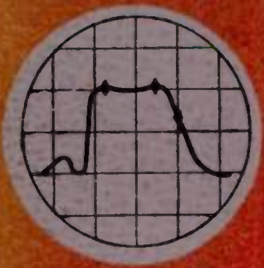

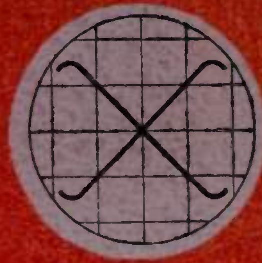

THE OSCILLOGRAPH

IN MODERN AM, FM AND TV SERVICE

By

WALTER WEISS

TECHNICAL BULLETIN No. 342

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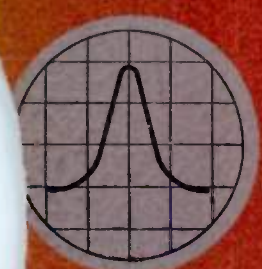


TECHNICAL BULLETIN No. 342

DYNAMIC VISUAL ANALYSIS

Dynamic visual analysis is now being accepted as the most rapid and thorough method of locating trouble in radio receivers. In older methods the indicating medium could only indicate the presence of a voltage or current and in some cases its magnitude. This method was necessarily slow and uncertain since the indicator could not differentiate between the nature of the voltage being measured, whether it be 60 or 120 cycle hum, 400 cycle modulation, distorted or undistorted. All these and other signals look alike on the older type of indicator whether it be an old-fashioned neon glow lamp, a magic eye indicator, or a precision voltmeter or ammeter. The advent of the Cathode Ray Oscillograph and subsequent technical improvements which have been made on it have brought us away from the old-fashioned method of groping in the dark wondering whether the indication on the magic eye tube or meter was hum, RF carrier, distortion, signal or what, and enabled us to immediately recognize it in its true form.

It is the purpose of this article to give enough concrete information along this line to enable the serviceman to immediately recognize from the appearance of the trace on the cathode ray tube screen faults or trouble which might occur in any section of a radio receiver.

The theory of operation of the cathode ray oscillograph will not be covered in this book since it is dealt with in detail in the instruction book accompanying the oscillograph to be used.

For simplicity in explaining the proper control settings of the cathode ray oscillograph being used, we have elected to identify the various control settings by position number.

Since most cathode ray oscillographs have in common most controls, the chart on page 51 is given for the proper settings of the various controls for the oscillograph figures referenced.

Some of the figures illustrated will presuppose the use of an oscillograph having certain features not found in all cathode ray oscillographs. These features are explained in the previously referenced chart on page 51.

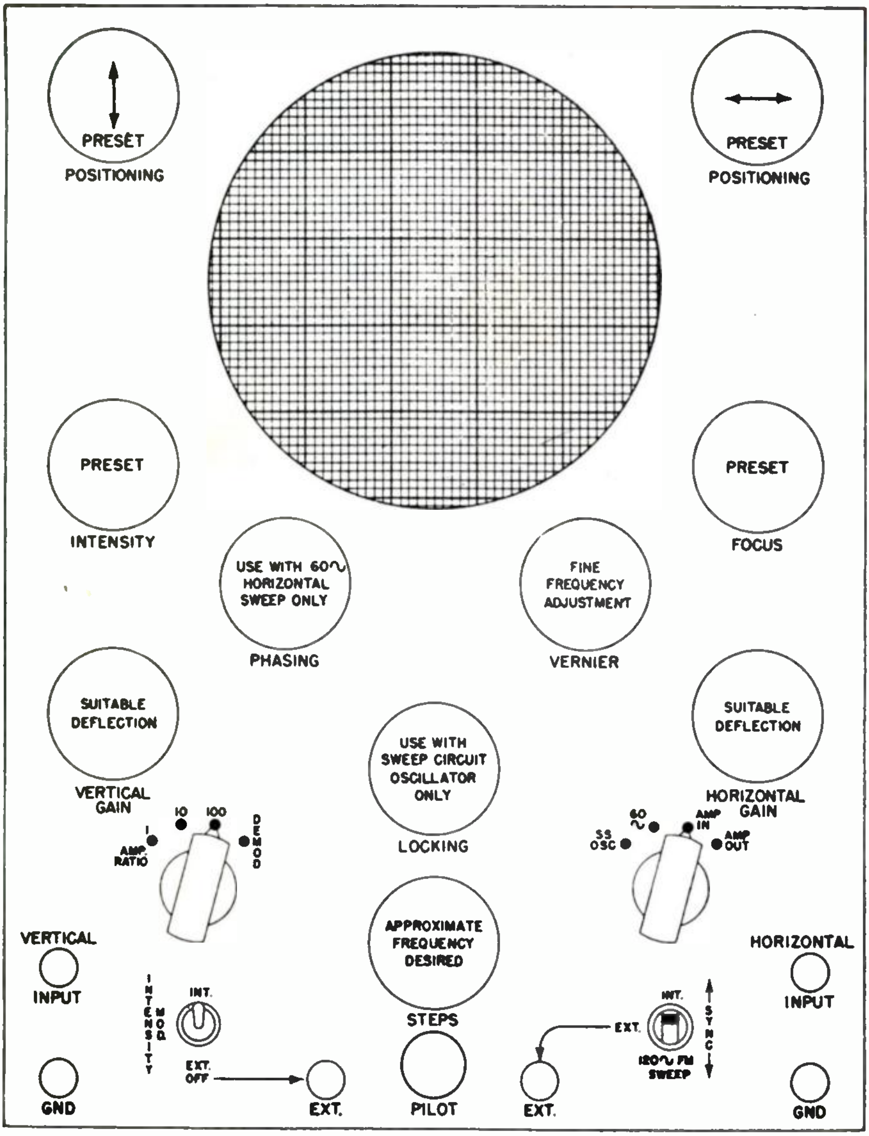


FIGURE 1

Figure 1 illustrates the panel of a catnode ray oscillograph with its associated controls. This oscillograph has provisions for all necessary controls and circuits to permit all of the tests illustrated in this manual. As previously mentioned, some oscillographs may not have all of the features found in the oscillograph in Figure 1.

Certain controls may be preset and should be adjusted as follows:

FOCUS CONTROL—adjusted to give the finest line which can be obtained.

INTENSITY CONTROL—adjusted to give suitable intensity, maintaining this as low as practical, consistent with general illumination.

HORIZONTAL AND VERTICAL POSITIONING CONTROLS—adjusted to center beam vertically and horizontally.

HORIZONTAL AND VERTICAL GAIN CONTROLS—adjusted for suitable horizontal and vertical deflection.

SWEEP CIRCUIT OSCILLATOR: STEP AND VERNIER CONTROLS—adjusted to give the required number of traces on the cathode ray tube screen.

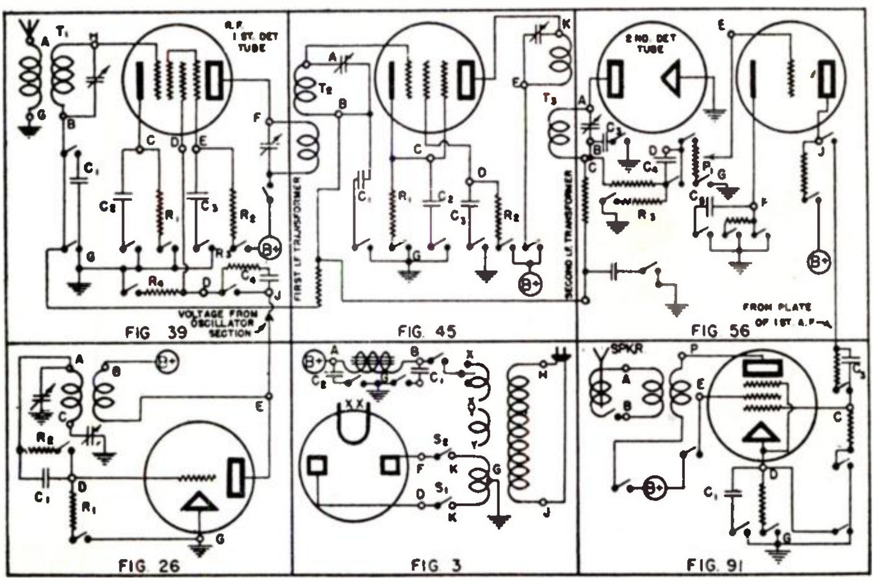


Fig. 2

To provide a basis for obtaining the various wave forms illustrated in the following test under amplitude modulated receivers, a modern 7 tube super-heterodyne receiver was constructed, the circuit diagram of which is illustrated in Figure 2. Switches were placed in the various circuits so that circuit elements could be opened up or closed to obtain the resultant patterns under these conditions.

This receiver has been divided into six sections, namely:

Section 1 — Power Supply
Section 2 — Oscillator Section
Section 3 — First Detector
Section 4 — Intermediate Frequency Amplifier
Section 5 — Second detector and first audio
Section 6 — Final Amplifiers
Section 7 — Vibrator Testing

We will take up each section independently and attempt to show any trouble which could develop in this section and how this trouble would be located and isolated through dynamic visual analysis.

POWER SUPPLY SECTION

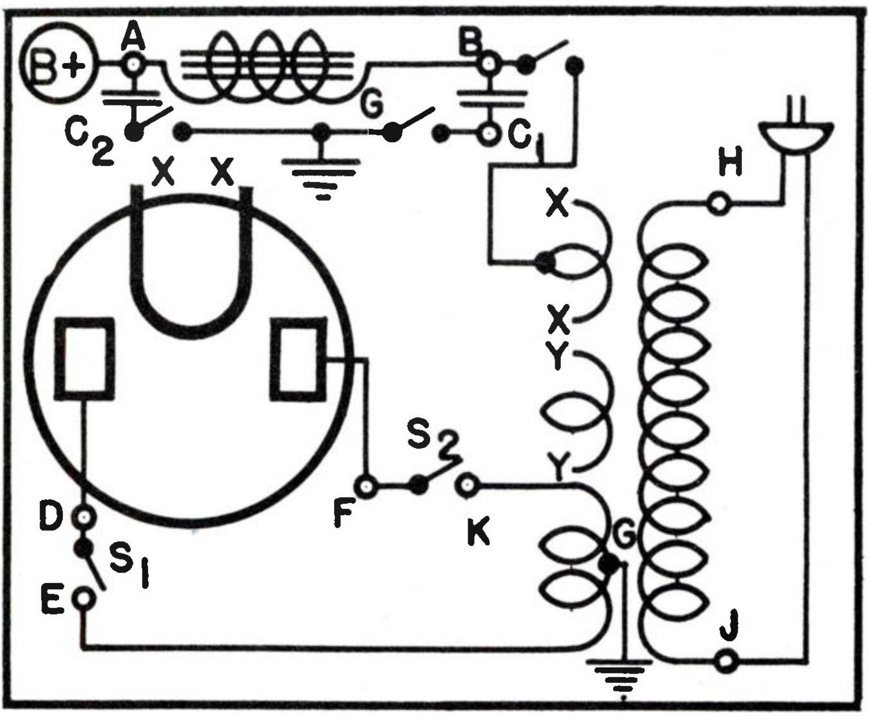


FIG. 3

Fig. 3 illustrates this section which consists of a power transformer, full wave rectifier tube, filter condensers and choke. While all of the tests taken up in this article would not be necessary in doing any one service job, we are going to consider the cases which could happen under any circumstances and therefore will omit no trouble which might not reasonably be encountered.

There are several types of traces which will be found quite often throughout the entire series of tests. These are being illustrated only once and they are as follows:

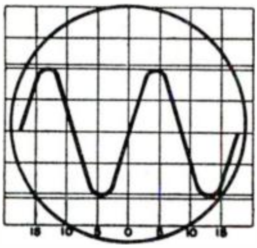


FIG. 4

Fig 4 represents a pure sine wave of any frequency being applied to the vertical plates. In this case the sweep circuit oscillator has been adjusted to a frequency which is one-half of the applied frequency thereby giving two sine waves on the screen. If the sweep circuit oscillator were adjusted to the same frequency as the applied frequency of course one sine wave would appear. or at one-third the frequency three sine waves etc.

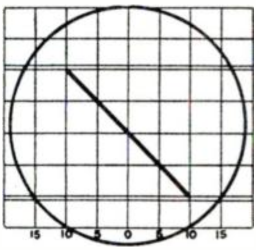


FIG 5

Fig. 5 represents a sine wave applied to both horizontal and vertical plates, the two frequencies being in phase.

Fig. 5A represents the same condition as Fig. 5 but with a slight phase discrepancy between the two frequencies.

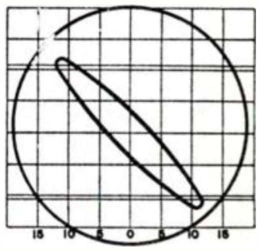


FIG. 5A

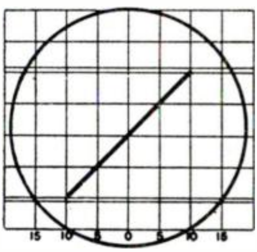


FIG. 6

Fig. 6 represents a sine wave applied to both horizontal and vertical plates but with the frequencies exactly 180 degrees out of phase.

