the horizontal axis to that on the vertical axis.

(5) Phase Difference Patterns

(a) Introduction. - Coming under the heading of Lissajous figures is the method used to determine the phase difference between signals of the same frequency. The patterns involved take on the form of ellipses with different degrees of eccentricity.

(b) Obtaining the Phase-Difference Pattern. To obtain an accurate pattern from which phase difference can be determined, the following procedure must be followed.

Step 1. Turn the VERTICAL AMP control and the HORIZONTAL AMP control to 0 and with the calibrated screen in place, center the spot on the screen of the cathode-ray tube.

Step 2. Connect one signal to the VERTICAL INPUT terminal and the other signal to the HORIZONTAL INPUT terminal.

Step 3. Connect a common ground between the two frequencies under investigation and the oscillograph.

Step 4. If the frequency of the signals is less than 50 KC set the COARSE FREQUENCY switch to HOR INPUT AMP and the VERTICAL INPUT switch to AMP.

Step 5. If these frequencies are more than 50 KC, set the COARSE FREQUENCY switch to HOR INPUT DIR and the VERTICAL INPUT switch to DIR.

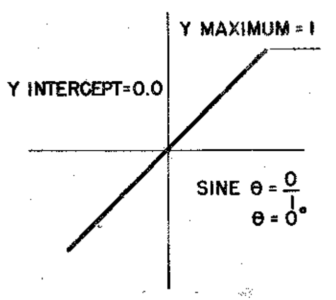


Figure 3 - 13

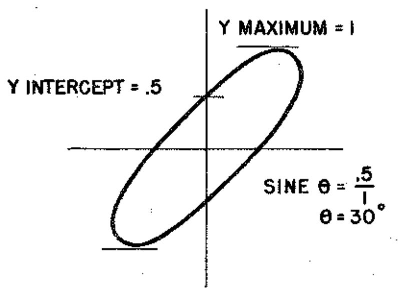


Figure 3 - 14

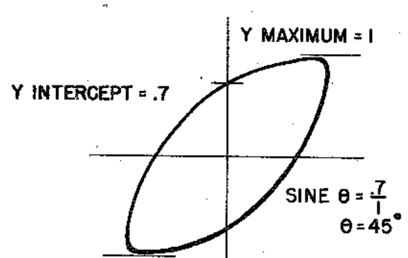


Figure 3 - 15

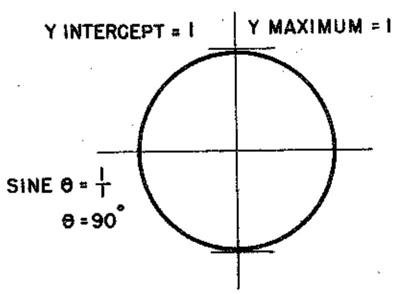


Figure 3 - 16

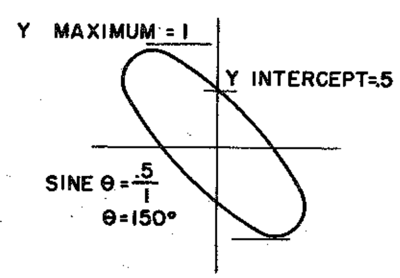


Figure 3 - 17

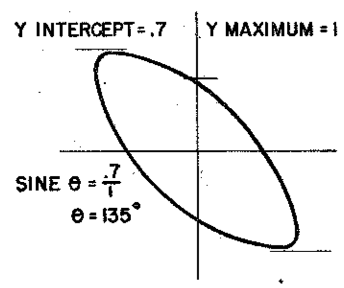


Figure 3 - 18

Examples showing the use of the formula for determination of phase difference

Step 6. Assuming the signals to be less than 50 KC, the COARSE FREQUENCY switch is set on HOR INPUT AMP and the VERTICAL INPUT switch is set on AMP.

Step 7. Adjust the VERTICAL AMP control to give approximately 3 inches of vertical deflection and adjust the calibrated scale so that the vertical axis of the scale coincides precisely with vertical deflection of the spot.

Step 8. Be extremely careful not to change the setting of the VERTICAL AMP control even the slightest amount. Remove the signal from the VERTICAL INPUT terminal and the trace will collapse to form a spot again.

Step 9. Increase the setting of the HORIZONTAL AMP control to give a deflection exactly the same as that to which the VERTICAL AMP control is adjusted (3 inches).

Step 10. Again connect the signal which was just removed from the VERTICAL INPUT terminal.

The resulting pattern will give an accurate picture of the exact phase difference between the two waves. If these two patterns are exactly the same frequency but different in phase and maintain that difference, the pattern on the screen will remain stationary. If, however, one of these frequencies is drifting slightly, the pattern will drift slowly through 360°. The phase angles of 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315° are shown in Figure 3-11.

(c) Presentation. - Each of the eight patterns in Figure 3-11 can be analyzed separately by the previously used projection method. Figure 3-12 shows two sine waves which differ in phase being projected on to the screen of the cathode-ray tube. These signals represent a phase difference of 45°.

Note

It is extremely important: 1. that the spot has been centered on the screen of the cathode-ray tube, 2. that both the horizontal and vertical amplifiers have been adjusted to give exactly the same gain, and 3. that the calibrated scale be originally set to coincide with the displacement of the signal along the vertical axis.

If the amplifiers of the oscillograph are not used for conveying the signal to the deflection plates of the cathode-ray tube, the COARSE FREQUENCY switch should be set to HOR INPUT DIR and the VERTICAL INPUT switch to DIR and the outputs of the two signals must be adjusted to result in exactly the same vertical deflection as horizontal deflection. Once this deflection has been set by either the oscillator output controls or the amplifier gain controls in the oscillograph, it should not be changed for the duration of the measurement.

(d) Determination of the Phase Angle. - The relation commonly used in determining the phase angle between signals is

$$\text{Sine } \theta = \frac{\text{Y intercept}}{\text{Y maximum}}$$

where θ = phase angle between signals

Y intercept = point where ellipse crosses vertical axis measured in tenths of inches (Calibrations on the calibrated screen)

Y maximum = highest vertical point on ellipse in tenths of inches

Several examples of the use of the formula are given in Figures 3-13 through 3-18. In each case the points Y intercept and Y maximum are indicated together with the sine of the angle and the angle itself.

(e) Phase Shifters. - For the operator to observe these various patterns with a single signal source such as the test signal, there are many types of phase shifters, which can be used. Circuits can be obtained from a number of radio text books. The procedure is to connect the original signal to the horizontal channel of the oscillograph and the signal which has passed through the phase shifter to the vertical channel of the oscillograph, and follow the procedure set forth in this discussion to observe the various phase shift patterns.

c. OTHER TIME BASES

Numerous new applications have been developed and are being developed daily. Many of these applications require time bases which are different from either the sawtooth time base or the sine wave time base just discussed. These applications are too numerous and too specialized to be considered to any great extent in this instruction book. However, some special types of time bases are listed as follows: 1. Circular sweep 2. Spiral sweep 3. Radial sweep 4. Delayed sweeps 5. Expanded sweeps.

5. LECTURE AND LABORATORY APPLICATIONS

a. INTRODUCTION

The cathode-ray oscillograph is an ideal instrument for lecture demonstration and laboratory experiments in conjunction with the subjects of light, sound, electricity, and electronics. The Du Mont Type 274 Cathode-ray Oscillograph was developed with this function being one of the primary design considerations. It is suggested that instructors and lecturers in the field of electronics prepare a series of demonstration units to aid in the explanation of the theory of the various electronic circuits. If these circuits are designed so that the critical components are variable, the effects on the waveforms at various points in the circuit can be demonstrated very clearly with the Type 274 cathode-ray oscillograph.

In addition to its use with the demonstration units, many further uses can be found when the instrument is available in the laboratory and the operator becomes familiar with its versatility. For instance, it serves as: (1) an excellent nul-indicator on inductance-capacitance bridges, (2) as a means for viewing voltage wave forms in various electronic circuits, (3) as an output meter, (4) a means for measuring time and amplitude of electrical impulses, (5) as an indicator in studies pertaining to sound and light, and many other applications.

b. DEMONSTRATION UNITS

(1) GENERAL. - Since B+ and heater voltage is available at the octal plug on the rear of the Type 274, the series of demonstration units, which was previously suggested, can be designed to derive their power from this source.

As an example of the use of a typical demonstration unit, the following demonstrations and experiments can be conducted with a single-stage audio-amplifier: measurement of frequency response versus gain; effect of screen and cathode impedances; measurement of pentode and triode characteristics; phase distortion; square wave testing; and microphone operation. Naturally, any demonstration unit which is prepared on a typical power supply would not derive its power from the Type 274 but rather from a 115 volt 50-60 cycle line. Such a unit is very convenient to demonstrate the following: full-wave rectification; half-wave rectification, the various filtering networks, and voltage regulation by means of bleeders.

The demonstrations suggested herein are merely to present ideas as to how the 274 may be used as a demonstrator. It is left to the individual instructor to incorporate this instrument into his course of study as he sees fit.

c. NUL-INDICATOR FOR INDUCTANCE-CAPACITANCE BRIDGES

(1) General. - Precise measurements by the bridge method require a sensitive nul-indicator. Since bridges for measurements of inductance and capacitance utilize an a-c signal, the oscillograph is probably the most sensitive nul-indicator. With the Type 274 amplifier at full gain approximately one inch deflection on the cathode-ray tube screen results with a signal input voltage of ½ volt.

(2) Procedure

Preliminary Settings

COARSE FREQUENCY	— on the line between 8 and 30
FINE FREQUENCY	— at 0
HORIZONTAL AMP	— to give approximately 3" horizontal deflection
SYNC AMP	— at 0
VERTICAL INPUT switch	— AMP
SYNC SELECTOR switch	— INT

Step 1. Connect VERTICAL INPUT and GROUND across the terminals provided at the bridge for the nul-indicator.

Step 2. Prepare the bridge for testing an unknown quantity.

Step 3. Turn on the bridge signal source.

Step 4. Obtain a pattern of convenient size by adjusting the VERTICAL AMP control (this pattern need not be stationary because amplitude is the only measurement concerned).

Step 5. Adjust the bridge controls to achieve balance indicated by minimum vertical deflection of the pattern on the screen.

Step 6. As the balance point is approached, the deflection on the cathode-ray tube will become less. It will probably be necessary to increase the setting of the VERTICAL AMP control as the balance point is approached so that the oscillograph gives a positive indication as the bridge dial is rotated through the nul-point.

Note

Some individuals find it desirable to set the HORIZONTAL AMP control at 0 in using the oscillograph as a nul-indicator. The pattern resulting is merely a vertical line which obtains a minimum length as the bridge dial passes through the nul-point. Be sure to keep intensity low if this method is used, in order to avoid burning the screen. Frequency setting is a matter of choice in this case, but some individuals prefer to set the sweep high enough to get a raster and collapse it down by balancing the bridge.

d. PRECISE MEASUREMENT OF ELECTRICAL IMPULSES

(1) Preliminary. - In many cases the wave form of a signal of unknown frequency prevents the use of a Lissajous figure for frequency determinations. For example, it may be desirable to measure the frequency of a series of pulses. In addition, it may be desirable to measure precisely the duration of a pulse, or the time it requires a pulse to reach its peak amplitude. Measurements such as this may be made by utilizing intensity modulation. Intensity modulation is the result of applying a signal of varying potential to the control grid of the cathode-ray tube thereby varying the intensity of the trace at the frequency of the signal applied.

(2) Procedure for Frequency Measurement by Intensity Modulation.

Preliminary Settings

COARSE FREQUENCY	— on the line between 30 and 150
FINE FREQUENCY	— at 0
SYNC AMP	— at 0
HORIZONTAL AMP	— to give approximately 3" deflection
VERTICAL INPUT switch	— AMP
SYNC SELECTOR switch	— INT

Step 1. Locate a calibrated audio oscillator, whose output voltage is at least 10 rms volts, conveniently near the oscillograph.

Step 2. Connect the output of the oscillator between INTENSITY MOD and GROUND.

Step 3. Connect TEST SIGNAL to VERTICAL INPUT with a short lead.

Step 4. Turn on the audio oscillator and the oscillograph.

Step 5. Set the calibrated audio oscillator on a multiple of 60 cycles, for example, 480 c.p.s.

Step 6. Locate a pattern of convenient size on the screen.