Fig. 6A represents the same condition as Fig. 6 but with the frequencies slightly different than 180 degrees out of phase.

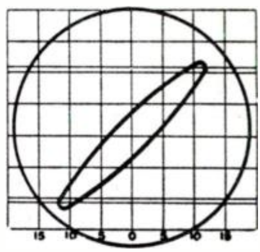


FIG. 6A

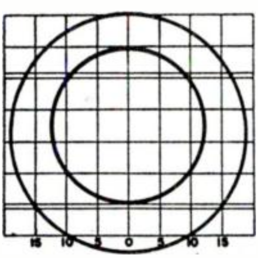


FIG. 7

Fig. 7 represents a sine wave applied to both horizontal and vertical plates but 90 or 270 degrees out of phase.

Fig. 7A represents sine waves applied to both plates with the frequency on the vertical plate double that of the frequency on the horizontal plate.

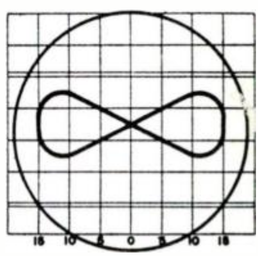


FIG 7A

Any of the following measurements of primary or secondary voltage could be made with a reliable A.C. voltmeter to determine the magnitude of the voltage. The oscillograph goes a step further and indicates not only the magnitude but the characteristics of this voltage. The following tests are given to demonstrate how the oscillograph might be used for this service

PRIMARY VOLTAGE

Connection H-J — Oscillograph Position 10 Fig. 4

With the proper voltage at the primary of the transformer Fig. 4 should be obtained The indicated voltage on the vertical gain control should correspond to the line voltage

Connection H-J — Oscillograh Position 3 Figs. 5 to 7 Inclusive

Fig 5 or Fig 6 will be obtained if there is no phase discrepancy between the primary voltage and the internal 60 cycle sweep voltage. Slight phase discrepancies would show up as illustrated in Fig. 5A or Fig. 6A. Excessive phase discrepancies, as illustrated in Fig. 7 would indicate the presence of a capacity or inductance between the supply line and the primary of the transformer

SECONDARY VOLTAGE

Connections X-X or Y-Y — Oscillograph Position 2 Fig. 4

The results obtained should be identical to those outlined when checking primary voltage as shown in Fig. 4 with the exception that the indicated magnitude of the voltage should be in the neighborhood of 5 or 6 volts as indicated on the calibrated voltage scale. The vertical amplifier must be used and consequently position 2 rather than position 10.

Connections X-X or Y-Y — Oscillograph Position 1 Figs. 5 to 7

Results should be identical to those obtained when checking primary voltage with position 3 with the exception of the magnitude of the voltage.

Connections K-G, E-K, E-G — Oscillograph Position 10 or 3 Figs. 4 to 7 Inclusive

Results should be identical to those shown in Figs. 4 to 7 inclusive with the exception of the magnitude of the voltage indicated on the calibrated voltage scale.

In the foregoing tests no actual voltage readings have been given for the secondary voltages since these vary so much with various receiver designs. In general, however, the high voltage secondary should indicate approximately twice the rated D.C. voltage for the rectifier system when measured between E and K. The connections Y-Y which represent the heater voltage supply are in general found to be either 6.3 volts for the more modern receivers or 2.5 volts for the older type receivers. In measuring the voltage supply to the filament in the rectifier tube, this voltage should correspond to the voltage rating of the rectifier tube. Of course, voltage measured from center tap of the filament winding to either side would be one-half of the total voltage reading.

FILTER SYSTEM

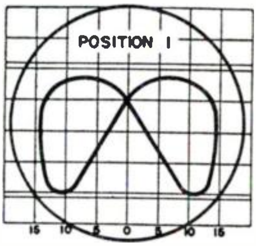


FIG. 8

Condition — Normal System, Full Wave Rectification. Normal Loading Condenser Input.

Connections G-B. (Fig. 3)

Oscillograph — Positions 1-2. (Fig. 1)

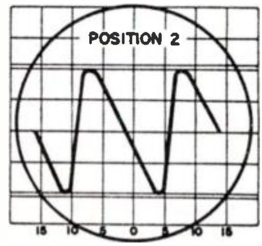


FIG. 9

Fig. 8 (Position 1) illustrates the curve as it should appear at the input of the filter section when using condenser input. Note the trace in Fig. 9 (Position 2) differs from a sine wave as illustrated in Fig. 4 in that one side of the curve is almost vertical whereas the other side has a distinct slope. The magnitude of the voltage will normally be between 5 and 15 volts R.M.S. A.C. Should the voltage be found to be considerably higher than this it would probably be an indication of excessive loading on the output of the filter system. This might be caused by a shorted output filter condenser or any short from a B plus connection in the receiver back to ground In general, the effect of such a loading on the trace would be to cause a smoothing out of the corners in the trace illustrated in Fig 8 or to cause the trace illustrated in Fig. 9 to be more nearly a pure sine wave as illustrated in Fig. 4

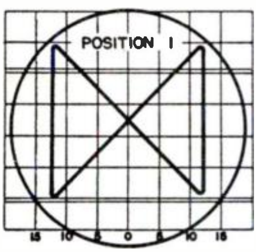


FIG. 10

Condition — Normal System, **No Loading.** Full Wave Rectification. Condenser Input.

Connections G-B.

Oscillograph — Positions 1-2.

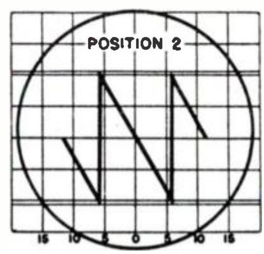


FIG. 11

If as a result of defective wiring or broken connection the loading caused by the plate current, bleeder system etc., on the filter system was relieved or lightened we would have traces as illustrated in Fig. 10 (Position 1) and Fig. 11 (Position 2) In Fig 10 note the extremely sharp corners on the curve which are in exact contrast to the smooth rounded corners illustrated in Fig. 8. Fig. 11 illustrates the same condition when using the sweep Circuit oscillator and it will be noted that the curve no longer resembles the sine wave since it has very sharp corners and straight sides, the voltage rising almost vertically during the first half of the cycle and descending quite gradually during the other half of the cycle.

In many sets the greater part of the load on the filter system is caused by the audio stages, especially the final amplifier and when such a condition has been encountered it would be well to check this stage first.

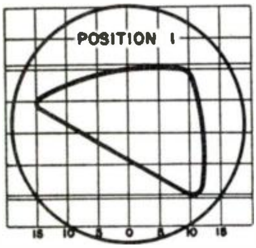


FIG. 12

Condition — Normal System, Half Wave Rectification. **Normal Loading.** Condenser Input.

Connections G-B.

Oscillograph — Positions 1-2

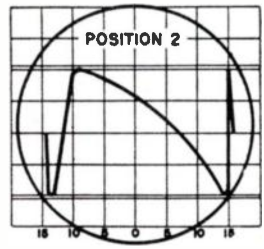


FIG. 13

In the case of half wave rectification in a filter system which we can simulate by merely opening up either S1 or S2, we obtain Fig. 12 (Position 1) or Fig. 13 (Position 2). This is under a condition of normal loading and in this case it will be found that the A C voltage developed across the input condenser will be somewhat higher, in fact almost twice as great as might be expected from full wave rectification. The magnitude of this voltage being generally between 15 and 30 volts.

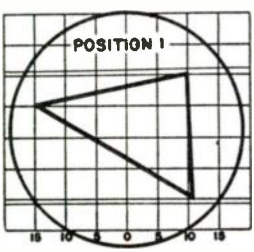


FIG. 12 A

Condition — Normal System, Half Wave Rectification. **No Loading** Condenser Input.

Connections G-B.

Oscillograph — Positions 1-2

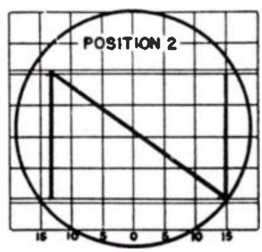


FIG 13 A

Figs. 12A and 13A are illustrative of a case of no loading on the filter system with half wave rectification. The voltage will drop down to a considerably lower value, probably not over 1 volt R.M.S.

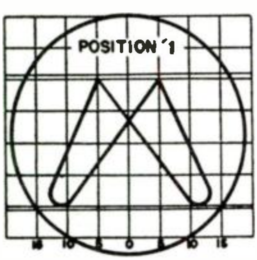


FIG. 14

Condition — Normal System. Normal Loading. Full Wave Rectification. **Choke Input.**

Connections G-B.

Oscillograph — Positions 1-2.

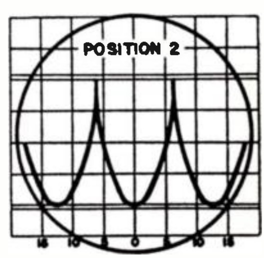


FIG 15

Fig. 14 (Position 1) and 15 (Position 2) are illustrative of the above condition. The magnitude of the A.C. voltage appearing at point B in this case will be probably over 100 volts if the D.C. supply system is desinged for 250 to 300 volts supply.

It would be well to remember that if the system were designed for condenser input but the input condenser "C1" had become defective and opened up the resultant condition would be the same as illustrated for choke input This same thing would also apply for the following condition of half wave rectification

If the voltage is found to be over 100 volts it would be advisable to change from position 1 to position 3 or from position 2 to position 10 Since the vertical amplifier would not be required

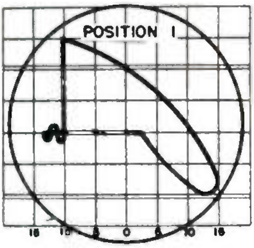


FIG 16

Condition — Normal System, Normal Loading. **Half Wave Rectification.** Choke Input.

Connections G-B.

Oscillograph — Positions 1-2.

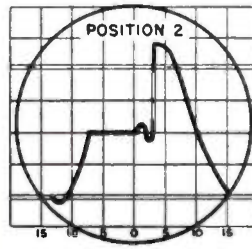


FIG 17

Fig. 16 (Position 1) and 17 (Position 2) are illustrative of the foregoing condition. The magnitude of the voltage appearing at the input section in this case will probably be approximately 100 volts R.M.S A.C , if over this value use positions 3-10.

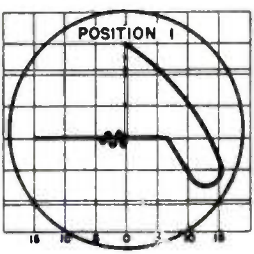


FIG. 16A

Condition — Normal System, **No Loading.** Half Wave Rectification. Choke Input.

Connections G-B

Oscillograph — Positions 1-2

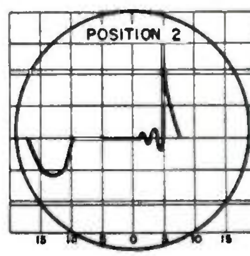


FIG. 17A

The effect of lack of loading under the above condition will tend to greatly reduce the A.C voltage present in the input of the filter system, probably bringing it down to 1 or 2 volts. The effect on the curve will be as illustrated in Fig 16A (Position 1) and 17A (Position 2).

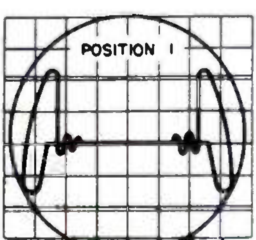


FIG 18

Condition — Normal System, **No Load,** Full Wave Rectification. Choke Input

Connections G-B.

Oscillograph — Positions 1-2.

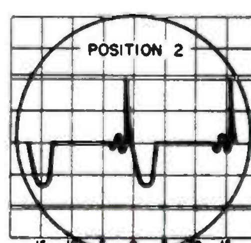


FIG 19

Fig. 18 (Position 1) and 19 (Position 2) are illustrative of the above condition with no loading. The magnitude of voltage developed would depend upon the extent of the loading. In the case of absolute zero loading on the output of the filter system the magnitude of the voltage would probably be in the neighborhood of 5 volts whereas any increase in loading would naturally give a corresponding increase in voltage developed.

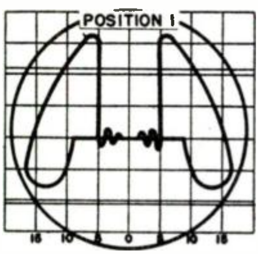


FIG. 18 A

Condition — Normal System, **Light Loading.** Full Wave Rectification. Choke Input.

Connections G-B

Oscillograph — **Positions** 1-2

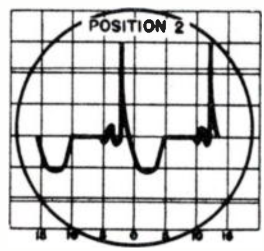


FIG. 19 A

Fig 18A (Position 1) and 19A (Position 2) are taken under the same conditions as Fig. 18 and 19 but are illustrative of light loading.

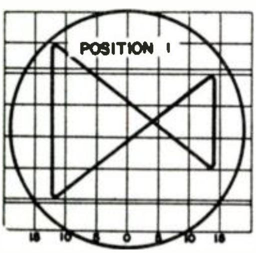


FIG. 20

Condition — Normal System, No Loading. **Rectifier Tube Filament Not Center Tapped.** Full Wave Rectification. Condenser Input.