Step 7. With the FINE FREQUENCY control obtain a trace of two complete cycles and advance the SYNC AMP control sufficiently to "lock in" the pattern.

Step 8. Adjust the INTENSITY control and the voltage output control on the audio oscillator simultaneously until dark spaces are observed on the pattern.

Step 9. Count these dark spots as they appear on the pattern. In this case, we have adjusted the intensity modulation to 480 c.p.s., and the frequency on the vertical channel is 60 c.p.s.; therefore, eight dark spots should occur on each cycle of the pattern being observed as shown in Figure 3-19.

Note

To obtain more precise timing markers with a sharp definition of intensity modulation, it is more desirable to use a square wave as the intensity modulating signal. This example was chosen for the instruction book because it is felt that more users would have an oscillator of sine wave output than one with square wave output.

e. USE AS AN OUTPUT METER

(1) Preliminary. - Among the many important applications of the oscillograph, is its use as an output meter. An output meter, in addition to being merely a voltmeter, must be singular in its ability to indicate the signal strength of signals of all frequencies. The cathode-ray oscillograph is extremely useful in this capacity up to the limits of the frequency response of its vertical amplifier; and the cathode-ray tube itself, can go far beyond this point as discussed in Section 1.

In addition to the fact that the output meter must respond to all frequency signals, another requirement is that the output meter should not act as a load to the circuit it is measuring. The cathode-ray oscillograph also fulfills this requirement in view of the fact that it possesses extremely high input impedances. An example of the use of the oscillograph for indicating signal strength is given in the following procedure.

(2) Procedure for Measuring Gain of an Amplifier.

(a) Obtain an audio amplifier which may be a homemade "single stage" amplifier, the audio section of a radio receiver, or an audio amplifier demonstration unit.

(b) Set the controls of the Type 274 Oscillograph to the following positions:

COARSE FREQUENCY	— on the line between 30 and 150
SYNC SELECTOR switch	— INT
VERTICAL INPUT switch	— AMP

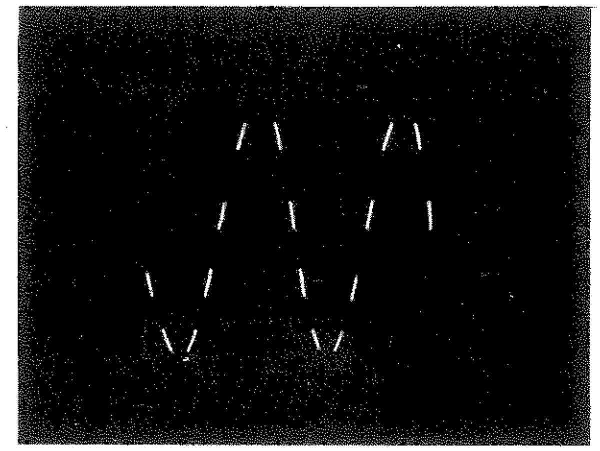


Figure 3 - 19

Example of intensity modulation with a sine wave signal.

Step 1. Assuming that an audio amplifier demonstration unit is used, connect the TEST SIGNAL terminal of the oscillograph to the INPUT jack of the demonstration unit (this is the grid of the audio amplifier).

Step 2. Connect the VERTICAL INPUT of the oscillograph to the input of the amplifier and connect GROUND of the oscillograph to GROUND of the amplifier.

Step 3. Remove the plug from the socket on the rear chassis of the Type 274 Oscillograph and insert the plug on the power cord of the amplifier demonstration unit.

Step 4. Turn on the oscillograph (thus the audio amplifier).

Step 5. With the HORIZONTAL AMP and VERTICAL AMP controls, obtain a pattern on the screen of the cathode-ray tube which gives about 3 inches of horizontal deflection and about 2/10" vertical deflection (the calibrated screen can be used for this measurement).

Step 6. Remove the connection between the VERTICAL INPUT terminal of the oscillograph and the INPUT terminal of the amplifier.

Step 7. Connect the VERTICAL INPUT of the oscillograph to the OUTPUT of the audio amplifier.

Step 8. With the calibrated screen measure the number of inches of vertical deflection.

Step 9. If the vertical deflection is now 3.0", the gain of the amplifier just measured is 15.

$$\text{gain} = \frac{\text{output voltage}}{\text{input voltage}} = \frac{3.0}{0.2} = 15$$

Note

The gain of this amplifier can also be measured without using horizontal deflection since the input and output signals are both measured on the vertical channel and amplitude is the only measurement being made. It is extremely important, however, that the setting of the vertical amplitude should not be changed between measurements of the input voltage and the output voltage. All voltage measurements under these circumstances are made as peak to peak voltage.

f. USE OF THE OSCILLOGRAPH FOR LECTURE DEMONSTRATION

In explaining electronic and electrical theory, the instructor will find numerous demonstrations for illustrating his lectures which require the use of the cathode-ray oscillograph. For the discussion of such electronic circuits as multivibrators, integrating and differentiating circuits, delay circuits and others, the instructor will find the oscillograph to be an invaluable tool. Magnetic properties of metals and hysteresis can also be investigated. Utilizing the oscillograph in conjunction with the photo-electric cell, offers many more interesting experiments in the study of light. By employing a microphone in conjunction with the oscillograph, phenomena such as resonance and beats will provide other demonstrations. The details of these and other applications are left to the ingenuity and resourcefulness of the instructor. Specific questions pertaining to the use of the oscillograph should be referred to the Manager of Instrument Sales, Allen B. Du Mont Laboratories, Inc., 2 Main Avenue, Passaic, New Jersey.

6. RADIO TRANSMITTER APPLICATIONS

a. INTRODUCTION

The Type 274 Oscillograph is a useful tool for operating and servicing radio transmitters (which procedure, incidentally, can be used as a separate demonstration or experiment). This discussion concerning radio transmitters is directed to the radio instructor, amateur, and commercial transmitter operator and includes instructions for aligning or adjusting, monitoring, and trouble shooting an amplitude-modulated transmitter.

The discussion of the use of the oscillograph for radio transmitters requires familiarity with a basic amplitude-modulated transmitter. Briefly, this type of transmitter consists of two separate channels: the carrier wave, or r-f channel, and the audio frequency, or a-f channel. The carrier wave channel includes: an oscillator, generally crystal controlled; a buffer amplifier, to isolate the oscillator; and an output stage, generally a push-pull, power-amplifier. The audio frequency channel generally is made up of: a voltage amplifier; a phase inverter, to obtain two voltage wave-forms 180° out of phase; and a modulator stage, generally push-pull in design. The modulator stage in small transmitters generally feeds into the output stage of the carrier wave channel.

There are many variations of this type of transmitter. For example, several stages of amplification can be used in the a-f and r-f channels, frequency multiplier stages are often employed to operate the transmitter at a higher carrier wave frequency than that of the crystal, the push-pull feature can be replaced by single amplifiers, or modulation can be introduced into a lower-level stage rather than the output stage.

In maintaining an amplitude-modulated transmitter at optimum performance; there are tank circuits, consisting of a capacitor and coil, which must be adjusted to resonate at the crystal frequency, or a harmonic of that frequency, (tuning the carrier wave channel). Also, interaction between grid and plate tank circuits must be minimized (neutralizing the transmitter). Then, the audio frequency channel must be investigated for faithful reproduction of the input signal. (Checking or trouble shooting the audio channel). Next, the output signal of the transmitter must be monitored. Finally, a quick, efficient method of trouble shooting must be developed.

b. ALIGNING THE TRANSMITTER

(1) Introduction. - The object in aligning the transmitter is to adjust the tank circuits to resonance at the required frequency.

(2) Procedure

Preliminary Settings:

SYNC SELECTOR	— EXT
COARSE FREQUENCY	— between 750 and 5500
FINE FREQUENCY	— 50
SYNC AMP	— 0
HORIZONTAL AMP	— 20
VERTICAL AMP	— 0
VERTICAL INPUT switch	— DIR

Step 1. Connect a pick-up loop of two or three turns of wire, equipped with shielded leads long enough to extend from the oscillograph to the transmitter, between VERTICAL INPUT and GROUND.

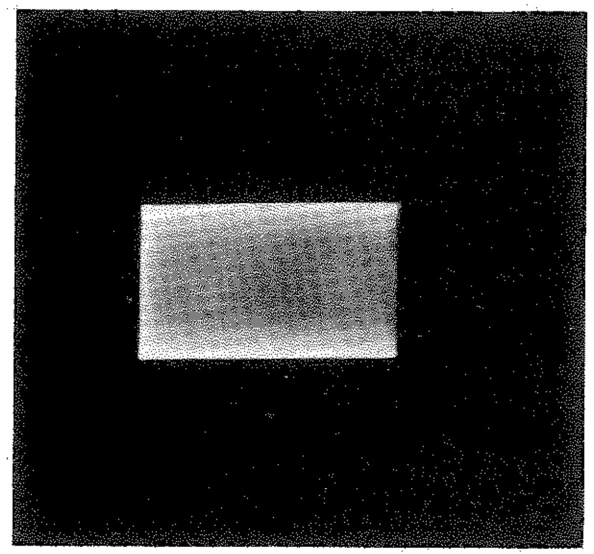


Figure 3 - 20

R-F Carrier wave of a transmitter

Step 2. Loosely couple the pick-up loop to the tank coil of the oscillator stage of the transmitter.

WARNING

CLOSE COUPLING BETWEEN TANK COIL AND PICK-UP LOOP ALTERS THE RESONANT CONDITIONS OF THE TANK CIRCUIT. THEREFORE, THIS COUPLING SHOULD NOT BE CLOSER THAN NECESSARY TO OBTAIN SUFFICIENT DEFLECTION ON THE CATHODE-RAY TUBE.

Step 3. Turn on the oscillograph and transmitter.

Step 4. Obtain a pattern similar to Figure 3-20 by adjusting the coupling between pick-up loop and the tank coil.

Step 5. (Optional) In the event that the signal picked up is too small to achieve sufficient vertical deflection, construct a high Q tank circuit to resonate at the crystal frequency. Connect the tank circuit in parallel with VERTICAL INPUT and GROUND and adjust its tuning to obtain maximum vertical deflection. If the resultant signal produces more than full scale deflection on the CRT, loosen the coupling between the oscillator coil and the pick-up loop.

Step 6. Adjust the setting of the oscillator tank circuit capacitor until the pattern on the screen reaches maximum vertical deflection. Maximum vertical deflection indicates correct adjustment of the oscillator tank circuit to the crystal frequency.

Step 7. Proceed in order to adjust all other tank circuits of the transmitter with the same method as described above. Frequency multiplier stages are aligned in the same manner except the vertical deflection will be less than that achieved at the preceding fundamental frequency. Remember, however, that as the signal is further amplified, the signal reaching the oscillograph becomes greater and the coupling of the oscillograph can become less in the higher-level stages.

c. NEUTRALIZING THE TRANSMITTER

(1) Introduction. - The object in neutralizing a transmitter stage is to permit a minimum of signal transfer between the grid and plate tank circuits within any single stage. Neutralization is performed with the transmitter in operation but without plate voltage at the stage to be neutralized.

(2) Procedure

Step 1. Capacitively couple the oscillograph to the stage to be neutralized as shown in Figure 3-21.

Step 2. The signals from these two sources are connected to the binding post on the front panel of the oscillograph and the VERTICAL INPUT switch is set to DIR and the COARSE FREQUENCY switch is set to HOR INPUT DIR.

Step 3. Tune the grid tank circuit for maximum horizontal signal.

Step 4. Tune the plate tank circuit to produce a horizontal elipse as shown in Figure 3-22A.