Connections G-B.

Oscillograph — **Positions** 1-2.

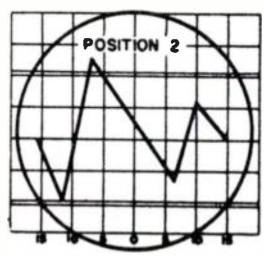


FIG 21

Fig. 20 (Position 1) and 21 (Position 2) are illustrative of the above condition. With reference to Fig. 20 the difference in the height of the two sides of the curve will vary depending upon the amount of loading. If the loading is very light or no loading at all there will be an extreme difference between the heights of the side of these two curves whereas if the loading is increased the difference in the heights will be reduced and the trace will more nearly approach a uniform pattern as illustrated in Fig. 10. It is perfectly normal in some receiver design not to center tap the filaments for the rectifier tube in which case the foregoing curve would indicate normal operation. However, in cases where the rectifier tube filament is supposed to be center tapped the above type curves are an indication of defective connection or transformer winding.

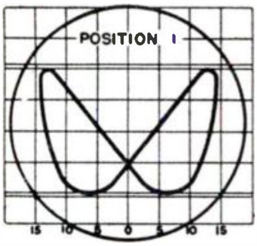


FIG. 22

Condition — Normal System, **Normal Loading.** Full Wave Rectification, Condenser Input.

Connections G-A.

Oscillograph — Positions 1-2

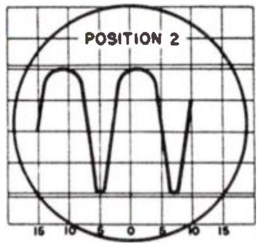


FIG. 23

Fig. 22 (Position 1) and 23 (Position 2) are illustrative of the above condition under the basis of normal loading. The voltage at this point will probably be in the neighborhood of .2 of 1 volt or less. Should the output condenser be opened which would result in lack of filtering, the shape of the traces would not change appreciably, however, the voltage as indicated at this point will probably increase to the neighborhood of 1½ to 2½ volts.

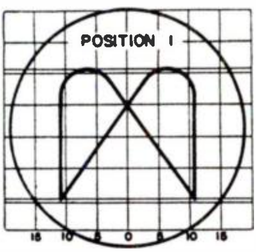


FIG. 24

Condition — Normal System Normal Loading. **Filter Choke Shorted Out.** Full Wave Rectification. Condenser Input.

Connections G-A or G-B.

Oscillograph — Positions 1-2.

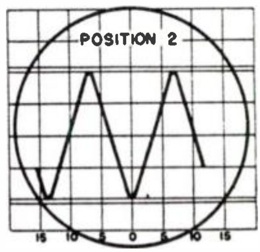


FIG 25

In this case of course the pattern observed at either point A or point B would be identical due to the fact that the choke was shorted out. The mangitude of the R.M.S. A.C. voltage under this condition would probably be in the neighborhood of 4 to 8 volts. Should this condition be encountered in a case where choke input was used the trace would be approximately identical to those illustrated in Fig. 24 (Position 1) and 25 (Position 2) but the measured voltage would probably be between 10 and 15 volts R.M.S.

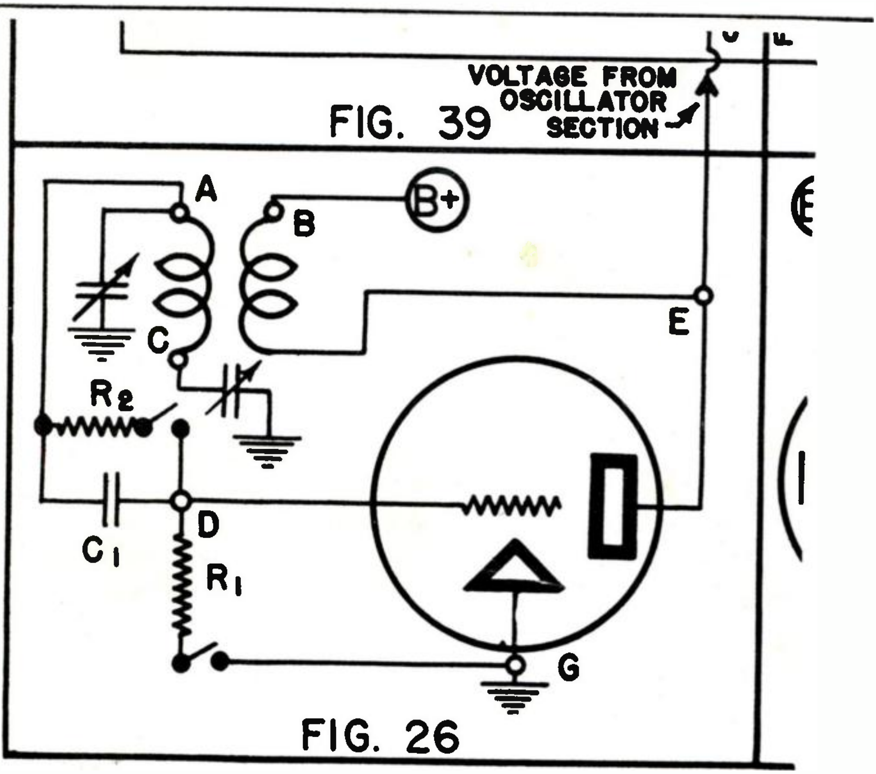


FIG. 26

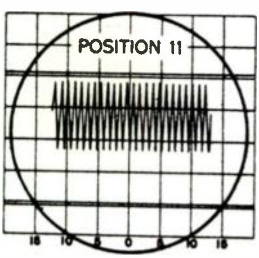


FIG. 27

Condition — Normal System. Oscillator Output Voltage.

Connections E-G.

Oscillograph — **Position** 11.

Figure 27 (Position 11) is illustrative of the above condition. It will be noted that it will probably be impossible to obtain sufficient vertical deflection on the cathode ray tube screen to have the trace reach the voltage reference lines. The vertical deflection from the video amplifier is lower than that from the standard amplifier. In general, the vertical deflection should be from 1 to 2 divisions on the calibrated scale with the vertical amplifier gain control turned to a maximum sensitivity. Note the sine waves are evenly spaced and producing a uniform density of illumination throughout the trace. The amplitude of the wave will vary as the main tuning dial is rotated from one end of the band to the other. If oscillation fails entirely at either end or any portion of the rotation, it indicates a defective oscillator circuit. If an abrupt failure is noticed at any point it would be well to check the oscillator variable condenser plates as they might be shorting out at this point. If oscillation is relatively weak and it is impossible to get sufficient amplitude, especially at the low frequency end of the band, check the "B" supply voltage to make certain that this is up to the specified voltage. Also, check the oscillator tube for mutual conductance, as low mutual conductance would result in low output at the lower frequencies.

Identical results should be obtained when connected between A.G. or D.G. with the exception that at D.G. the vertical displacement will probably be somewhat less than with the other connections.

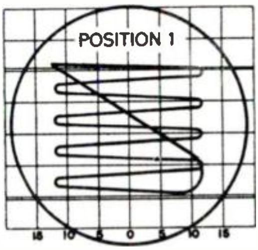


FIG. 28

Condition — Open Grid Leak

Connections E-G

Oscillograph — Positions 1-2 Sweep Circuit Oscillator--Step 1

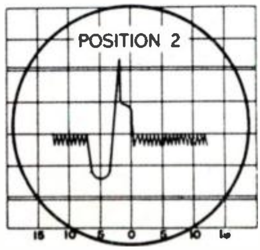


FIG. 29

In the case of an open grid leak which would result in the control grid obtaining no bias voltage, no oscillation as illustrated in Fig. 27 will be noticed.

The trace will periodically change from a straight line of no vertical displacement to a trace as illustrated in Fig. 28 (Position 1). The rate at which it changes would depend on the amount of leakage from the control grid of the tube back to ground. The normal period of this would probably be one second. This condition, of course, would necessitate the replacement of the grid resistor R1. In position 2 the curve would appear as illustrated in Fig. 29.

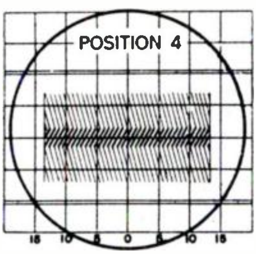


FIG. 30

Condition — Leaky or Shorted Grid Condenser C1

Connections E-G.

Oscillograph — Positions 4-11.

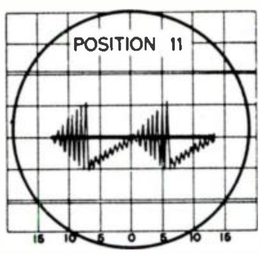


FIG. 31

In Fig. 30 (Position 4) note the extremely heavy or dark band near the center of the horizontal sweep and the lighter band extending upward and downward from this. This is a definite indication that Grid condenser C1 is either leaky or shorted causing excessively heavy regeneration with consequent distortion. Fig. 31 (Position 11) illustrates the type of trace which would be obtained with the same condition using the sweep circuit oscillator. The number of waves appearing on the screen would be determined by the sweep circuit oscillator frequency. In the figure given the sweep circuit oscillator had been adjusted to approximately 8000 cycles.

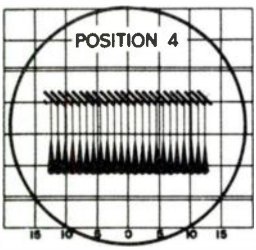


FIG. 32

Condition — Grid Condenser C1—Leaky or Shorted Out.

Connection G-A or G-D.

Oscillograph — **Positions** 4-11

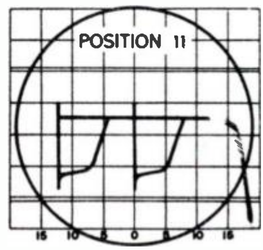


FIG. 33

The above condition is similar to that previsouly described Figs. 30-31 but with the oscillograph connected at the grid of the oscillator tube rather than at the plate. It will be noted that when using (Position 4) Fig. 32 with the 60 cycle sweep that the dark area changed from the center of the screen as illustrated in Fig. 30 to the outer edges. Also note Fig. 33 (Position 11) the change of wave shape when using the linear sweep from that observed when the voltage was viewed at the plate of the tube.

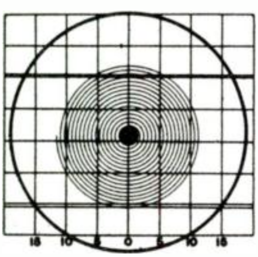


FIG. 34

Condition — Leaky Grid Condenser C1

Connections E-G.

Oscillograph — **Position** 4. See note below for change.

By turning the horizontal control to the amplifier out position, rather than to 60 cycle sweep as indicated in Position 4 and connecting a jumper between the horizontal input binding post and the vertical input binding post the Figure 34 may be obtained. Normally, this type of test would seldom be used for trouble shooting but it does present a very interesting figure. The figure appears to be a spiral starting from a very intense spot on the center of the screen and extending spirally outwards to form almost a complete circle.

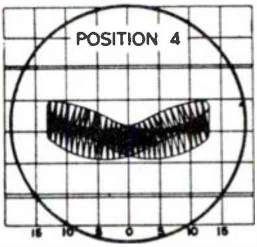


FIG 35

Condition — Normal Oscillator Section with Improperly Filtered D.C. Supply Voltage. Full Wave Rectification.

Connections E-G.

Oscillograph — Positions 4-11.

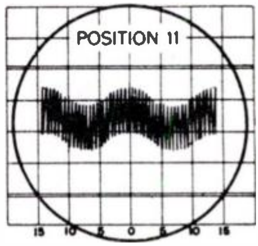


FIG 36

Traces as illustrated in Fig. 35 (Position 4) and Fig. 36 (Position 11) would be obtained if through the lack of filtering in the power supply section the voltage delivered to the oscillator tube was not a pure D.C. but contained an A.C. ripple

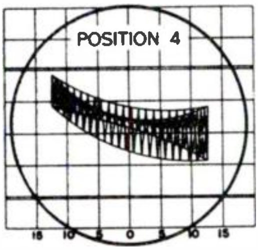


FIG. 37

Condition — Normal Oscillator Section. Improperly Filtered D.C. Supply Voltage. Half Wave Rectification.

Connections E-G

Oscillograph — Positions 4-11

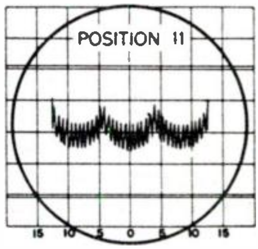


FIG 38

Figures 37 (Position 4) and 38 (Position 11) are illustrative of the above condition and are similar to Fig. 35 and Fig. 36 with the exception that the rectifier system in the receiver was designed for half wave rectification rather than full wave rectification.