Step 5. Tune C_n (the neutralizing capacitor) to obtain a straight horizontal line as shown in Figure 3-22B. The waveforms shown in Figures 3-22C and 3-22D may also be observed. The legend on this figure explains these patterns.

d. CHECKING THE A-F CHANNEL

(1) Introduction. - The a-f channel of a transmitter should have a frequency response which is flat at all audio frequencies in order to faithfully reproduce the audio input signals which it is required to amplify. Since the aging of components may change the frequency response of audio amplifiers, the frequency response of the a-f channel of a transmitter should be checked at regu-

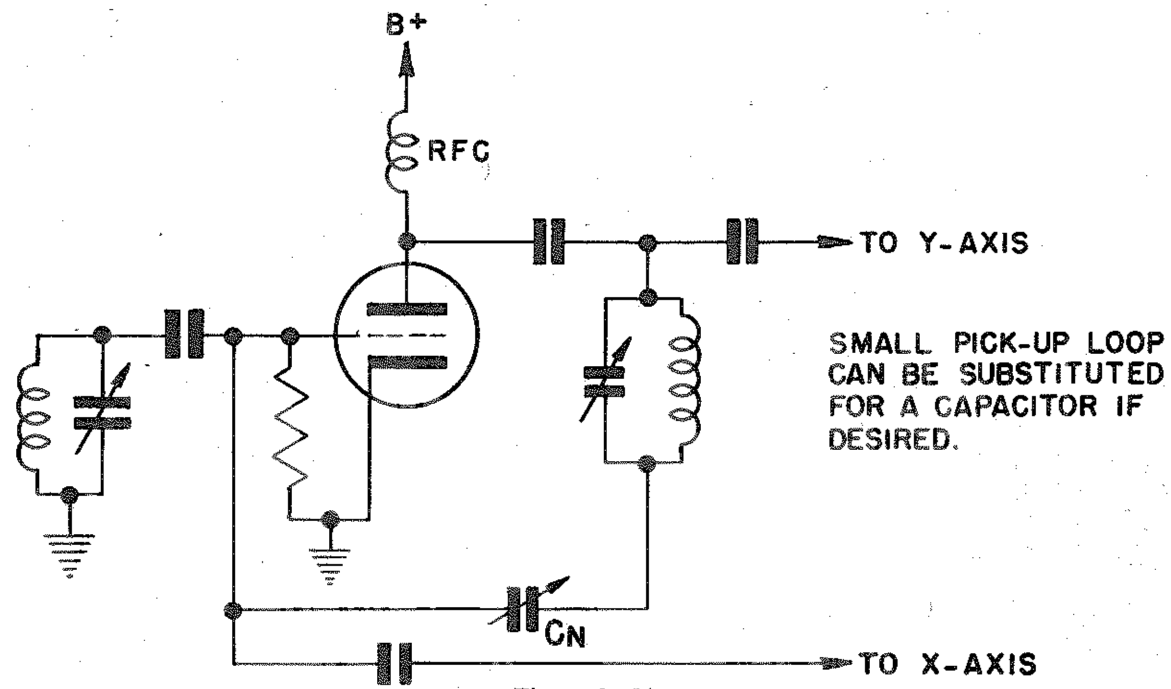


Figure 3 - 21
Capacitive coupling for neutralization procedure

lar intervals for the true reproduction.

A customary quick check on the frequency response of an amplifier is accomplished with an audio oscillator. The output of the audio oscillator is first fed into the vertical channel of the oscillograph, but is shunted around the vertical amplifier and capacitively coupled to the vertical deflection plates. The frequency of the audio oscillator is set to the low frequency limit of the a-f channel of the transmitter as set forth in its specification. The frequency of the audio oscillator is then slowly advanced in the direction of the upper frequency limit of the a-f channel of the transmitter. Any deviation in the amplitude of the signal, as shown on the screen of the cathode-ray tube, should be noted along with the frequency at which that deviation occurs. This deviation indicates a change in the output voltage of the audio oscillator at that frequency. If the audio oscillator has a built-in output meter, the output of the oscillator should always be maintained at a constant level and the deviation previously observed on the cathode-ray tube will no longer be apparent. However, if there is no means for controlling the output voltage of the audio oscillator, these deviations should be noted so that the operator will not blame them on the a-f channel about to be tested.

After the output of the audio oscillator has been checked for the frequencies which are to be used, the audio oscillator is connected to the input terminals of the a-f channel to be tested. The oscillograph is connected across the output of this channel. The same procedure is followed again but at this time the a-f channel is being checked for frequency response. Any deviations from the deflection originally produced on the oscillograph should be noted. If these deviations are outside the limits set forth in the specification for the a-f channel, the a-f channel should be investigated to correct the trouble.

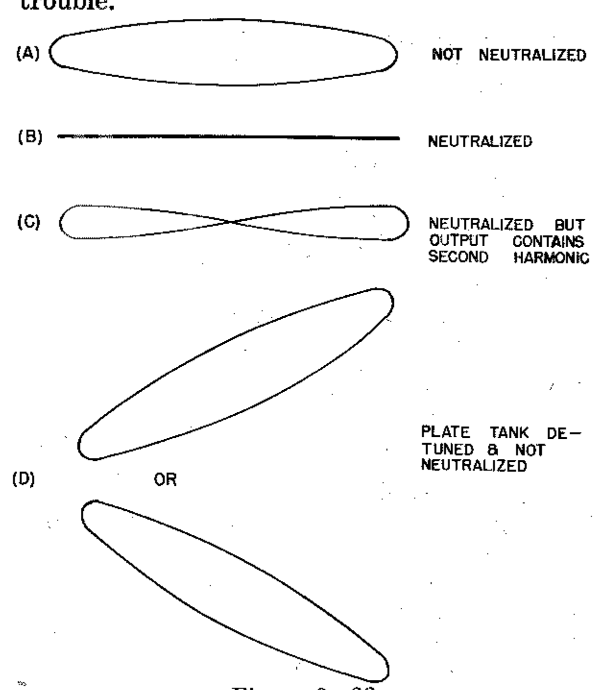


Figure 3 - 22
Patterns observed during neutralization

(2) Procedure

Preliminary Settings

COARSE FREQUENCY — between 30 and 150

SYNC SELECTOR — INT

VERTICAL INPUT — DIR

Step 1. Connect the output terminal of the audio oscillator to the VERTICAL INPUT terminal of the oscillograph and ground of the oscillator to GROUND of the oscillograph.

Step 2. Turn on the oscillograph and the audio oscillator and set the audio oscillator at the low frequency limit of the a-f channel of the transmitter.

Step 3. Synchronize several cycles of the sine wave and note deflection produced on the cathode-ray tube.

Step 4. Increase the frequency of the audio oscillator noting any deviation in the deflection produced on the cathode-ray oscillograph.

Step 5. Turn off the audio oscillator.

Step 6. Connect the output of the audio oscillator to the input terminals of the a-f channel of the transmitter.

Step 7. Connect the VERTICAL INPUT of the oscillograph to the output terminal of the a-f channel of the transmitter.

Step 8. Connect a common ground between all three units: the oscillograph, the a-f channel, and the audio oscillator.

Step 9. Turn on the a-f channel of the transmitter and the audio oscillator.

Step 10. Synchronize the same number of waves at the same amplitude as that used in Step 2 (adjust the output of the audio oscillator to result in the same vertical deflection).

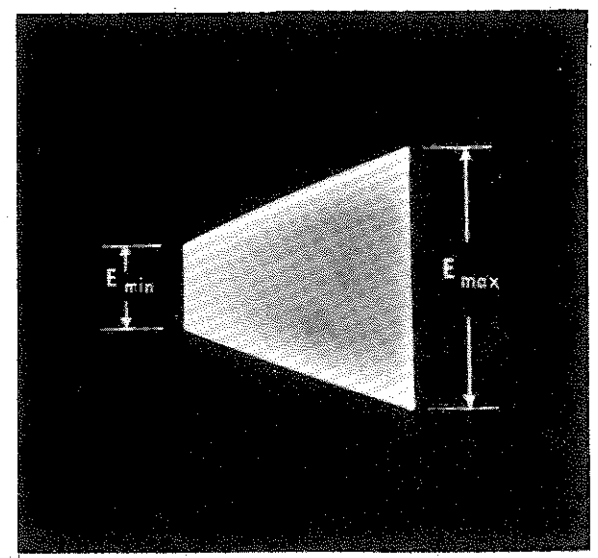


Figure 3 - 23
Trapezoidal modulation pattern

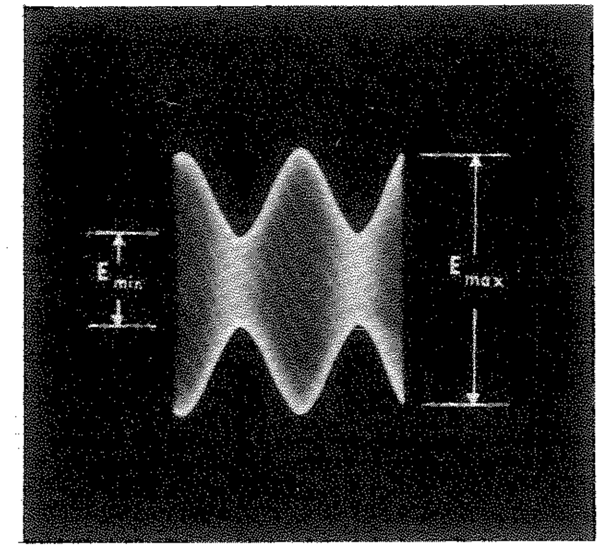


Figure 3 - 24
Modulated carrier wave pattern

Step 11. Increase the frequency of the audio oscillator to the upper limit of the a-f channel noting any change in amplitude of the pattern on the oscillograph.

Note

Since a low setting of the gain control on the oscillograph may attenuate the signal unevenly, the amplifier in the oscillograph is shunted in this procedure and the output of the a-f channel is capacitively coupled to the deflection plates.

(3) Trouble Shooting. - If the output signal is not comparable to the input from the audio oscillator, trouble within the a-f channel is indicated. To localize this trouble, the operator should remove the connection from the output terminal of the a-f channel and connect it to the input of the last stage. If the irregularity in the wave form clears up at this point, the trouble is localized to the amplifier output stage.

If the distortion still appears, the operator should continue working backwards through the channel until he finds the point where distortion is no longer in evidence. At this time, he can be assured that the circuit causing this distortion is the following stage and he should, therefore, check that stage carefully.

e. MONITORING THE TRANSMITTER OUTPUT

(1) Introduction. - Once the transmitter is aligned and adjusted the oscillograph may be used as an indicator of the overall performance of the transmitter output signal, and as a modulation monitor.

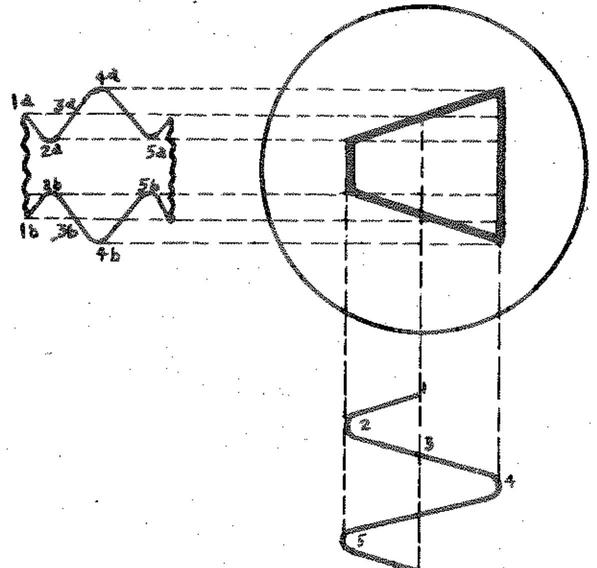


Figure 3 - 25
Projection drawing showing trapezoidal pattern

(2) Waveforms. - There are two types of patterns that can serve as indicators, the trapezoidal pattern (Figure 3-23) and the modulated wave pattern (Figure 3-24). The trapezoidal pattern is presented on the screen by impressing a modulated carrier wave signal on the vertical deflection plates and the signal that modulates the carrier wave signal (the modulating signal) on the horizontal deflection plates. The trapezoidal pattern can be analyzed by the method used previously in analyzing waveforms. Figure 3-25 shows how the two signals cause the electron beam to trace out the pattern.

The modulated wave pattern is accomplished by presenting a modulated carrier wave on the vertical deflection plates and by using the time-base generator for horizontal deflection. The modulated wave pattern also can be analyzed by the method used previously in analyzing waveforms. Figure 3-26 shows how the two signals cause the electron beam to trace out the pattern.

(3) Procedure for Obtaining the Trapezoidal Pattern.

Preliminary Settings

SYNC SELECTOR — EXT
VERTICAL INPUT switch — DIR
COARSE FREQUENCY— HOR INPUT DIR

Step 1. Construct a monitor circuit in the output (modulator) stage of the a-f channel. The circuit in Figure 3-27 is satisfactory.

Step 2. Connect the output from the monitor circuit across HORIZONTAL INPUT and GROUND.

Step 3. Loosely couple a pick-up loop (see the preceding paragraph b. for description) to the modulated stage of the r-f channel of the transmitter.

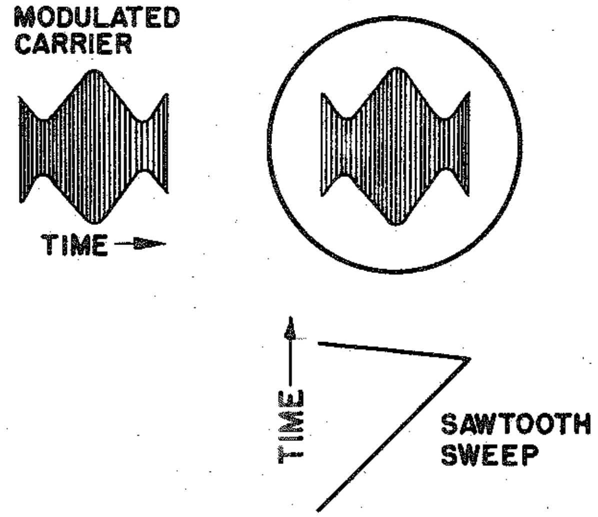


Figure 3 - 26
Projection drawing showing modulated carrier wave pattern.

Step 4. Connect the leads from the pick-up loop to VERTICAL INPUT and GROUND.

Step 5. Using a sine wave oscillator for the a-f (modulating) signal, turn on the transmitter, sine wave oscillator and the oscillograph.

Step 6. If the vertical size of the pattern is inconveniently small refer to paragraph b. Step 5. for instructions.

Step 7. Control the size of the pattern on the vertical plane by adjusting the coupling and in the horizontal plane by adjusting the volume control in the monitor circuit (Figure 3-25).

(4) Procedure: Modulated Wave Pattern

Preliminary Settings

SYNC AMP control — 0
SYNC SELECTOR — EXT
VERTICAL INPUT switch — DIR

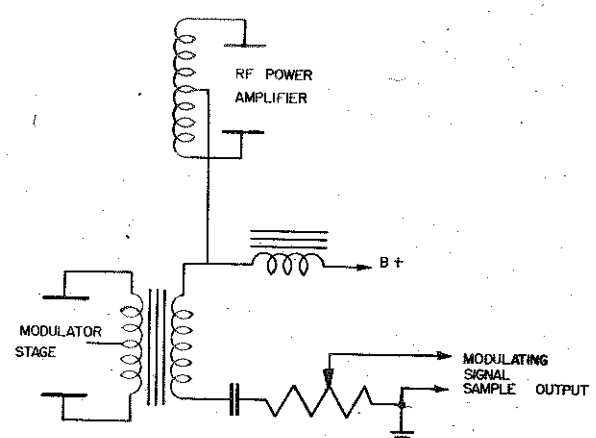


Figure 3 - 27
Monitor circuit for the modulating signal

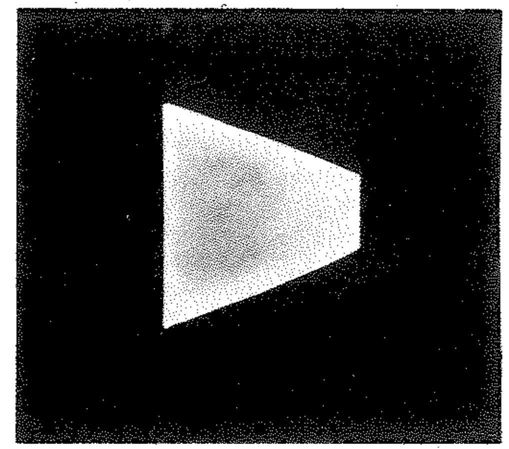


Figure 3-28
Trapezoidal wave pattern (less than 100% modulation)

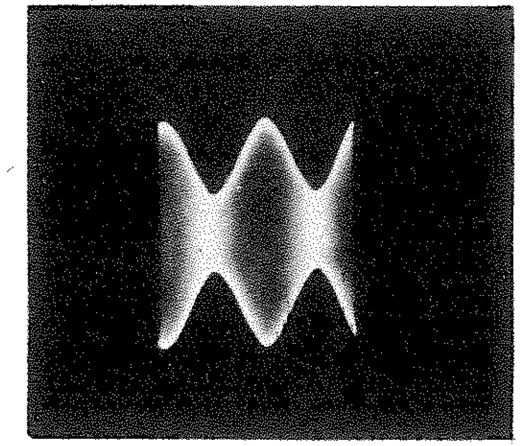


Figure 3-29
Carrier wave pattern (less than 100% modulation)

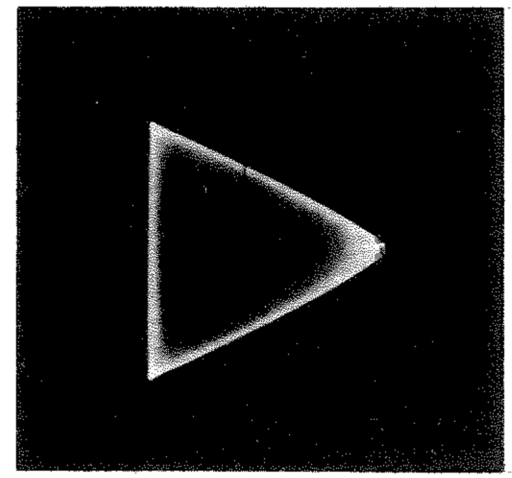


Figure 3 - 30
Trapezoidal wave pattern (100% modulation)

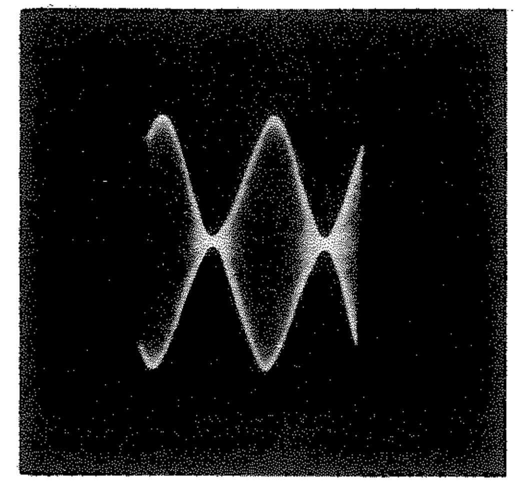


Figure 3-31
Carrier wave pattern (100% modulation)

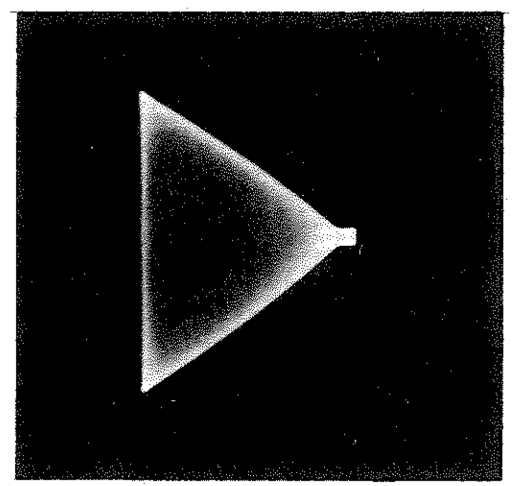


Figure 3-32
Trapezoidal wave pattern (over modulation)

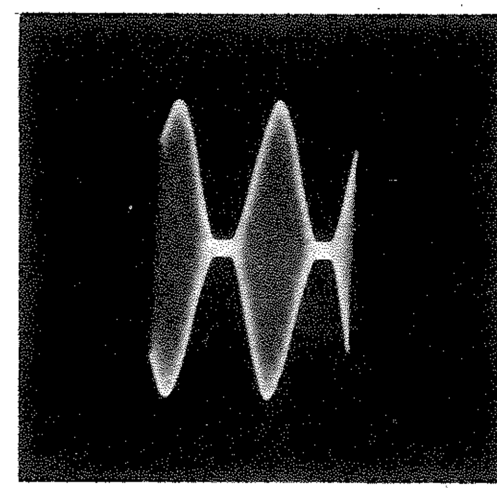


Figure 3-33
Carrier wave pattern (over modulation)

Step 1. Follow Steps 1 through 4 of the preceding paragraph.

Step 2. Remove the lead from the HORIZONTAL INPUT and place it on the EXT SYNC terminal.

Step 3. Set the COARSE FREQUENCY switch to include the frequency of the modulating sine wave signal.

Step 4. Set the HORIZONTAL AMP control to result in convenient horizontal deflection.

Step 5. Adjust the FINE FREQUENCY control to obtain 2 or 3 cycles of the modulating frequency on the screen of the cathode-ray tube.

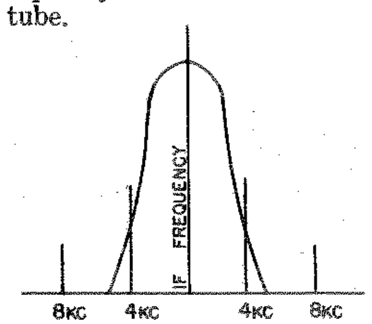


Figure 3 - 34
Frequency response curve of the i-f of a low priced receiver

Step 6. Add enough SYNC AMP to "lock-in" the pattern.

Remarks. - The trapezoidal and modulated wave patterns show a picture of the overall performance of the transmitter. By changing the degree of modulation of the carrier wave the shape of the pattern changes. Figures 3-28 through 3-33 show the trapezoidal and modulated wave patterns in various degrees of modulation.

Modulation percentage may be determined by the following formula:

$$\text{Modulation percentage} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100$$

E_{max} and E_{min} are defined in Figures 3-23 and 3-24.

f. TROUBLE SHOOTING

The trapezoidal and modulated wave patterns can serve as indicators for trouble shooting the transmitter. The method employed is to observe the pattern and note any distortion. Then the shape of the pattern reveals the position of the trouble. This method of trouble shooting requires a certain amount of experience, but proves to be highly satisfactory.

7. ALIGNING A-M RADIO RECEIVERS

a. INTRODUCTION

To complete the discussion of the use of the oscillograph in aligning amplitude modulated radio systems there remains the subject of radio receivers. Included in receiver servicing is the adjustment of the radio frequency (r-f) and intermediate frequency (i-f,) in superhetrodyne type radio receivers, and the servicing of audio frequency (a-f) amplifiers.

b. A-F AMPLIFIERS

The object of the a-f amplifier of a receiver is to provide amplification for the detected signal which has uniform response throughout the desired frequency limits. The equipment necessary for checking audio amplifiers consists of: An audio oscillator of sine wave output in combination with an oscillograph. The procedure for checking an audio amplifier with a sine wave oscillator is identical with that used in checking the audio frequency channel of a transmitter as described earlier in this section.

c. I-F SYSTEMS

(1) Introduction. - The alignment of the i-f amplifiers of a receiver consists of adjusting all the tuned circuits to resonance at the intermediate-frequency and at the same time to permit passage of a predetermined number of side bands. The best indication of this adjustment is a resonance curve representing the response of the i-f circuit to its particular range of frequencies.

As a rule medium and low-priced receivers use i-f transformers whose band-width is about 5 kc on each side of the fundamental

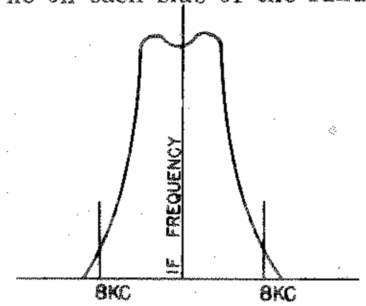


Figure 3 - 35
Frequency response curve of high-fidelity i-f stages

frequency. The response curve of these i-f transformers is shown in Figure 3-34. High fidelity receivers usually contain i-f transformers which have a broader band-width which is usually 10 kc on each side of the fundamental. The response curve for this type transformer is shown in Figure 3-35.

Resonance curves such as these can be displayed on the screen of an oscillograph. For a complete understanding of the procedure it is important to know how the resonance curve is traced.