RADIO FREQUENCY — FIRST DETECTOR

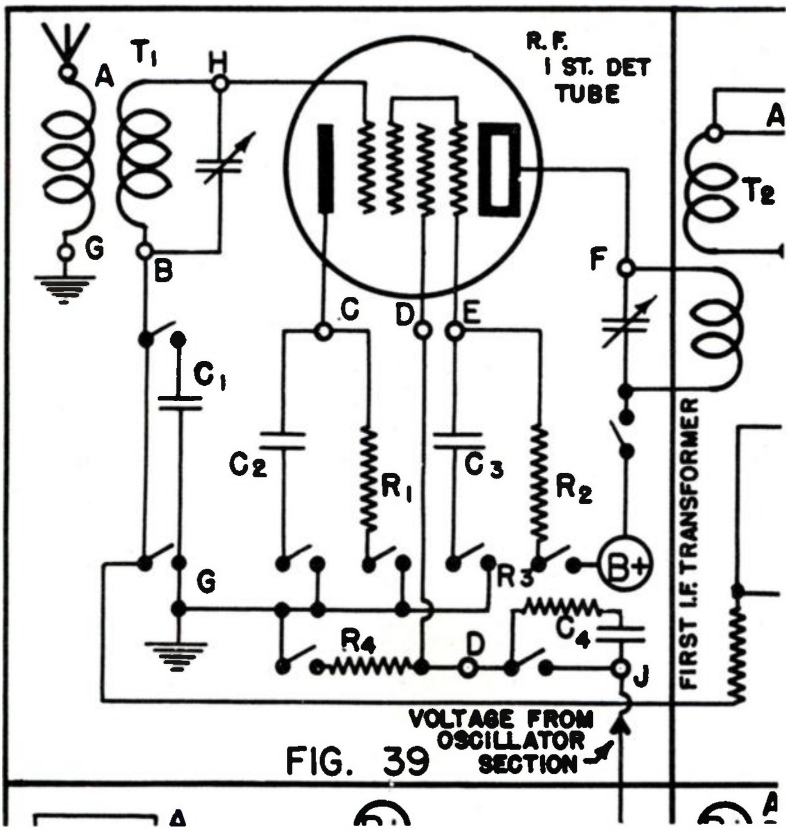


FIG. 39

In general any defects which might be found in the radio frequency section will not contribute to changing the shape of the observed trace but will merely change its amplitude. There are several fundamental types of traces which will be observed in the radio frequency of first detector section and these are listed as follows:

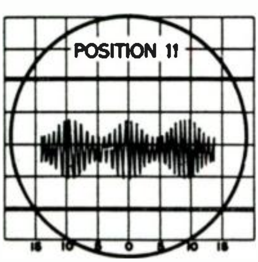


FIG. 40

Condition — Amplitude modulated radio frequency applied to the vertical plate of the oscillograph (Modulation 50%). Fig. 40.

Oscillograph — Position 11.

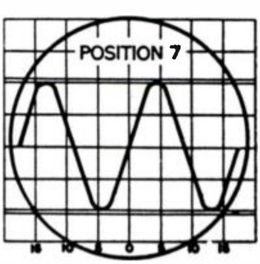


FIG. 41

Fig. 41 (Position 7)— **Condition** Amplitude modulated radio frequency applied to vertical input of the oscillograph.

The following checks on the radio frequency section will be made to determine primarily whether or not an actual voltage exists at the point under test. The nature of the voltage being supplied from the signal generator is optional. In checking radio frequency stages it is not advisable to use a frequency modulated signal, due to the lack of selectivity in a single radio frequency stage there would be little tendency for the circuit to discriminate in amplification between the various frequencies being generated.

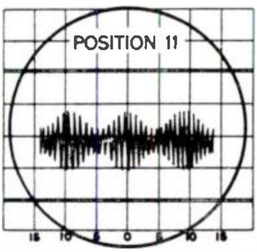


FIG. 40

Condition — Open By Pass Condenser C1.
Signal Supplied. Amplitude Modulated R.F.
Signal Connections A-G.
Oscillograph Connection B-G.
Oscillograph — Positions 7-11.

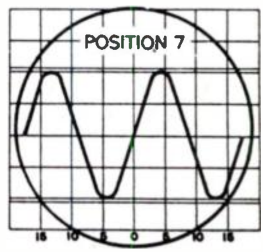


FIG. 41

If by pass condenser C1 were opened up this would result in a radio frequency voltage being built up between "B" and ground with the result that Fig. 40 (Position 11) would be obtained, or Fig. 41 (Position 7). The magnitude of the voltage in this case would probably be quite low giving a maximum of one-half inch or so deflection on the screen in either case.

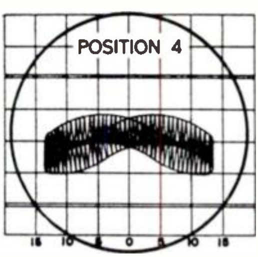


FIG 42

Condition — Injector Grid Resistance R4 Open. Signal Generator not used.
Oscillograph Connections D-G.
Oscillograph — Positions 4-11.

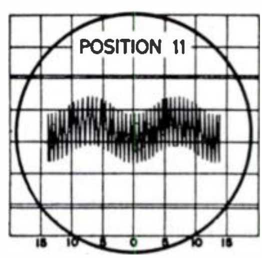


FIG. 43

In case the injector grid resistance R4 were opened up this would allow the injector grid to float at a negative potential above ground. The result would undoubtedly be an A.C. hum pick-up on this grid which will give a trace similar to Fig. 42 (Position 4) or Fig. 43 (Position 11).

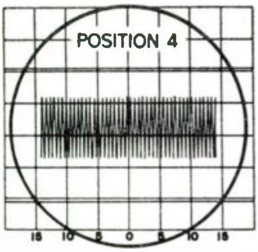


FIG 44

Condition — Coupling Condenser C4 Leaky or Shorted. Signal Generator not used.

Oscillograph Connections D-G or J-G.

Oscillograph — Position 4

A trace similar to Fig ·44 (Position 4) should be obtained when checking either from D-G or J-G however, if capacitor C3 is operating normally the amplitude of the trace should be approximately ½ to ⅔ as great when checking from D to G. as that obtained from J. to G. If the condenser were leaky or shorted out the amplitude of the trace as viewed on either side of this coupling capacitor would be approximately equal.

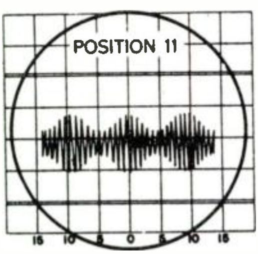


FIG. 40

Condition — Screen By-Pass Condenser C3 Open.

Signal Supplied — Amplitude Modulated R.F.

Signal Connections A-G.

Oscillograph Connections E-G.

Oscillograph — Positions 7-11

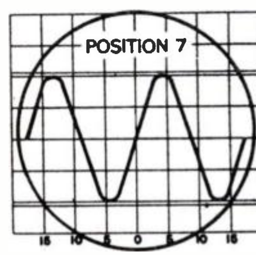


FIG. 41

In the case illustrated there is no stage of preselection and consequently the control grid circuit of the first detector stage is tuned to a different frequency than the plate circuit The plate, of course, is tuned to the frequency of the intermediated frequency stages, and the control grid tuned to the frequency of the oncoming signal In such a case there would be no tendency for this tube to oscillate as a result of open screen connection.

Therefore, the effect of an open screen condenser would manifest itself only in the presence of radio frequency voltage between point E and ground as illustrated in Fig. 40 (Position 11) and Fig. 41 (Position 7). If, however, we consider the case of a stage of R.F preselection in which the control grid of the tube is tuned to the same frequency as the plate circuit an open screen condenser would normally cause serious oscillations. Cases of this nature are taken up in the chapter on intermediate frequency and the effect would be identical to the case where the screen by-pass in the intermediate frequency stages would become open.

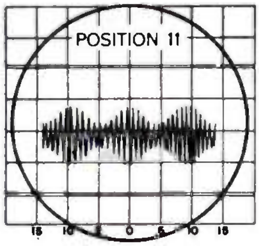


FIG. 40

Condition — First Detector Tube: Normal Operation.

Signal Supplied — Amplitude Modulated R.F.

Signal Connections A-G.

Oscillograph Connections H-G or F-G.

Oscillograph — Positions 7-11.

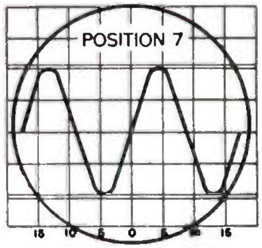


FIG. 41

The signal generator should be adjusted to a frequency equal to that of the intermediate frequency of the receiver under test. The oscillograph will be first connected between point H and ground and the deflection noted. The oscillograph is then connected between F and ground and the wave form should remain the same but an increase in amplitude noted. Fig. 40 (Position 11) and Fig. 41 (Position 7) are again illustrative of the proper trace.

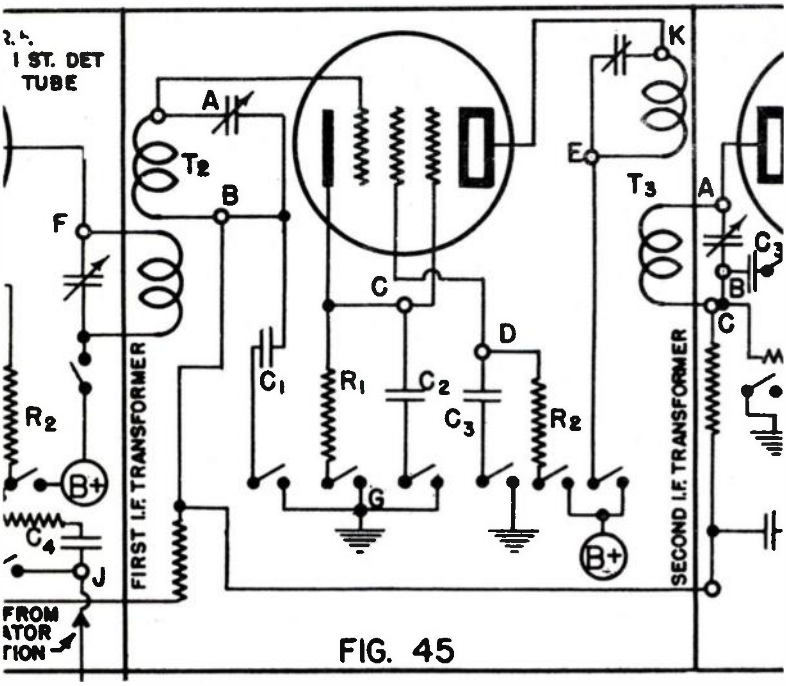


FIG. 45

Signal Supplied

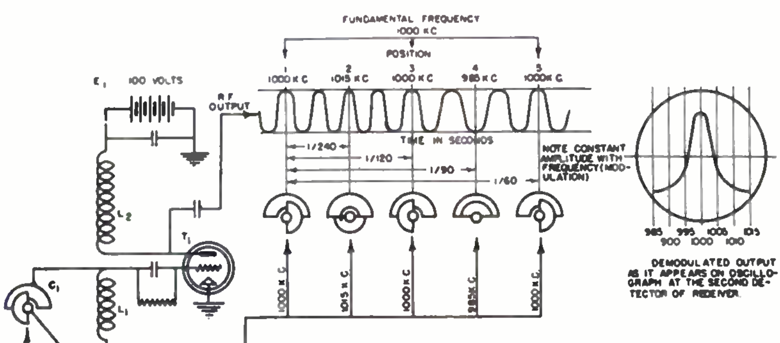
The signal generator output could be fed in at the primary of the intermediate frequency transformer between point F and ground. However, the deflections obtained would be very low if this procedure was followed and consequently the trace more difficult to study. The output from the signal generator may be fed in at point "H" (R.F. section) which is the grid of the first detector tube, and the frequency of the signal generator adjusted to correspond to the intermediate frequency of the receiver under test. With this connection we get the amplifying action of the first detector tube and consequently higher voltage in the intermediate frequency stages. With this connection it is recommended that the oscillator tube be removed or the oscillator section shorted out so that there will be no interference between the voltage developed by the oscillator section of the receiver, and the voltage being supplied directly from the signal generator.

Another option, would be to feed the output from the signal generator in at the antenna post at some frequency within the range of the receiver. Adjust the main tuning dial to correspond to this frequency so that the resultant mixed output between the signal generator and the local oscillator would produce the proper intermediate frequency. If frequency modulated output is to be used and fed to the antenna and ground of the receiver this could be supplied directly from the built in frequency modulated oscillator in the oscillograph. In this case the receiver should be tuned to the frequency of the oscillator (665 KC) or some harmonic.

In the following tests on the intermediated frequency stages the type of signal (frequency or amplitude modulated) only is specified. It may be fed into the receiver either at the antenna or first detector grid at the discretion of the operator.

FREQUENCY MODULATION (See Figure 46)

The characteristics of a frequency modulated signal are that the frequency is constantly changing. Starting with a fundamental frequency the frequency gradually increases to a value 15 kilocycles higher than the fundamental then reduces at the same rate to the fundamental, then decreases at that same rate to a value 15 kilocycles below the fundamental and then increases again to the fundamental frequency, completing the cycle.



FREQUENCY MODULATION
FIG. 46

The rate at which this cycle is completed is 60 cycles per second with the "K.C. Sweep" control as illustrated in Position 1, or 120 cycles per second with the K.C. Sweep control in Position 8.

The amplitude or output voltage of a frequency modulated signal remains constant throughout the entire cycle. Fig. 46 is an illustration of the principles involved in producing frequency modulation. Actually the varying of the capacity is not accomplished by a rotating condenser but is effected electronically by vacuum tubes in the oscillograph.