(2) The Resonance Curve on the Screen. - To present a resonance curve on the screen, a frequency-modulated signal source must be

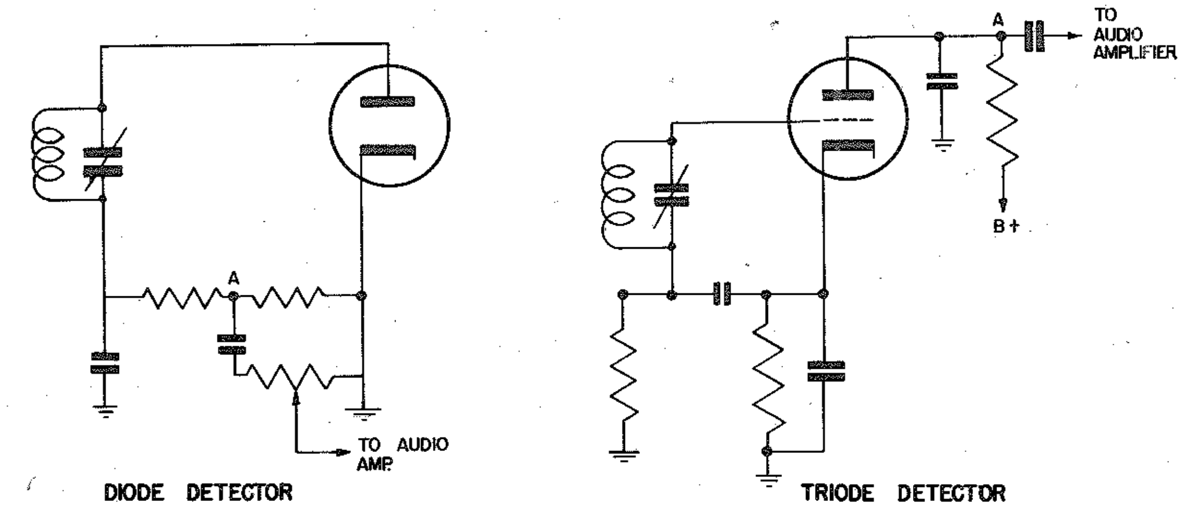


Figure 3 - 36
Connection of the oscillograph across the detector load

available. This signal source is a signal generator whose output is the fundamental i-f frequency which is frequency-modulated 5 to 10kc each side of the fundamental frequency. A signal generator of this type generally takes the form of an ordinary signal generator with a rotating motor driven tuned circuit capacitor, called a wobulator, or its electronic equivalent, a reactance tube.

The method of presenting a resonance curve on the screen is to connect the vertical channel of the oscillograph across the detector (demodulator) load of the receiver as shown in the detectors of Figure 3-36 (between point A and ground) and the time-base generator output to the horizontal channel. In this way the d-c voltage across the detector load varies with the frequencies which are passed by the i-f system. Thus, if the time-base generator is set at the frequency of rotation of the motor driven capacitor, or the reactance tube, a pattern resembling Figure 3-37, a double resonance curve, appears on the screen.

Figure 3-37 is explained by considering Figure 3-38. In half a rotation of the motor driven capacitor the frequency increases from 445 kc to 465 kc, more than covering the range of frequencies passed by the i-f system. Therefore, a full resonance curve is presented on the screen during this half cycle of rotation since only half a cycle of the voltage producing horizontal deflection has transpired. In the second half of the rotation the motor driven capacitor takes the frequency of the signal in the reverse order through the range of frequencies passed by the i-f system. In this interval the time-base generator saw-tooth waveform completes its cycle, drawing the electron beam further across the screen and then returning it to the starting point. Subsequent cycles of the motor driven capacitor and the sawtooth voltage merely retrace the same pattern. Since the signal being viewed is applied through the vertical amplifier, the sweep can be synchronized internally.

Some signal generators, particularly those employing a reactance tube, provide a sweep output in the form of a sine wave which is

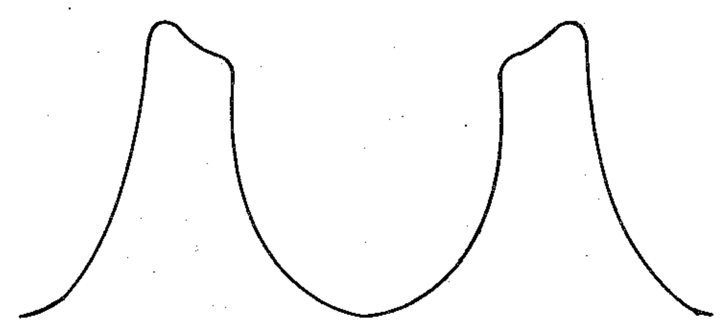


Figure 3 - 37
Double resonance curve

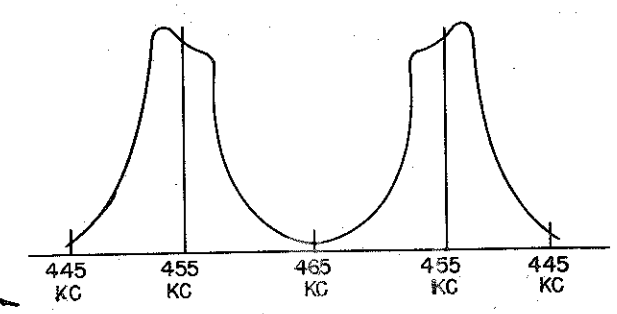


Figure 3 - 38
Double resonance achieved by complete rotation of the motor driven capacitor

synchronized to the frequency with which the reactance tube is swinging the fundamental frequency through its limits, usually 60 cycles. If such a signal is used for horizontal deflection, it is already synchronized.

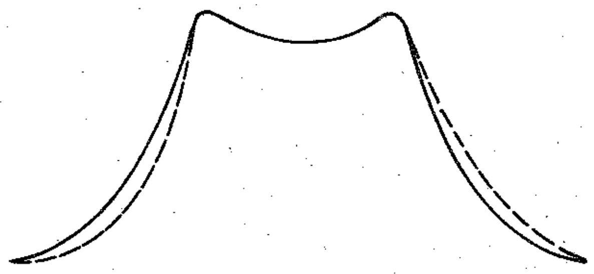


Figure 3 - 39

Super-position of resonance curves

Since this signal is a sine wave, the response curve is observed as it sweeps the spot across the screen from left to right; and it is observed again as the sine wave sweeps the spot back again from right to left. Under these conditions the two response curves are superimposed on each other and the high frequency responses of both curves are at one end and the low frequency response of both curves is at the other end. The i-f trimmer capacitors are adjusted to produce a response curve which is symmetrical on each side of the fundamental frequency.

When using sawtooth sweep, the two response curves can also be superimposed. If the sawtooth signal is generated at exactly twice the frequency of rotation of the motor driven capacitor, the two resonance curves will be superimposed (Figure 3-39) if the i-f transformers are properly tuned. If the two curves do not coincide the i-f trimmer capacitors should be adjusted. At the point of coincidence the tuning is correct. It should be pointed out that rarely do the two curves agree perfectly. As a result, optimum adjustment is made by making the peaks coincide. This latter procedure is the one generally used in i-f adjustment. When the two curves coincide, it is evident that the i-f system responds equally to signals higher and lower than the fundamental i-f frequency.

Note

Before correcting the setting of the trimmer capacitors, it is necessary to adjust the FINE FREQUENCY control to make the two peaks of the frequency response curves coincide. After these two curves are thus superimposed, the operator should then proceed with the adjustment of the trimmer capacitors to achieve coincidence of the two curves as nearly as possible. It will probably be necessary to use a high setting of the SYNC AMP control to maintain this pattern in synchronization.

(3) Procedure. - Since most i-f systems contain several stages the number of variables must be decreased by starting the alignment at the last i-f circuit and working backward from the detector.

Preliminary Settings:

SYNC SELECTOR	— INT
VERTICAL INPUT	— AMP

Step 1. Join the antenna and ground connections of the receiver together with a 0.001 mfd capacitor.

Step 2. Short out the tank circuit of the receiver beat frequency oscillator with a wire lead connecting the rotor and stator of its variable capacitor (steps 1 and 2 prevent unwanted signals from entering the i-f system)

Step 3. Connect the output of the frequency-modulated signal generator between grid and ground of the last i-f amplifier tube.

Step 4. Connect VERTICAL INPUT and GROUND across the detector load impedance (Figure 3-36)

Step 5. Set the frequency dial of the frequency-modulated signal generator to the intermediate-frequency to be passed by the i-f system.

Step 6. Turn on the signal generator, oscillograph, and radio receiver.

Step 7. Assuming that the time-base generator of the oscillograph is used, set COARSE FREQUENCY to include twice the frequency of rotation of the motor driven capacitor (or the reactance tube) and adjust the FINE FREQUENCY and SYNC AMP controls to obtain stationary superimposed resonance curves.

Step 8. Adjust HORIZONTAL AMP and VERTICAL AMP controls for a conveniently sized pattern.

Step 9. Adjust the i-f trimmer capacitors in the plate circuit of this i-f stage until the two response curves are superimposed on each other.

Step 10. Move the input of the signal generator from the grid of this tube to the grid of the preceding i-f amplifier. (On small receivers having only one i-f tube, the signal is placed on the grid of the mixer or the converter tube).

Step 11. Turn on the receiver and adjust the trimmer capacitors in the i-f transformer for this stage as in Step 9. The receiver output to the oscillograph is still

taken at the same point, across the detector load resistor. Because of the gain of this stage, it will probably be necessary to reduce the output of the signal generator.

CAUTION

Once an i-f transformer has been aligned, do not change the setting of its i-f trimmer capacitors, or the alignment will have been changed.

d. R-F SECTION

Following the alignment of the i-f amplifiers in the superhetrodyne receiver, the next section of the circuit to be adjusted is the r-f section.

(1) Introduction. - The main objects in aligning the r-f systems of a receiver are: (1) to adjust the r-f tank circuits to resonance at the frequency indicated by the receiver dial setting and; (2) to adjust tank circuit of the local oscillator in the receiver to resonance at the frequency indicated by the dial setting **plus** the intermediate frequency of the receiver.

(2) Equipment. - Together with the oscillograph, the necessary equipment is a frequency-modulated signal generator, similar to the one used in aligning i-f systems.

(3) Operation. - As in i-f alignment, the r-f signal is fed into the circuit under examination and the response of that circuit tested by observing the signal voltage across the receiver detector load. The r-f stages are in alignment when the normal i-f response curve is at maximum amplitude.

(4) Aligning the r-f Section. - For r-f alignment the frequency modulated signal is capacitively coupled into the antenna. Both the signal generator and the receiver dial are set for the same fundamental frequency approximately 650 kc. The local oscillator padding capacitor is then tuned to result in the correct i-f frequency. The i-f curve which appears on the screen of the cathode-ray tube varies in amplitude as the local oscillator is tuned. Correct tuning is indicated by maximum amplitude of the i-f response curve.

The signal generator and the receiver dial are both set at the same high fundamental frequency, approximately 1400 kc. The trimmer capacitor, in parallel with the local oscillator tuning capacitor, is then adjusted to result in the maximum amplitude of the i-f frequency response curve.

This procedure of adjusting the dial at approximately 1/4 maximum and 1/4 minimum range insures reasonably good tracking of the oscillator over the entire broadcast band. Of course, the adjustment of the high end after that of the low end requires a resetting of the low end again. These two settings affect each other and they are balanced as closely as possible after two or three settings.

After the oscillator has been aligned, the final step in aligning the r-f section is the trimmer capacitor on the r-f tuning capacitor. This is adjusted to the optimum setting for maximum amplitude of the i-f response curve over the entire band. This capacitor will naturally have more effect on the high frequency than that on the low frequency end of the band. Sets having one or more r-f stages have other trimmers on their tuning capacitors which should be adjusted similarly. The alignment of receivers with the oscillograph permits the serviceman to observe the overall performance of the receiver.

(5) Procedure

Step 1. Connect the oscillograph across the detector load resistor as explained in the alignment of i-f circuits.

Step 2. Set the receiver tuning dial at approximately 650 kc.

Step 3. Set the fundamental frequency of the FM signal generator to 650 kc.

Step 4. Connect the output of the signal generator through a capacitor of about 1000 μμf to the antenna terminal and ground of the signal generator to ground of the receiver. (Naturally the capacitor connected between the antenna and ground and the shorting wire across the receiver oscillator capacitor should be removed. These special connections were made for i-f alignment only).

Step 5. Turn on the signal generator, the receiver, and the oscillograph.

Step 6. Adjust the local oscillator padder capacitor (in some cases the oscillator inductance) to obtain the maximum amplitude of the i-f response curve which appears on the oscillograph.

Step 7. Set the receiver tuning dial at 1400 kc and the fundamental frequency of the signal generator also at 1400 kc.