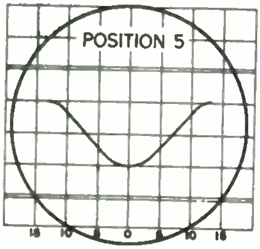


FIG 47

Condition — Normal Operation. First Intermediate Frequency Transformer.
Signal Supplied — Frequency Modulated R.F.
Signal Connections Antenna-Ground. (Recommended).
Oscillograph Connections F-G, A-G.
Oscillograph — **Position** 5.

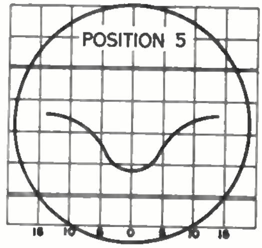


FIG 48

Fig. 47 (Position 5), connection F-G and Fig. 48 (Position 5), connection A-G are illustrative of the above condition for checking the first intermediate frequency transformer. In this case, however, we are using a frequency modulated output from the signal generator or oscillograph Fig. 47, connection F-G illustrates the selectivity trace as it will be obtained at the primary of the first intermediate frequency transformer when using the demodulator in the oscillograph. Fig. 48, connection A-G is an illustration of the trace which should appear at the secondary of the first intermediate frequency transformer showing increased selectivity.

The actual voltage delivered at the secondary will, of course, be somewhat lower than that delivered to the primary, but the selectivity will be correspondingly greater.

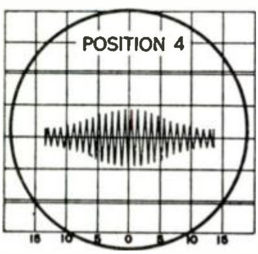


FIG. 49

Condition — Normal Operation. First Intermediate Frequency Transformer.
Signal Supplied — Frequency Modulated R.F.
Signal Connections Antenna-Ground. (Recommended).
Oscillograph Connections F-G, A-G.
Oscillograph — **Position** 4.

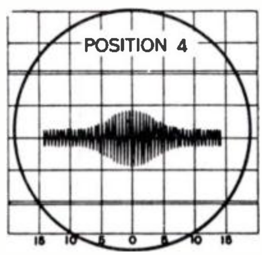


FIG. 50

The following Fig. 49 (Position 4), connection F-G and Fig. 50 (Position 4), connection A-G illustrate the same condition as previously outlined on the intermediate frequency transformer, however, in this case the video amplifier is used. It will be noted that the center of the traces show greater amplitude than the outer edges. This is indicative of the fact that the transformer tends to amplify the frequency to which it is tuned more than it does the frequencies either above or below this value. It is not recommended that the first intermediate frequency transformer be aligned with connections as previously outlined. This test is purely a test to determine whether or not the intermediate frequency transformer is operating properly.

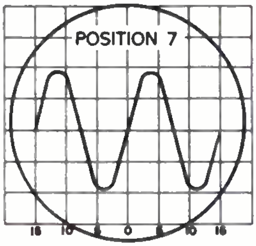


FIG. 51

Condition — By-Pass Condenser C1. Open.
Signal Supplied — Amplitude Modulated R F
Signal Connections Antenna-Ground
Oscillograph Connections B-G
Oscillograph — Positions 7-11

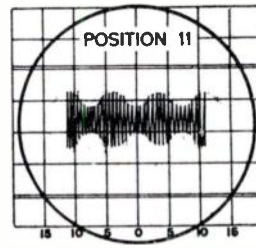


FIG. 51 A

Should the by-pass condenser C1 be open this would permit a radio frequency voltage to be built up between point B and ground The oscillograph connected as indicated would give a trace similar to Fig 51A (Position 11) or Fig 51 (Position 7) if this condition existed.

It is quite possible that if condenser C1 were the only condenser in the filter system of the AVC voltage, the audio frequency voltage developed at the second detector would feed back through the AVC line causing an audio voltage to be developed between point B and ground This can be readily checked by changing the oscillograph to Position 2 in which case the standard amplifier would be in the circuit. This amplifier will pass only audio frequency and would amplify the audio frequency being fed back from the second detector thereby giving an indication that the foregoing condition existed If this condition did not exist no vertical deflection would be obtained

See Fig. 51 above

Condition — Cathode By-Pass Condenser C-2. Open.
Signal Supplied — Amplitude Modulated R.F
Signal Connections Antenna-Ground
Oscillograph Connections C-G.
Oscillograph — Positions 7-11

See Fig. 51A above

If the cathode by-pass condenser C2 becomes open a radio frequency voltage would appear between C and ground and could be checked by the oscillograph as outlined in the foregoing connections The resultant trace as viewed at point C would correspond to Fig. 51 (Position 7) or Fig. 51A (Position 11). If the condenser were normal no R.F voltage would be present between C and ground.

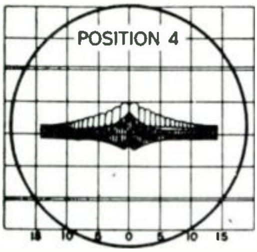


FIG 52

Condition — Screen By-Pass Condenser C3 Open
Signal Supplied — Frequency Modulated R F
Signal Connections Antenna-Ground
Oscillograph Connections D-G
Oscillograph — **Position** 4

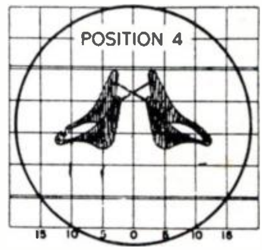


FIG 53

The opening up of the screen by-pass condenser in intermediate frequency stages almost invariably result in oscillation to a varying degree. Overloading of the I.F stage will generally show up this condition more readily The oscillation may be very slight, just barely showing up in the trace as illustrated in Fig. 52 (Position 4) or may vary from this to an extreme degree as illustrated in Fig 53 (Position 4).

It is generally advisable to use the video amplifier in checking for oscillation rather than the demodulator since it shows up the state of sustained oscillation much more readily than when using the demodulator which actually removes most of the R.F oscillation and leaves only the resultant modulated envelope Tests made at the second detector will illustrate the trace under a condition of oscillation in I.F stages when using the demodulator.

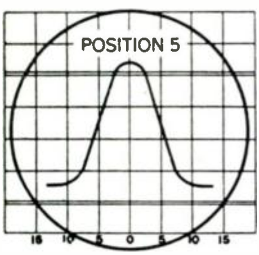


FIG 54

Condition — Normal Operation Second Intermediate Frequency Transformer
Signal Supplied — Frequency Modulated R F
Signal Connections Antenna-Ground
Oscillograph Connections K-G, A-G
Oscillograph — **Position** 5

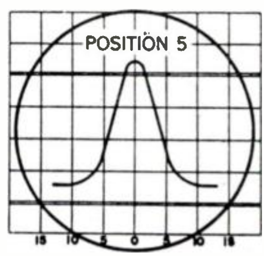


FIG. 55

Fig. 54 (Position 5) is illustrative of the trace as it should appear at the primary of the second I F. transformer, connections K-G Fig 55 (Position 5) shows the increase in selectivity resulting from the signal passing through the second I F transformer, connection A-G.

SECOND DETECTOR, R.F.-I.F. ALIGNMENT, AND FIRST AUDIO AMPLIFIER

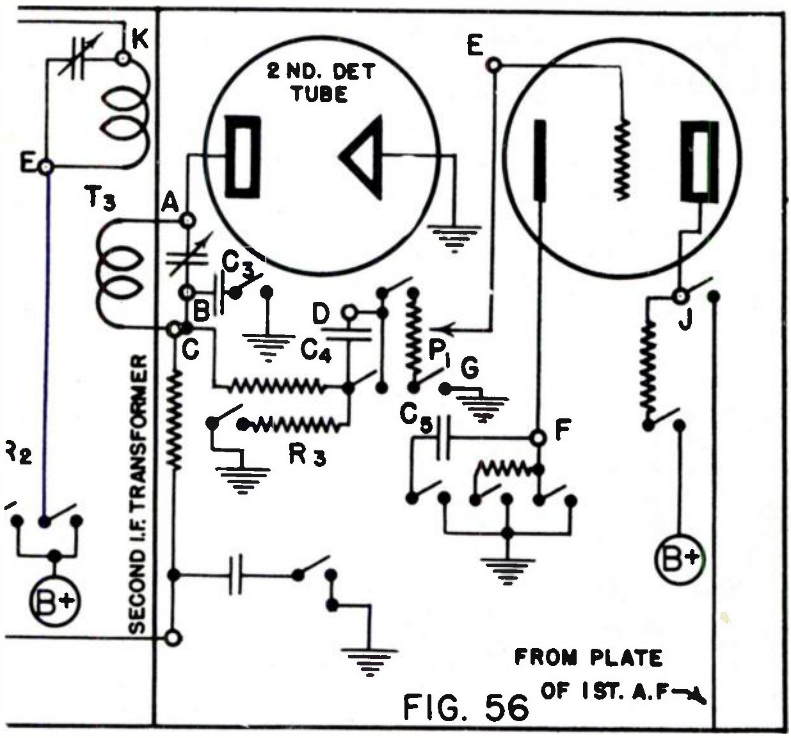


FIG. 56

SECOND DETECTOR

Signal Supplied: If the signal to be supplied for the test is frequency modulated R.F. this could be obtained from the oscillograph or from a suitable signal generator outlined in the chapter on I.F. stages. If amplitude modulated R.F. it must be supplied from a signal generator.

Signal Connections: Connections from the signal source to receiver; Signal could be fed to the receiver in a manner identical to that outlined in the chapter on I.F stages with the addition that it might be fed to the grid of the First I.F. Amplifier tube at the proper I.F. frequency. In the following tests we have indicated the signal to be supplied at the antenna or ground connections. This could be altered in accordance with the foregoing if so desired.

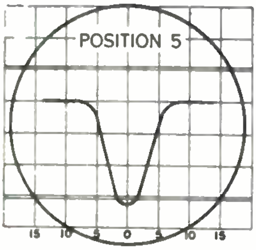


FIG. 57

Condition — Defective Diode Detector Tube.
Signal Supplied — Frequency Modulated R.F.
Signal Connections Antenna-Ground.
Oscillograph Connections C-G.
Oscillograph — Positions 1-5-4.

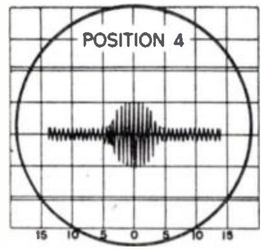


FIG 58

If, the second detector were defective and not rectifying the R.F. carrier at Position 1 no deflection will be obtained due to the fact that standard amplifiers are not capable of amplifying the high frequency encountered in intermediate frequency stages. By switching to the demodulator, Position 5 the trace as illustrated in Fig. 57 will be obtained, thereby giving an immediate indication that the second detector were defective. By using Position 4 a trace as illustrated in Fig. 58 would be indicative of the same condition.

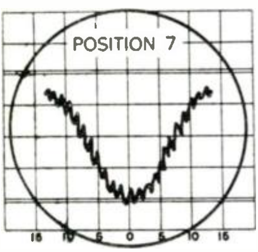


FIG 59

Condition — By-Pass Condenser C3 Open.
Signal Supplied — Frequency Modulated R.F. and Amplitude Modulated R.F.
Signal Connections Antenna-Ground.
Oscillograph Connections C-G.
Oscillograph — Positions 1-2.

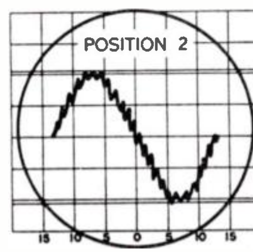


FIG 60

If R.F. By-pass Condenser C3 were to become opened this would allow a decided amount of radio frequency to appear on the demodulated R.F. carrier as shown in Fig. 59 (Position 1). Fig. 60 (Position 2) is illustrative of the same condition but with amplitude modulated signal supplied rather than frequency modulated. The remedy in this case, of course, is to replace the condenser or to install a condenser of higher value.

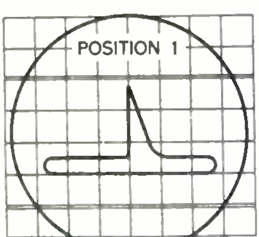


FIG 61

Condition — Open Load Resistance R3.
Signal Supplied — Frequency Modulated R.F.
Signal Connections Antenna-Ground.
Oscillograph Connections C-G.
Oscillograph — Positions 1-2.

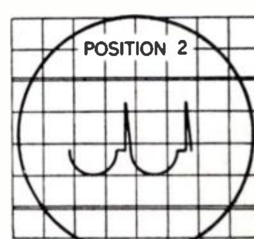


FIG 62

Fig. 61 (Position 1) illustrates this condition when using the 60 cycle sweep. Fig. 62 (Position 2) is the same condition when using the sweep circuit oscillator.

INTERMEDIATE FREQUENCY
RADIO FREQUENCY ALIGNMENT

The following is a brief resume of the types of traces which will be obtained as a result of correct and incorrect alignment in these stages.

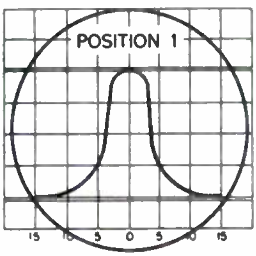


FIG 63

Condition — Correct Alignment.
Signal Supplied — Frequency Modulated R.F.
Signal Connections Antenna-Ground. (R.F.) First Detector Grid (I.F.)
Oscillograph Connections C-G.
Oscillograph — Positions 1-8.

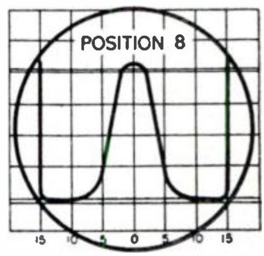


FIG 64

The above are used for all Alignment Procedure.

Fig. 63 (Position 1) illustrates the trace as it should appear when using 30 KC sweep with the receiver in normal operating condition. Fig. 64 (Position 8) illustrates this same condition when using the 120 cycle sweep.

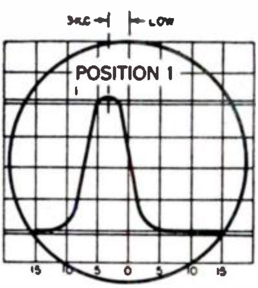


FIG 65

Condition — Intermediate Frequency Stages Aligned at Wrong Frequency.

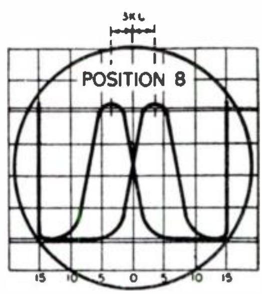


FIG 66

Alignment at the wrong frequency when using a 60 cycle sweep will result in both traces moving an equal distance to the left or right. Alignment at 3 KC below the correct frequencies is illustrated in Fig. 65 (Position 1). Fig. 66 (Position 8) is illustrative of the same condition with the exception that the 120 cycle sweep is being used rather than a 60 cycle sweep. It will be noted that the two traces separate rather than both traveling together in the same direction across the screen.

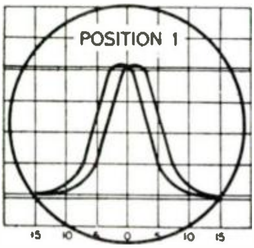


FIG. 67

Condition — Phase Distortion in Intermediate Frequency Stages.

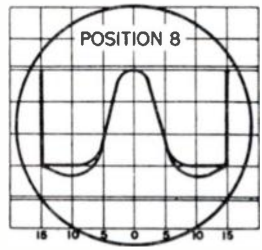


FIG 68

Fig. 67 (Position 1) is illustrative of a condition of phase distortion when using 60 cycle sweep and it will be noted that the two traces tend to open up from each other. Fig. 68 (Position 8) is illustrative of the same condition when using 120 cycle sweep. In the latter case it is necessary to note the departure of the response curve from the correct curve as being indicative of phase distortion since mistuning the receiver would cause the two peaks to overlap as illustrated.

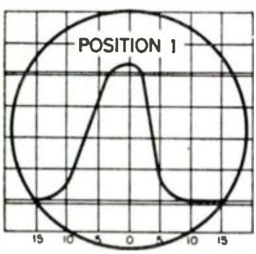


FIG. 69

Condition — Misalignment of One or Two Tuned Circuits in Intermediate Frequency Stages.

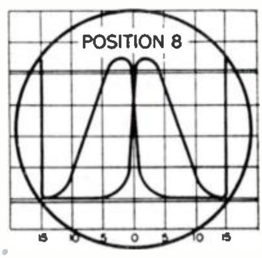


FIG 70

In cases of misalignment of some of the intermediate or radio frequency stages there will be a tendency for the response curve to appear as illustrated in Fig. 69 (Position 1) or Fig. 70 (Position 8). Note the curve is no longer symmetrical.

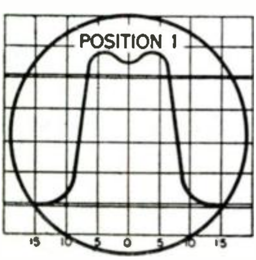


FIG 71

Condition — Flat Topping High Fidelity Receivers.

Fig. 71 (Position 1) is illustrative of correct alignment curves in cases of receivers adjusted for high fidelity reception. It will be noted that the wide band pass characteristics are quite in contrast to the relatively sharp peak obtained when adjusting receiver for maximum selectivity.

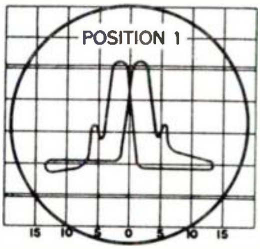


FIG. 72

Condition — Regeneration In I.F. Stages.

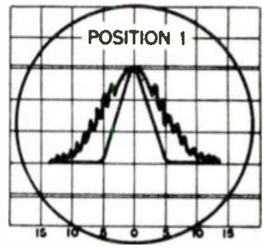


FIG 73

Fig. 72 (Position 1) is illustrative of slight regeneration in the I.F. stages. Fig. 73 (Position 1) illustrates severe regeneration.

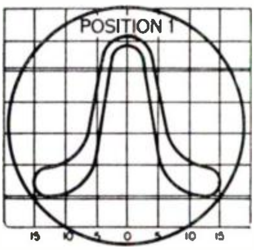


FIG 74

Condition — Hum.

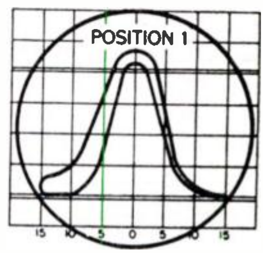


FIG 75

Fig. 74 (Position 1) illustrates hum as it would effect the response curve where the receiver is using full wave rectification.

Fig. 75 (Position 1) is the same condition in case where the rectifier system is half wave.

FIRST AUDIO AMPLIFIER

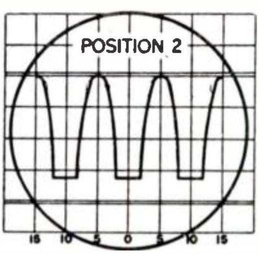


FIG 76

Condition — Leaky Coupling Condenser C4.

Signal Supplied — Amplitude Modulated R.F.

Signal Connections Antenna-Ground

Oscillograph Connections E-G

Oscillograph — Position 2.

In checking leaky coupling condenser C4 it is only necessary to increase the output of the signal generator to a relatively high output and with the oscillograph connections at E-G Fig. 76 (Position 2) should be obtained if the coupling condenser C4 is normal. It will be noted how the bottom of the sine wave tends to flatten off indicating that the control grid is being swung positive with respect to the cathode thereby drawing current and reducing the voltage during this half of the cycle. If, however, coupling condenser C4 were leaking an increase in negative voltage at point E. would bias the control grid negative as the signal increases and will not permit the grid to be swung positive with respect to the cathode: A pure sine wave would result.

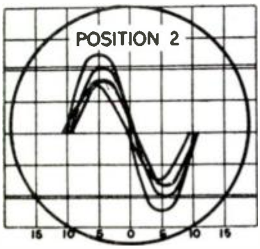


FIG 77

Condition — Open Volume Control P1.
Signal Supplied — Amplitude Modulated R.F.
Signal Connections Antenna-Ground.
Oscillograph Connections E-G.
Oscillograph — Position 2.

If the volume control labeled P1 were either disconnected at the low end or had become opened so that there was no direct current return back to ground this would allow the grid to float at an infinite D.C. impedance above ground and the result, of course, would be a certain amount of A.C. pick-up on the grid. The resultant trace is illustrated in Fig. 77 (Position 2) and shows the effect of an A.C. ripple on the 400 cycle demodulated voltage.

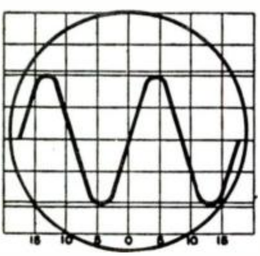


FIG 4

Condition Cathode By-Pass Condenser C5 Open.
Signal Supplied — Variable Audio from 100 to 10,000 Cycles.
Signal Connections D-G.
Oscillograph Connections F-G.
Oscillograph — Position 2.

If the by-pass condenser C5 has become open an audio frequency voltage would be built up between point F and ground which would be approximately equal to the voltage supplied to the grid of the first audio amplifier by the signal generator. This voltage would appear as a pure sine wave. (Fig.4) This will probably be about 1 or2 volts as indicated on the calibrated voltage Scale.

If condenser C5 were operating normally a very small voltage could be built up from F to ground, the magnitude of this voltage would depend largely upon the frequency impressed. When the variable audio signal were reduced to approximately 50 or 100 cycles a relatively large voltage would probably be built up, .2 of 1 volt or greater, whereas if the frequency from the signal generator were increased towards 10,000 cycles the magnitude of the voltage would decrease rapidly until at 10,000 cycles it would hardly be perceptable on the cathode ray tube screen

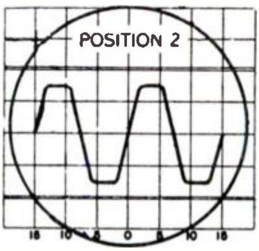


FIG 78

Condition — Normal Operation and Overload. First Audio Amplifier Tube
Signal Supplied — 400 Cycle A F
Signal Connections D-G.
Oscillograph Connections E-G, J-G.
Oscillograph — **Position** 2

With the sine wave of any frequency fed into the control grid of the first audio amplifier the trace as observed at the plate of the tube should represent a pure sine wave, The voltage should be from 20 to 50 times greater at the plate connection J-G than the voltage measured at the control grid connection E-G. In case of high gain pentodes used as first audio amplifiers the amplification might be as high as 150 or 200.

In a case of overload of this stage Fig. 78 (Position 2) would be observed at the plate of the tube connection J-G.

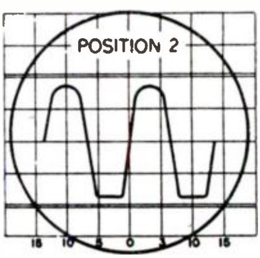
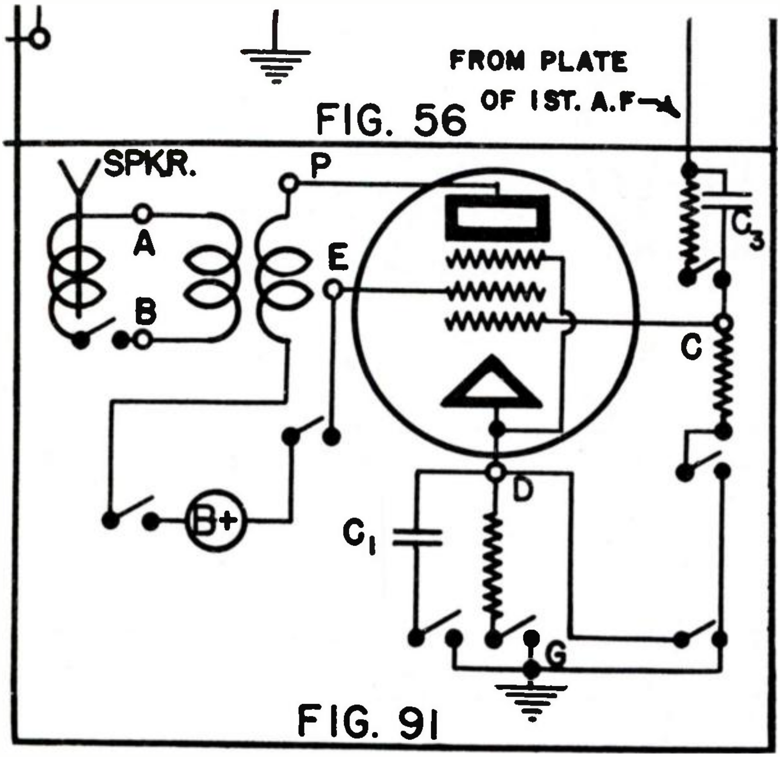


FIG 79

Condition — Shorted By-Pass Condenser C5
Signal Supplied — 400 Cycle A.F
Signal Connections D-G.
Oscillograph Connections J-G.
Oscillograph — **Position** 2

Fig 79 (Position 2) is an illustration of the distortion caused by swinging the control grid positive with respect to cathode Normally the cathode is operating at a positive potential above ground which puts the grid at negative potential with respect to the cathode. In the condition illustrated, however, the by-pass condenser was shorted out thereby putting both the grid and the cathode at ground potential. Any A. C. voltage applied to the grid would swing it positive with respect to the cathode giving the distortion as illustrated in the above figure.



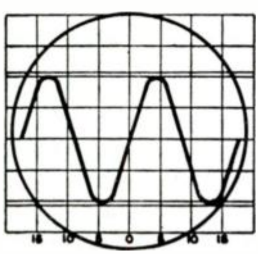


FIG 4

Condition — Normal Operation.

Signal Supplied — 100 to 10,000 Cycle A.F.

Signal Connection To Grid of First Audio Amplifier.

Oscillograph Connections See Text Below.