Step 8. Adjust the trimmer capacitor in parallel with the oscillator tuning capacitor to result in maximum amplitude of the i-f response curve.

Step 9. Then turn to the settings for aligning the low frequency end of the dial and adjust the oscillator padder capacitor again to result in maximum amplitude.

Step 10. Return to the high frequency position on the dial and adjust the trimmer capacitor again to maximum amplitude.

Note

Probably two or three settings at both of these points will determine the optimum setting for good tracking over the entire band.

Step 11. A final check of tracking is determined by checking the amplitude of the i-f response curve at about 1000 kc. If this amplitude is approximately the same as that at each of the other two settings, good tracking is practically assured.

Step 12. After the oscillator has been aligned for tracking, the trimmer capacitor in parallel with the r-f tuning capacitor should be adjusted to result in optimum amplitude of the i-f response curve throughout the dial range.

Note

In the cheaper models of the a-c - d-c sets it is extremely difficult to align the receiver by this method because 60 cycle pick up is prevalent throughout the chassis with practically the entire receiver operating above ground potential. Such prevalence of 60 cycle pick-up may make it very awkward to align a receiver by this method. In this case it is possible to capacitively couple the incoming signal to the antenna with a very small capacitor. The output to the oscillograph is taken across the two terminals of the speaker coil. The IF signal is fed into the antenna with the local oscillator shorted out while the IF amplifiers are being adjusted. This shunt should then be removed for the alignment of the RF section.

8. ALIGNING F-M RADIO RECEIVERS

a. INTRODUCTION

(1) Purpose of F-M. - The narrow channel permitted a-m broadcasting limits the modulating signal to the lower audio frequencies, but with a top audio frequency of 15,000 cycles, f-m broadcasting adds overtones and thus more perfect reproductions to music and speech. Therefore, f-m receivers are designed to offer listeners an output signal of higher fidelity than is possible with a-m receivers. To achieve this high fidelity, f-m is operated with broad channels on a high frequency band.

(2) F-M vs. A-M. - The essential difference between f-m and a-m receivers lies in the method of detection. An a-m detector receives an r-f signal, amplitude modulated at an audio rate, strips off the r-f carrier, and delivers the audio signal to the audio amplifiers. An f-m detector receives a very high frequency, (v.h.f.) signal, frequency modulated at an audio rate; removes the v.h.f. carrier; and delivers an audio signal, directly proportional to the amount of frequency modulation, to the audio amplifiers. The f-m circuit comparable to the a-m detector is called the discriminator.

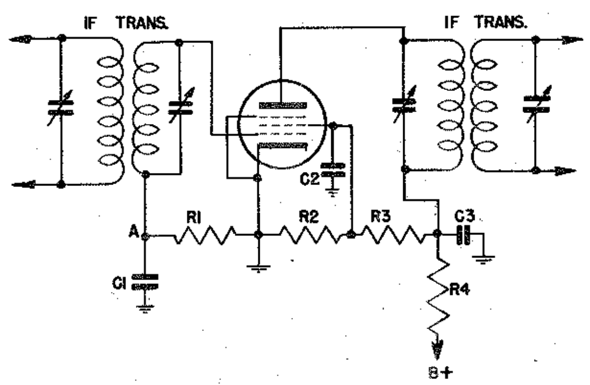


Figure 3 - 40
Oscillograph connection to obtain i-f curve in F-M receivers

The equipment necessary for f-m receiver alignment is an oscillograph and a frequency modulated signal generator, similar to the equipment required in a-m receiver servicing. Also, in f-m servicing the nature of the system demands that the signal generator frequency be in the f-m range and frequency modulated over a 200 kc band.

Aligning the i-f amplifiers of f-m receivers with an oscillograph is similar to the procedure for a-m except that all f-m amplifiers are high fidelity circuits and therefore have broad-band i-f transformers resulting in a broad-band i-f response curve.

b. I-F AND R-F ALIGNMENT

(1) Procedure. - The procedure for aligning the i-f and r-f sections of an f-m receiver is identical with that of aligning the a-m receiver except that the oscillograph is connected to a different section of the circuit and the frequencies are much higher.

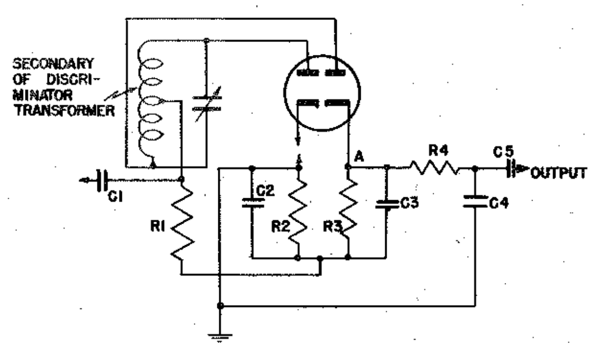


Figure 3 - 41
Alternate method of obtaining i-f curve in F-M receivers

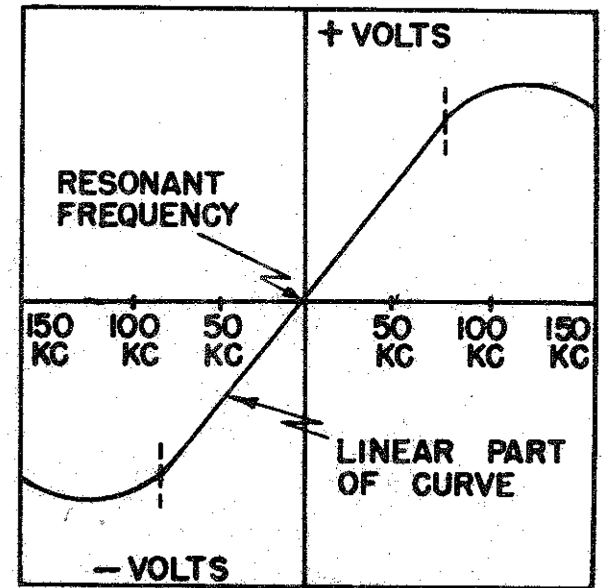


Figure 3 - 42
Characteristic discriminator curve

(2) Connecting the Oscillograph. - The oscillograph is connected across the grid resistor R1 of the first limiter stage as shown in Figure 3-40. If the load across this resistor is used for a.v.c., however, it is necessary to remove the connections from one of the cathodes of the discriminator as shown in Figure 3-41. This results in the discriminator becoming an a-m detector and the oscillograph is connected across the diode load which is still connected in the circuit.

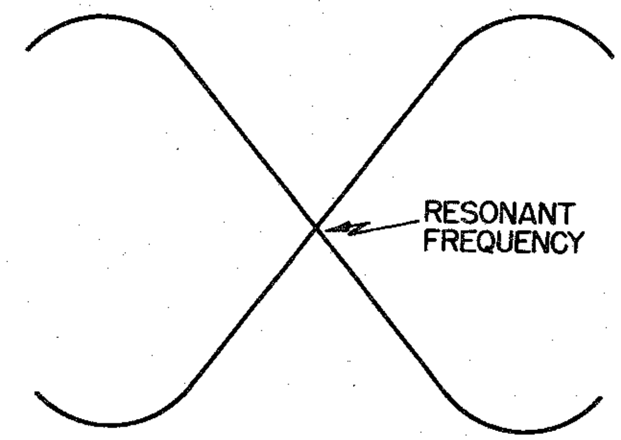


Figure 3 - 43
Super-imposed discriminator curves

The transformer in the discriminator stage then must be tuned first as a regular i-f transformer.

c. DISCRIMINATOR ALIGNMENT

(1) General. - There are several f-m discriminator circuits but, they all depend on approximately the same output circuit to the audio stages. This output has opposite polarity for frequencies on either side of resonance of the discriminator tank circuit and becomes greater in amplitude with deviation from the resonant frequency up to a certain point. Diagrammatically, Figure 3-42 shows a characteristic curve of a typical discriminator. Then, on the screen of the oscillograph, with a complete cycle of the output, from the frequency modulated signal generator, two curves similar to the one shown in Figure 3-42 result if the time base of the oscillograph is set at the frequency of the rotating capacitor. If, however, the time-base is set to twice the frequency of the output cycle from the signal generator, a pattern resembling Figure 3-43 can be obtained. This latter type pattern is the one generally used in discriminator servicing.

(2) Factors Affecting Correct Adjustment. - The primary and secondary of the discriminator transformer generally contain parallel trimmer condensers which can be adjusted. In most cases the primary trimmer affects the symmetry of the pattern and the secondary trimmer the position where the curves cross. It must be remembered that if the cross-over point of the two curves is not at the center of the pattern, the circuit is not tuned to the correct resonant frequency.

(3) Procedure.

Step 1. Reconnect R2 and C2 into the discriminator circuit if they were removed for i-f alignment.

Step 2. Connect the oscillograph between grid and ground of the first audio stage.

Step 3. If the alignment of the i-f and r-f sections of the circuit has already been performed, the input signal may be fed into the antenna. However, if the preceding circuits have not been aligned, the input signal should be connected between grid and ground of the limiter stage preceding the discriminator.

Step 4. Obtain a pattern which is symmetrical and approaches as closely as possible that shown in Figure 3-42.

Section IV
MAINTENANCE

1. GENERAL

The components used in the Type 274 Cathode-ray Oscillograph have been selected and tested to provide long, trouble-free operating life. It must be recognized however that trouble may be expected at some time during the life of the instrument. This section is included to provide useful information for the location and correction of such trouble.

2. DRAWINGS

The schematic of the circuit located just inside of the rear cover and the component parts diagram located at the center fold give the complete information as to how the various components are connected and their physical location. A list of parts with their descriptions is given on the page accompanying the schematic diagram.

WARNING

DANGEROUS POTENTIALS, AS HIGH AS 1200 VOLTS, ARE FOUND IN THIS INSTRUMENT. SINCE THESE POTENTIALS MAY BE DANGEROUS TO HUMAN LIFE, THEY SHOULD BE TREATED WITH PROPER CAUTION.

3. CIRCUIT VOLTAGES

Table 4-1 is included to give the various voltages and resistances that are found between the socket connections of the various tubes and ground. The meter used for these measurements has an internal resistance of 20,000 ohms per volt. Naturally voltages or resistance measurements taken with a meter having a lower internal resistance will differ from this table.

It should be remembered that the values given are nominal and considerable variation may be experienced due to various line voltage conditions and component tolerances. Generally, a variation of ±10% is to be expected and 20% may not be uncommon. Judgement is often required to determine if a particular deviation is indicative of trouble.

WARNING

EXERCISE EXTREME CARE WHEN HANDLING THE CATHODE-RAY TUBE. IT IS EASILY SCRATCHED AND THEREBY WEAKENED TO THE POINT WHERE IT MAY EASILY BE BROKEN. THE BREAKING OF THIS TUBE MAY CAUSE AN IMPLOSION AND RESULT IN PERSONAL INJURY FROM FLYING GLASS PARTICLES.

4. WARRANTY

All instruments manufactured or sold by the Allen B. Du Mont Laboratories are guaranteed against defective workmanship and materials for a period of one year from date of sale. Guarantee cards, which are shipped with the instrument or cathode-ray tube, must be returned to us upon receipt of the equipment in order to make this guarantee valid, since we maintain a permanent file of all equipment sold for the convenience of our customers. All cathode-ray tubes manufactured by us are guaranteed for a life of 1,000 hours, or six months, which ever expires first. Guarantees, in addition to the statements given above are to be defined by the specifications of equipment as given in our current advertising information and catalog, and they are subject only to specific modification.

5. RETURNS TO FACTORY

In some cases, or for major repairs, it may be desirable to return the instrument to the factory. **Under no circumstances should the instrument or the cathode-ray tube be returned to the factory without proper return authorization and shipping instructions.** In any correspondence with the factory concerning repairs, the type and serial number of the instrument must be given together with a description of the trouble encountered. Letters pertaining to repairs should be addressed to Allen B. Du Mont Laboratories, Inc., National Service Department, Passaic, New Jersey.