Under a condition of normal operation the trace as observed at either the control grid (C-G) plate (D-G) or voice coil (A-B) of the final amplifier should represent a sine wave (Fig. 4). In normal operation of class A amplifiers the audio requency voltage as measured at the control grid (C-G) should never exceed approximately .7 of the D.C. bias voltage measured from cathode to ground (D-G). If the voltage applied at the control grid (C-G) were in excess of this amount it would result in the grid swinging positive with respect to the cathode thereby inducing distortion. In the case of class AB or B amplifiers this relation would no longer hold true since in this type of amplifier it is necessary to swing the grid positive with respect to the cathode.

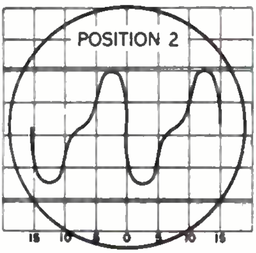


FIG. 80

Condition — Leaky Coupling Condenser C3.
Signal Supplied — 400 Cycles A.F.
Signal Connection Grid of First Audio Frequency Amplifier Tube.
Oscillograph Connections C-G.
Oscillograph — Position 2.

Should the coupling condenser C3 become leaky or shorted out a trace similar to Fig. 80 (Position 2) would be obtained with the oscillograph connection C-G, rather than a pure sine wave.

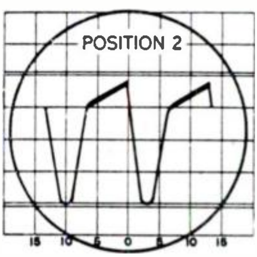


FIG. 81

Condition — Leaky Coupling Condenser C3.
Signal Generator as previously Connected.
Oscillograph Connections P-G.
Oscillograph — Position 2.

The same condition as previously outlined of a leaky coupling condenser would show up as illustrated in Fig. 81 (Position 2) when the oscillograph is connected at the plate of the output tube.

If the oscillograph has been connected across the voice coil from A to B rather than from the plate of the tube back to ground a curve exactly the same as Fig. 81 Position 2) should be obtained with the exception that the voltage would naturally be lower due to the step-down voltage effect of the output transformer.

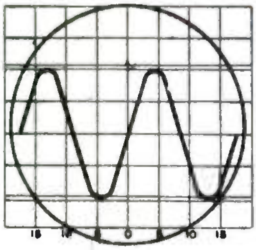


FIG 4

Condition — Open Cathode By-Pass Condenser C1.
Signal Supplied — 100 to 10,000 Cycles. Variable Audio Frequency Output.
Signal Connection At Grid of First Audio Amplifier Tube.
Oscillograph Connections D-G.
Oscillograph — Position 2.

A pure sine wave (Fig. 4) should be obtained with this connection. The amplitude of this sine wave should increase rapidly as the frequency from the signal generator were decreased due to the increased reactance of by-pass condencer C1 at lower frequencies. If, however, C1 were open it will be found that the amplitude of the trace on the screen would remain almost constant as the signals were varied from approximately 100 cycles up to 10,000 cycles.

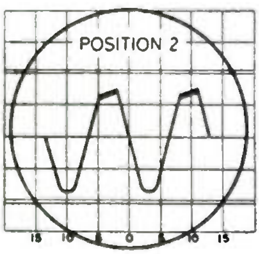


FIG 82

Condition — Cathode By-Pass Condenser C1 Shorted Out.
Signal Supplied — 400 Cycle A. F.
Signal Connection At Grid of First Audio Amplifier Tube.
Oscillograph Connections P-G.
Oscillograph — Position 2.

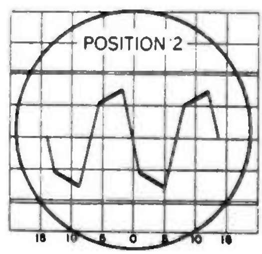


FIG 83

If the cathode by-pass condenser has become shorted out a trace as illustrated in Fig. 82 (Position 2) would be obtained.

If the output stage were push pull a trace as illustrated in Fig. 83 (Position 2) would be obtained.

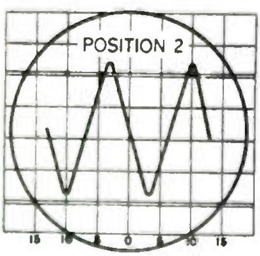


FIG 84

Condition — Mismatching of Plate Load.
Signal Supplied — 400 Cycle A.F.
Signal Connection To Grid of First Audio Amplifier Tube.
Oscillograph Connections P-G.
Oscillograph — Position 2.

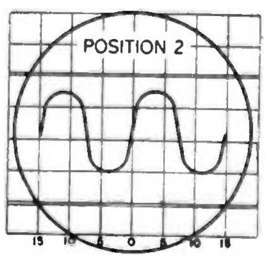


FIG 85

Fig. 84 (Position 2) is an illustration of the effect on the output wave trace of too light loading on the plate circuit of the tube. This might be caused by an open voice coil or high resistance in the voice coil connection.

Fig. 85 (Position 3) is illustrative of a condition of excessively heavy loading which could be caused by shorted voice coil or shorted turns in the output transformer.

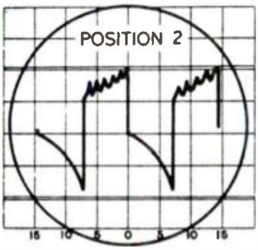


FIG 86

Condition — No Voltage at Screen of Output Tube.
Signal Supplied — 400 Cycle A.F.
Signal Connection To Grid of First Audio Amplifier Tube.
Oscillograph Connections P-G.
Oscillograph — Position 2.

Should the wiring to the screen of the output tube become defective thereby delivering no voltage to the screen, or should the screen of the tube become defective causing it to be inoperative a trace similar to Fig. 86 (Position 2) will be obtained.

Very strong signal will have to be delivered from the signal generator to show up this defect.

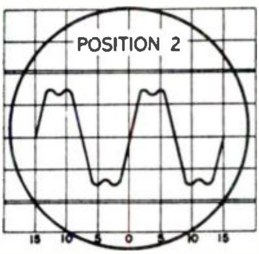


FIG 87

Condition — Overload In Final Amplifier.
Signal Supplied — 400 Cycle A.F.
Signal Connection To Grid of First Audio Amplifier Tube.
Oscillograph Connections P-G.
Oscillograph — Position 2.

Fig. 87 (Position 2) illustrates condition of overload in the final audio amplifier. The constants of the amplifier circuit are normal.

FIG. 88

Condition — Regeneration in Audio Frequency System.
Signal Supplied — 400 Cycle A.F.
Signal Connection To Grid of First Audio Amplifier Tube.
Oscillograph Connections P-G.
Oscillograph — Position 2.

Should defective wiring or placement of parts in the audio frequency amplifiers result in feed-back sufficient to cause oscillation a trace similar to that illustrated in Fig 88 (Position 2) would probably be obtained. This figure actually represents a high frequency oscillation being amplitude modulated at the signal frequency of 400 cycles

DYNAMIC VISUAL AUDIO FREQUENCY RESPONSE CURVES

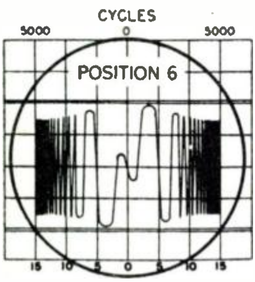


FIG 89

Condition — Normal Operation

Signal Supplied — Frequency Modulated Audio Frequency

Signal Connection To Grid of First Audio Amplifier Tube.

Oscillograph Connections P-G.

Oscillograph — **Position** 6.

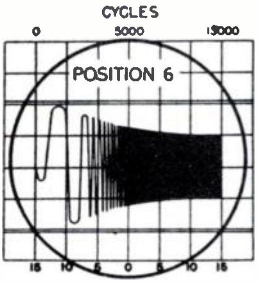


FIG. 90

If a signal generator is available which is capable of producing a frequency modulated audio frequency signal, curves as illustrated in Figures 89 or 90 may be obtained. Figure 89 illustrates a case where the frequency modulated signal is being swept from zero center frequency to about 5 kc. either side of center frequency. Figure 90 illustrates a condition in which the signal genreator is sweeping from zero cycles to about 10 kc. with zero frequency being adjusted to the left hand side of the screen.

FREQUENCY MODULATED RECEIVER ALIGNMENT

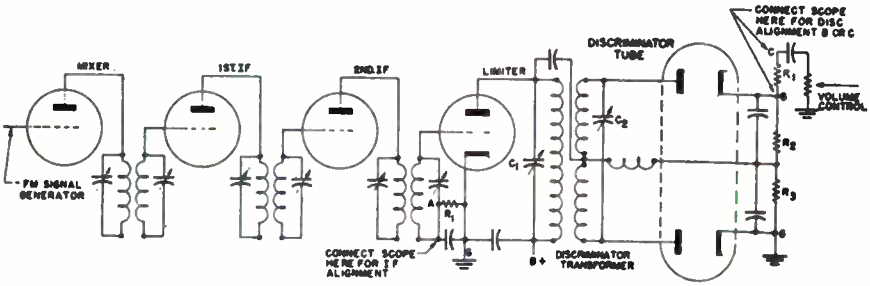


FIGURE 92 FOSTER-SEELEY DISCRIMINATOR CIRCUIT

PROCEDURE FOR ALIGNING FOSTER-SEELEY DISCRIMINATORS:

When FM receivers were first introduced, the circuits used were almost universally of the IF amplifier, limiter (necessary to remove amplitude modulation from the frequency modulated signal), and Foster-Seeley type of discriminator. Figure 92 illustrates the typical IF and discriminator stages in a receiver of this type of design.

With reference to this figure, the alignment procedure is to feed the frequency modulated signal in at the first detector at the proper IF frequency and, in general, the deviation was adjusted to approximately 200 kc. either side of center frequency. The oscillograph was first connected to the limiter load resistance, point "A", and alignment was made of the IF and limiter stages which resulted in a response curve as illustrated in Figure 99. The broadness of the curve was determined by the band pass characteristics of the IF stages and varied from one set to another. Alignment was made to get a maximum vertical deflection of the response curve consistent with symmetrical sides.

After the IF and limiter stages were aligned, the oscillograph was then reconnected to the discriminator load resistance at point "B" and the discriminator primary and secondary were then adjusted to give a curve as illustrated in Fig. 93 or 94. An incorrect adjustment of the primary would result in a non-linear trace between points "A" and "B" (Fig. 101). An incorrect secondary adjustment would result in traces as illustrated in Fig. 102. This completed the alignment of the IF, limiter and discriminator stages.

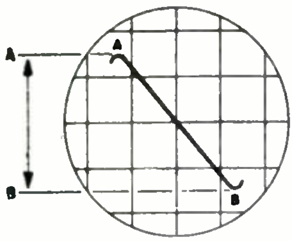


FIG 93

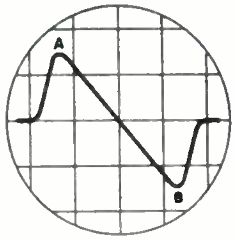


FIG. 94

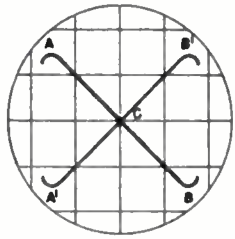


FIG. 95

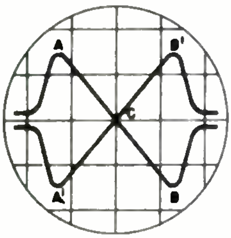


FIG. 96

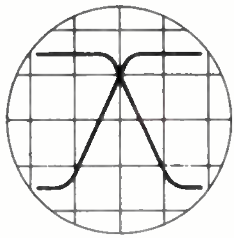


FIG. 97

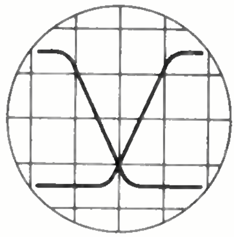


FIG. 98

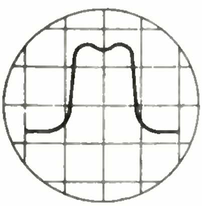


FIG. 99

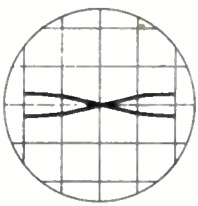


FIG. 100

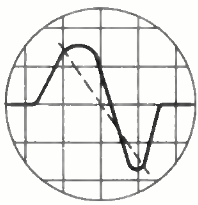


FIG. 101

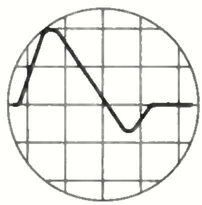


FIG. 102

At this point, we would like to deviate from the alignment procedure to point out a factor in connection with the alignment which is often confusing to many servicemen.

For technical reasons beyond the scope of this manual, it is advisable to generate a frequency modulated signal by heterodyning an unmodulated variable frequency oscillator, which in most cases is the main variable oscillator of the signal generator, against a fixed frequency modulated oscillator, and from properly designed mixer circuits, take the desired frequency modulated output. In most signal generators the frequency modulated oscillator operates at approximately 50 mc.

To generate the standard FM intermediate frequency of 10.7 mc., the variable oscillator was adjusted to 10.7 mc. above or below the fixed frequency modulated oscillator. In the case being considered, we would probably set the main oscillator at 10.7 mc. below 50 mc., or at 39.3 mc.