TABLE OF VOLTAGE AND RESISTANCE

Pin No.	Resistance to Ground in Ohms	D-C Voltage to Ground	Control Affecting Reading
	V-1 Type 6SJ7—Vertical Amplifier		
1	0	0	
2	0	0	
3	0	0	
4	0 to 1 meg.	0	VERTICAL AMP
5	2K	4	
6	200K	100	
7	0	6.3 ac	
8	150K	170	
	V-2 Type 6SJ7—Horizontal Amplifier		
1	0	0	
2	0	0	
3	0	0	
4	0 to 5 meg.	0	HORIZONTAL AMP
5	2K	4	
6	200K	100	
7	0	6.3 ac	
8	150K	250 - 150	COARSE AND FINE FREQUENCY CONTROL
	V-3 Type 884—Sweep Generator		
1	0 to 100K (only SYNC. Amp.)	0-2	FINE & COARSE FREQUENCY & SYNC AMP
2	0	0	
3	500K to 5 Meg.	25 - 45	FINE & COARSE FREQUENCY SYNC AMP
4	NC	NC	
5	10K to 110K (only SYNC. Amp.)	.25 - 1.5	SYNC AMP
6	NC	NC	
7	0	6.3 ac	
8	1.5 K	5	
	V-4 Type 80—High Voltage Rectifier		
1	3K	900 ac	
2	2 meg.	—1200	
3	2 meg.	—1200	
4	3K	900 ac	
	V-5 Type 80—Low Voltage Rectifier		
1	20K	400	
2	540 ohms	300 ac	
3	540 ohms	300 ac	
4	20K	400	
	V-6 Type 5BP1-A—Cathode-Ray Tube		
1	2 meg.	—1200	
2	NC	NC	
3	5 meg.	—75 to —50	VERTICAL POSITION
4	1 to 1.5 meg.	—600 to —950	FOCUS
5	1 to 1.5 meg.	—600 to —950	FOCUS
6	0	0	
7	0	0	
8	0	0	
9	5 meg.	—75 to —50	HORIZONTAL POSITION
10	3 meg.	—1200	
11	3 meg.	—1200	

DU MONT
CATHODE-RAY TUBES
Types 5BP1A, 5BP4A, 5BP11A

The Type 5BP-A Cathode-ray Tubes are designed for oscillographic and television-picture applications. The three types differ only in the characteristics of the fluorescent screens. The gun is designed to draw negligible focusing electrode current.

CHARACTERISTICS

Heater

Voltage, a.c. or d.c.	6.3 volts ±10%
Current	0.6 ampere

Deflection .... Electrostatic

Focus .... Electrostatic

Screen

RMA Type Number	5BP1A	5BP4A	5BP11A
Fluorescence	Green	White	Blue
Persistence	Medium	Medium	Short

Mechanical Characteristics

Overall Length	16¾″ ±⅜″
Maximum Diameter	5¼″ +1/16″, —3/32″
Base	Medium Magnal
Basing	RMA Basing Designation 11N

The basing is such that:

1. The direction of the trace produced on the screen by deflecting electrodes D_3 and D_4 will not deviate more than ±10° from a plane through pin No. 1 and the axis of the tube while the angle between the direction of this trace and that of the trace produced on the screen by deflecting electrodes D_1 and D_2 will be 90° ±3°.
2. With deflecting electrode D_3 (pin No. 9) positive with respect to D_4 (pin No. 6) the spot will be deflected approximately toward pin No. 1; while with deflecting electrode D_1 (pin No. 3) positive with respect to D_2 (pin No. 8) the spot will be deflected approximately toward pin No. 4.

Direct Interelectrode Capacitances (Nominal)

Control Electrode (grid) to all other electrodes	9.0 μμf.
Deflection Plate D_1 to Deflection Plate D_2	1.2 μμf.
Deflection Plate D_3 to Deflection Plate D_4	0.8 μμf.
D_1 to all other electrodes	14.0 μμf.
D_3 to all other electrodes	8.5 μμf.
D_1 to all other electrodes except D_2	13.0 μμf.
D_2 to all other electrodes except D_1	12.0 μμf.
D_3 to all other electrodes except D_4	8.0 μμf.
D_4 to all other electrodes except D_3	7.0 μμf.

Ratings (Design - center values)

Anode No. 2 (Accelerating Electrode) Voltage (E_{b2})	2000 volts (max.)
Anode No. 1 (Focusing Electrode) Voltage (E_{b1})	1000 volts (max.)

Grid (Control Electrode) Voltage (E_{c1})	Never positive
Peak voltage between Anode No. 2 and any Deflecting Electrode	550 volts (max.)
Grid Circuit Resistance	1.5 megohms (max.)
Impedance of any deflecting electrode circuit at heater supply frequency	1.0 megohm (max.)
Screen Radius	2.25″ (min.)

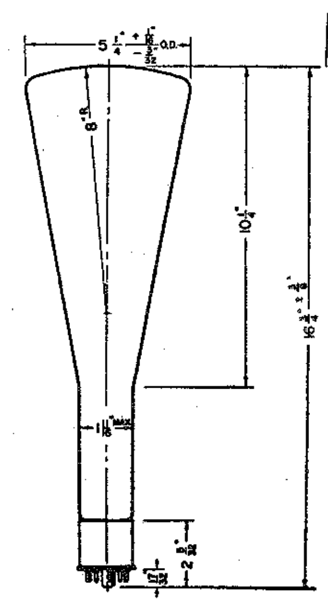
Typical Operation

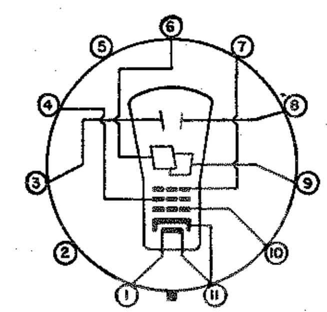
Heater Voltage	6.3	6.3 volts
Anode No. 2 Voltage (E_{b2})	1500	2000 volts
Anode No. 1 Voltage (E_{b1}) for Focus when E_{c1} is 75% of cut-off value	337	450 volts ±20%
Grid voltage, E_{c1}, for beam cut-off; i.e., visual extinction of undeflected, focused spot	—30	—40 volts ±50%
Light Output:		
5BP1A	2.0	— Ft.L. (min.)
5BP4A	1.0	— Ft.L. (min.)
5BP11A	*0.9	— "Ft.L." (min.)
Grid Drive (from cut-off) at minimum specified Light Output	35	— volts
Deflection Factor:		
D_1 D_2	63	84 d.c. volts/inch ±17%
D_3 D_4	57	76 d.c. volts/inch ±17%
Deflection Sensitivity:		
D_1 D_2	0.40	0.30 mm./d.c. volt (av.)
D_3 D_4	0.45	0.33 mm./d.c. volt (av.)

*Measured with type 3 photronic cell without eye correction.

Spot Position

When the tube is operated at (1) normal heater voltage; (2) E_{b2} = 1500 volts; (3) E_{b1} adjusted for focus; (4) E_{c1} set at such a value as will avoid damage to the screen and with (5) each of the deflecting electrodes connected to Anode No. 2; and (6) with the tube shielded against external influences: the spot will fall within a 15 mm. square, the center of which coincides with the geometric center of the tube face and the sides of which are parallel to the traces produced by deflecting electrodes D_1 and D_2 and by deflecting electrodes D_3 and D_4 respectively.





BOTTOM VIEW OF BASE

Pin No.	
1	Heater
2	No Connection
3	Deflection Plate D_1
4	Focusing Electrode
5	Internal Connection
6	Deflection Plate D_4
7	Accelerating Electrode
8	Deflection Plate D_2
9	Deflection Plate D_3
10	Control Electrode
11	Heater and Cathode

SYMBOL DESIGNATION	REFERENCE DRAWING OR PART NO.	DESCRIPTION
C1	3-152	CAPACITOR, fixed: paper; wax; 0.25 mfd; 600 V; +30-10%
C2	CM35B362J	CAPACITOR, fixed: mica; 3600 mmfd; 500 V; ±5%
C3	3-1140	CAPACITOR, fixed: paper; wax; 0.01 mfd; 1600 V; +30-10%
C4	3-1195	CAPACITOR, fixed: paper; wax; 0.1 mfd; 600 V; +30-10%
C5		Same as C4
C6		Same as C1
C7	3-1160	CAPACITOR, fixed: electrolytic; 20+20+20 mfd; 450 V
C8		Part of C7
C9		Part of C7
C10		Same as C4
C11	3-1082	CAPACITOR, fixed: paper; wax; 0.5 mfd; 600 V; +20-10%
C12	3-1138	CAPACITOR, fixed: paper; wax; 0.1 mfd; 600 V; ±25%
C13	3-1139	CAPACITOR, fixed: paper; wax; 0.02 mfd; 600 V; ±20%
C14	CM30B272J	CAPACITOR, fixed: mica; 2700 mmfd; 500 V; ±5%
C15	CM20B221K	CAPACITOR, fixed: mica; 220 mmfd; 500 V; ±10%
C16		Same as C11
C17		Same as C2
C18	3-360	CAPACITOR, fixed: paper; 0.5 mfd; 1500 V; +20-10%
C19		Same as C18
F1	11-3	FUSE, cartridge: 1 amp.
I1	39-4	LAMP, incandescent: miniature bayonet base
L1	21-338	INDUCTOR, fixed: filter; 8 hy.
P1	46-108	CABLE, power: copper; 2 #18 ga. stranded conductors; w/2 prong male plug one end
P2	9-294	CONNECTOR, male contact: 8 pin
R1	1-287	RESISTOR, variable: composition; 1 megohm; ½ W; ±20%
R2	RC21BF182J	RESISTOR, fixed: composition; 1800 ohm; ½ W; ±5%
R3	RC31BF474K	RESISTOR, fixed: composition; 470,000 ohm; 1 W; ±10%
R4	1-421	RESISTOR, variable: composition; 5 megohm; 2 W; ±20%
R5		Same as R2
R6	RC31BF124J	RESISTOR, fixed: composition; 120,000 ohm; 1 W; ±5%
R7		Same as R6
R8	RC21BF105K	RESISTOR, fixed: composition; 1 megohm; ½ W; ±10%
R9	RC21BF103K	RESISTOR, fixed: composition; 10,000 ohm; ½ W; ±10%
R10	1-388	RESISTOR, variable: composition; 100,000 ohm; ½ W; ±20%
R11	RC31BF471K	RESISTOR, fixed: composition; 470 ohm; 1 W; ±10%
R12	RC21BF152K	RESISTOR, fixed: composition; 1500 ohm; ½ W; ±10%
R13	RC21BF475K	RESISTOR, fixed: composition; 4.7 megohm; ½ W; ±10%
R14		Same as R1
R15	RC31BF473K	RESISTOR, fixed: composition; 47,000 ohm; 1 W; ±10%
R16		Same as R6
R17	2-257	RESISTOR, fixed: composition; 100,000 ohm; 3 W; ±10%
R18		Same as R13
R19		Same as R1
R20		Same as R8
R21	1-463	RESISTOR, variable: composition; 100,000 ohm; ½ W; ±20%; with SPST switch S4
R22		Same as R6
R23	1-288	RESISTOR, variable: composition; 500,000 ohm; ½ W; ±20%
R24	RC31BF274K	RESISTOR, fixed: composition; 270,000 ohm; 1 W; ±10%
R25		Same as R24
R26	RC31BF824K	RESISTOR, fixed: composition; 820,000 ohm; 1 W; ±10%
R27		Same as R3
R28		Same as R4
R29	RC21BF104K	RESISTOR, fixed: composition; 100,000 ohm; ½ W; ±10%
R30	2-8	RESISTOR, fixed: wire wound; 25,000 ohm; 10 W; ±5%
R31		Same as R9
S1	5-10	SWITCH, toggle: SPDT
S2	5-12	SWITCH, toggle: DPDT
S3	5B-4647	SWITCH, 2 gang 4 pole: 7 pos. (formerly 5-198)
S4		Part of R21
T1	20D-4641	TRANSFORMER, plate and filament: (formerly 20-329)
V1	25-6SJ7	TUBE, electron: Triple-grid detector amplifier
V2		Same as V1
V3	25-884	TUBE, electron: Thyratron
V4	25-80	TUBE, electron: Full wave high-vacuum rectifier
V5		Same as V4
V6	25-5BP1A	TUBE, electron: Cathode-Ray

V; +30-10%
-5%
V; +30-10%
; +30-10%

450 V

; +20-10%
; ±25%
V; ±20%
-5%
10%

0-10%

conductors; w/2

W; ±20%
V; ±5%
V; ±10%
W; ±20%

W; ±5%

V; ±10%
W; ±10%
½ W; ±20%
±10%
; ±10%
W; ±10%

V; ±10%

W; ±10%

½ W; ±20%;

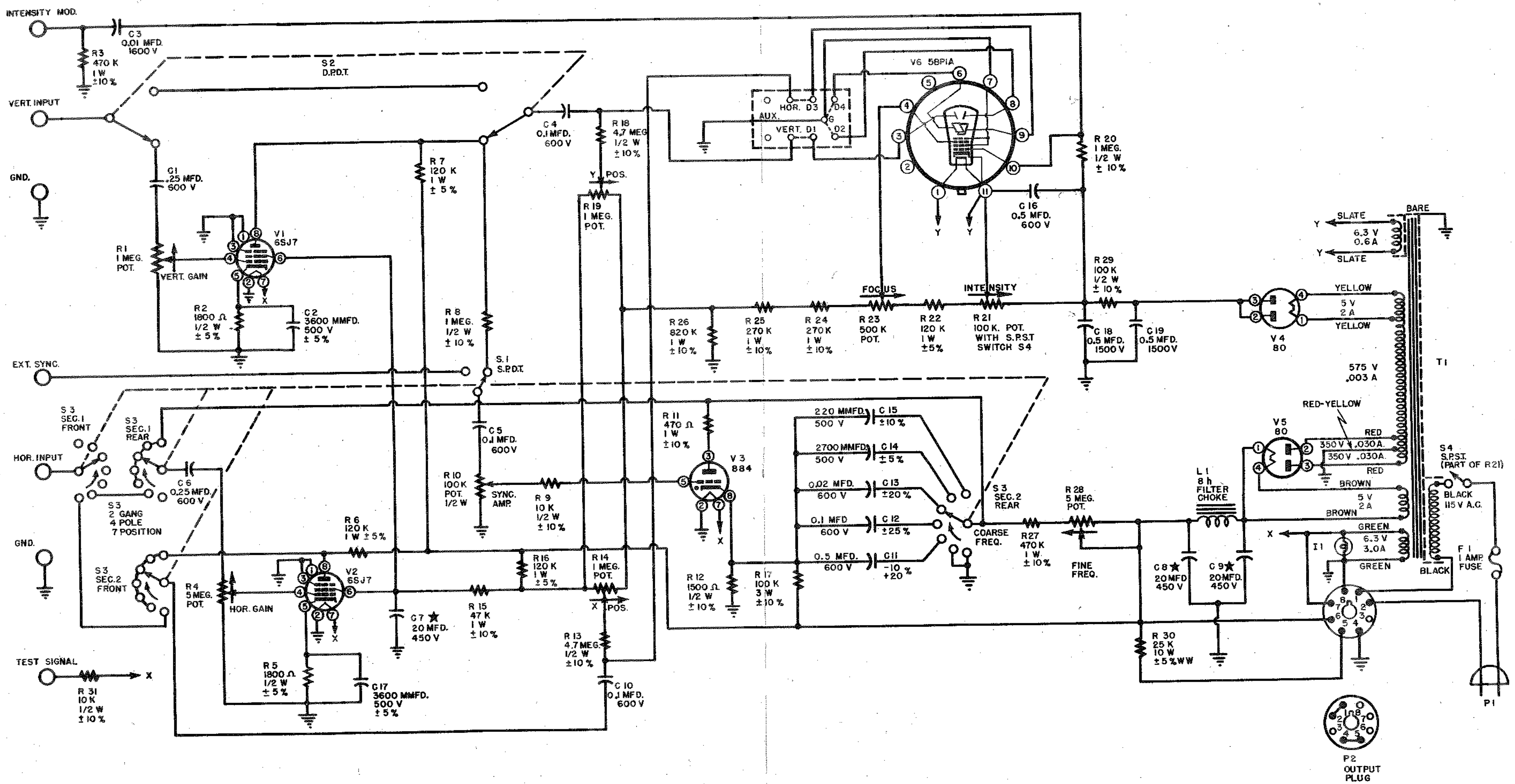
½ W; ±20%
W; ±10%

W; ±10%

W; ±10%
W; ±5%

)

20-329)



NOTE:
When ordering replacement parts, always give the Type number and Serial number of the instrument and refer to the part by its symbol designation and its description on the schematic.

SCHEMATIC OF CIRCUIT
TYPE 274 CATHODE-RAY OSCILLOGRAPH
Ref: DD—4652-C-5

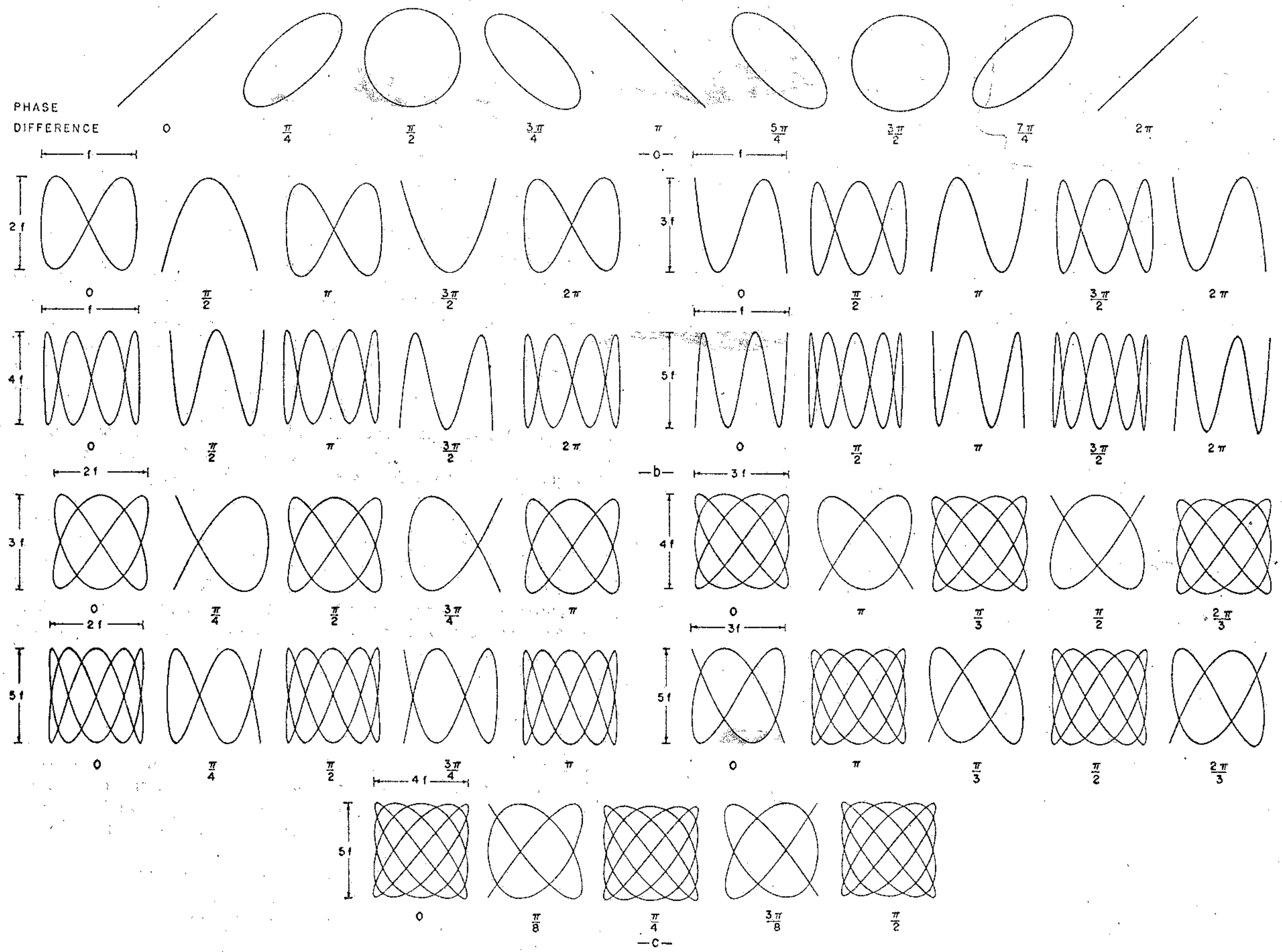

PHASE
DIFFERENCE
0
$\frac{\pi}{4}$
$\frac{\pi}{2}$
$\frac{3\pi}{4}$
π
$\frac{5\pi}{4}$
$\frac{3\pi}{2}$
$\frac{7\pi}{4}$
2π
—a—
f
2f
3f
4f
5f
$\frac{3\pi}{8}$
$\frac{\pi}{8}$
$\frac{\pi}{3}$
$\frac{2\pi}{3}$
—b—
—c—

Fig. 15.

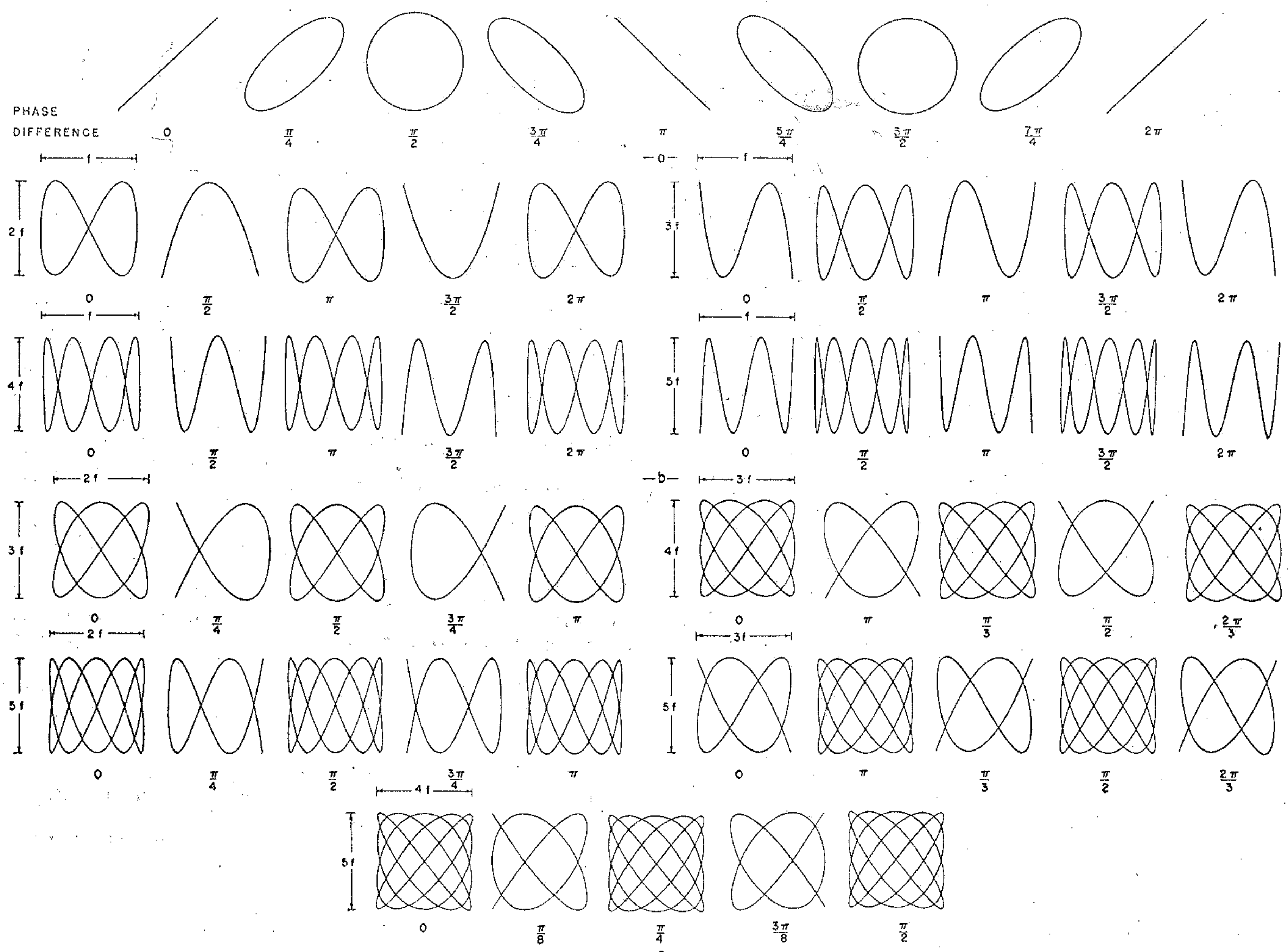


Fig. 15.