Considering potential errors in generating a frequency in this manner, we might conceive of an error of as much as 1% in the main variable oscillator. This could result in a frequency error of 1% of 39.3 mc., or .393 mc. Assuming that there might be a similar error in the frequency modulated oscillator, here again, there could be a potential error of .5 mc. If, by some chance, these two errors were in such a direction as to be additive, the potential error might be a total of .393 plus .50 mc., or almost .9 mc. At 10.7 mc., this error of .9 mc. would represent an error of over 8%.

Some servicemen have made a practice of roughly aligning the IF stages first with a regular amplitude modulated signal which, of course, should be well within an accuracy of ±1% at 10.7 mc., or .10 mc., and then making the final alignment using an FM signal. When the FM generator is first connected up for this final adjustment, the frequency should be adjusted in the vicinity of 39.3 mc. until the response curve is centered on the screen, regardless of whether or not the main dial is indicating exactly 39.3 mc. As the serviceman becomes familiar with a particular signal generator, he will soon learn what errors, if any, exist and then can automatically set the main tuning dial to the frequency which will give him the exact frequency desired.

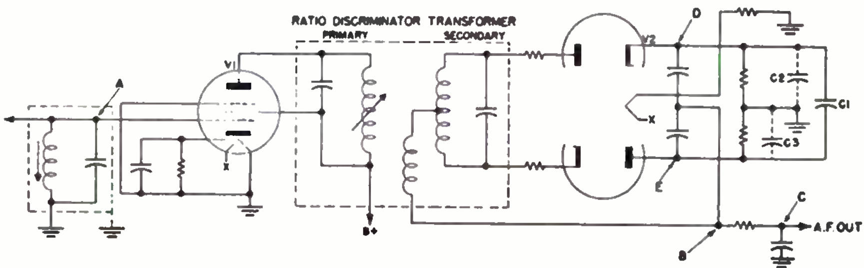


FIGURE 103 RATIO DISCRIMINATOR CIRCUIT

PROCEDURE FOR ALIGNING RATIO DETECTORS:

Now to get back to FM alignment. As the manufacturers of FM receivers gained experience in receiver alignment, new circuits were developed and new techniques were also found which, in many cases, resulted in faster and more accurate alignment of these receivers. One major change in circuit design of FM receivers has been the development of the ratio detector. This circuit resulted in the possibility of elimination of the limiter stages since this type of detector is virtually responsive to only frequency changes or frequency modulation, and essentially independent of amplitude changes or amplitude modulation. Also, this ratio type discriminator circuit produces a DC voltage in proportion to the strength of the incoming carrier wave. This can be used to supply A. V. C. voltage to the IF and RF stages. One form of this type of detector is illustrated in Fig. 103. It is not the intention of this discussion to go into the relative merits of the two types of detection as both types find uses in the design of FM receivers.

The alignment procedure of ratio detectors generally takes the following pattern. A frequency modulated signal generator is first fed in at the grid of the last IF amplifier tube, V1, at point "A". A decoupling resistor of several hundred ohms should be connected between the generator output and this point. The signal generator should be set to produce an FM signal of the proper IF frequency and deviation adjusted to about 200 or 300 kc. total, that is, 100 to 150 kc. either side of center frequency.

The vertical input to the oscillograph is generally connected at either point "B" or point "C". In some cases, it may be connected to the high side of the volume control although a certain amount of phase shift may be encountered by such a connection in some types of receivers. With this connection, the following formula may be used to determine whether or not the signal generator and oscillograph being used may have suitable characteristics to properly display a discriminator response curve.

The deflection in inches on the oscillograph screen will be approximately equal to three times the signal generator output in millivolts, divided by the oscillograph sensitivity in millivolts required per inch deflection. As an example, assume a case of an oscillograph which has a sensitivity of 30 millivolts (0.03 volts) per inch and a signal generator which has a maximum FM output voltage at, for example, 10.7 mc., of about 20 or 30 millivolts. The expected deflection in inches would then be, assuming 30 millivolts output for the generator, three times 30 (=90) divided by 30, or 3 inches.

There are many oscillographs on the market today which do not have 30 millivolts sensitivity, therefore, the use of such an oscillograph would result in much less expected vertical deflection of the pattern. In fact, if the sensitivity were as low as 500 millivolts which is common in some oscillographs, it would be practically impossible to align discriminator stage only in accordance with the following procedure.

If the oscillograph being used has provisions for only a 60 cycle sinusoidal horizontal sweep, proper alignment would result in a pattern as illustrated in Fig. 93

(200 kc. sweep from the generator), or Fig. 94 (400 kc. sweep). If the oscillograph being used also has provisions for a 120 cycle linear sweep, then it is possible to obtain what is known as the "X" type of pattern as illustrated in Fig. 95 (200 kc. sweep), or Fig. 96 (400 kc. sweep).

Some oscillographs do not have provisions for a synchronized 120 cycle horizontal sweep. If the oscillograph does not have such provisions but does have provisions for synchronizing a 120 cycle sweep from an external source, it is generally possible to obtain the proper synchronizing voltage by making a connection to the input of the full wave power supply filter of the receiver under test where a 120 cycle frequency will be available.

Correct alignment when using 60 cycles sinuosoidal horizontal sweep as illustrated in Fig. 93 or 94, should be obtained by an adjustment of the primary of the ratio discriminator transformer until a pattern of maximum height, between points "A" and "B", is obtained. Then the secondary is aligned to obtain as straight a curve or line as is possible between points "A" and "B", readjusting the primary if necessary.

Experience has shown that with most discriminator stages better and faster alignment can be obtained by the use of a relatively narrow (200 kc.) sweep. In the case of certain discriminator transformers the use of a wider sweep has given evidence of misalignment. It is an established fact that in actual operation the discriminator does not operate at a sweep width greater than 150 kc. total. Of course, the primary or secondary, or both, may be either tuned by iron core inductive slugs or by trimmer capacitors.

In using the 120 cycle linear sweep, the proper adjustment, as previously noted, will be obtained when the pattern as illustrated in Fig. 95 or 96 is observed. In alignment using this type of pattern, the primary is first adjusted to obtain maximum vertical deflection between points "AB" and "A 'B' ". The secondary is then adjusted until the cross-over point, "C", comes exactly in the center of the screen. Incorrect alignment of the secondary will produce patterns as illustrated in Fig. 97 or 98.

Once the correct alignment of the discriminator stages has been effected using 120 cycle sweep as illustrated in Fig. 95 or 96, a still further check can be made on the alignment as follows.

A perfectly aligned discriminator stage will result in two smaller "X" patterns as illustrated in Fig. 100 as the signal generator frequency is varied above or below the center frequency to which the curve of Fig. 95 was obtained. These smaller "X" patterns at about .4 mc. each side of the center frequency will be of the same amplitude and shape, provided that the circuits are properly aligned. This test has proved to be a quick and highly accurate method of determining correct discriminator adjustment.

In ratio type detectors it is possible to obtain a response curve as illustrated in Fig. 99 by utilizing the 60 cycle sinusoidal sweep for horizontal deflection and disconnecting electrolytic capacitor C1, or C2 and C3, as some circuits use two capacitors in place of one, and connecting the vertical input to the oscillograph at points "D" or "E". The secondary of the discriminator transformer can not be properly aligned with such connection, but it is possible to align the primary or, if the signal generator is being fed in at some point in the IF strip farther back toward the converter, the IF stages can be aligned for a symmetrical maximum amplitude pattern as indicated in Fig. 99.

TELEVISION RECEIVER ALIGNMENT

There seems to be one outstanding misconception in regard to what type of oscillograph and what characteristics it must have to be satisfactory for television servicing. Since television receivers have video amplifiers which are good to about 4.5 mc., the thinking, though in error, seems to be general that the oscillograph should have equally good, or better, amplifiers. If the cathode ray oscillograph were to be used in place of the picture tube in the television receiver and actually displaying television transmitted pictures, then the amplifier would have to be good to 4.5 mc. Of course, the oscillograph would never be used in this manner. There is only one other use of the oscillograph which might necessitate its having amplifiers of such characteristics. This use would be purely academic and confined to teaching the theory of television. In this case, the oscillograph might be used to demonstrate the appearance of the synchronizing pulses as transmitted by the television station.

Actually, an oscillograph may be used in one or both of two ways when servicing television receivers:

(1) It **must** be used as the indicating medium when aligning the IF and RF stages.

(2) It may have to be used for trouble shooting in the horizontal and vertical deflecting circuits.

For the visual alignment of RF and IF stages in television receivers, neglecting tube size, a most important characteristic of an oscillograph is its sensitivity. In making such alignments, which represent a large percentage of the use of an oscillograph in television servicing, the maximum frequency which is applied to the vertical deflecting plates is only 60 cycles since this is the modulating frequency used by television alignment generators.

Some manufacturers of television receivers give oscillographic pictures of the various wave forms to be expected throughout the deflecting circuits. The vertical deflecting circuit operates at only 60 cycles per second and the highest frequency which would have to be observed in such circuits would probably not represent more than the equivalent of five or ten thousand cycles of sine wave. In the horizontal deflecting circuits, however, where the operating frequency is 15,750 cycles, there are certain wave forms having steep wave fronts and pulses which would not be accurately portrayed on an oscillograph having amplifiers only to 50 or 100 thousand cycles. In this case, an oscillograph having vertical amplifiers good to 1 mc. would be desirable for accurate portrayal of any wave forms encountered in horizontal deflecting circuits.

One-half megacycle or 500,000 cycles seems to be about the boundaryline for an amplifier response above which quite accurate portrayal is assured and below this, portrayal is questionable. Of course, there are certain places, even in horizontal deflecting circuits, where amplifiers would give accurate portrayal without being good to .5 mc.

In using an oscillograph for trouble shooting in deflecting circuits there are certain of these circuits where no oscillograph can be directly connected without loading or disturbing the circuit to an extent that the observed pattern would not be a true representation of the actual wave form without the oscillograph being connected to the circuit. In view of this, television probes have been designed especially for television servicing in connection with oscillographs which will permit accurate wave form observations in any television circuit without disturbing that circuit.

It is beyond the scope of this manual to give detailed television procedures followed when using oscillographs for this service. The manual accompanying the Hickok television alignment generators does give detailed procedure for television alignment and is available from the factory at a net price of $1.00 per copy.

THE TELEVISION ALIGNMENT GENERATOR

Working on the assumption that the average serviceman who is contemplating going into television servicing has the routine test equipments such as volt-ohm-meters, capacity meters, etc., we approach the problem from the standpoint of special equipments which should be obtained in order to set up a shop to do a satisfactory job of television servicing. For this television servicing, two basic equipments are absolutely necessary: the cathode ray oscillograph discussed in the paragraph on TELEVISION RECEIVER ALIGNMENT, and a wide band television alignment signal generator. Several other pieces of special equipment might be used in television servicing which are not, for most servicing at least, considered very essential. These are such equipments as monoscopes, cross-hatch generators, high voltage voltmeters, etc. It would be impractical to go into detail on all of the characteristics of these units at this time, consequently, this explanation will deal only with the characteristics required of the television alignment generator.

To be really complete and to do the job fully, this generator should have many characteristics not found in any standard FM or AM generators. One of the major characteristic differences, however, between a television alignment generator and conventional generators lies in the width of sweep required to properly display a response curve on the cathode ray oscillograph. The sweep width, or deviation, of a television generator should be at least 15 mc., that is, 7.5 mc. each side of center frequency. For FM alignment, the generator need only have a sweep width of 300 or 400 kc., that is, .3 or .4 mc., as such a sweep is entirely adequate for such alignment. The reason that this is true is that in FM receivers the RF and IF amplifiers only have to pass a band width of about 150 to 200 kc., whereas in television receivers, the band pass characteristics have to be almost 5 mc. In order to properly display any band pass characteristics on an oscillograph, the signal generator should be capable of sweeping at least two or three times the band width of the circuits under test.

The second important characteristic of a television alignment generator is the frequency coverage. Some generators will be used on the older receivers built prior to the war which might have intermediate frequencies as low as 6 or 7 mc. Consequently, the generator should be capable of going down to this frequency although, by far, the vast majority of receivers, and practically all of those built since the war, have been using intermediate frequencies in the range of 20 to 40 mc. It is true that the conventional signal generator will generate these frequencies, but it is not, as previously mentioned, capable of sweeping the signal by the required amount.

At the present time, there are twelve television channels starting in with channel 2 at 54 mc. through channel 6 at 88 mc., and channel 7 through channel 13, starting at 174 mc. and going to 216 mc. Obviously, the signal generator should be capable of supplying frequencies as high as 216 mc. This is not a frequency range found in most conventional signal generators.

An important characteristic of a good television generator is its ability to supply its own marker frequencies. A typical television IF response curve is illustrated in Fig. 104, and it will be noted that as per the manufacturer's alignment instructions, marker frequencies should be put in at several points along the response curve. The accuracy of these marker frequencies is very important, in fact, most manufacturers utilize crystal control of the marker frequencies when making production alignments in order to assure a high degree of accuracy. The use of a second signal generator to provide these frequencies has two disadvantages, one being that it means an extra piece of equipment in the test setup which complicates the alignment procedure; and second, it is not, in general, possible to expect a higher degree of accuracy than about 1% from conventional signal generators.

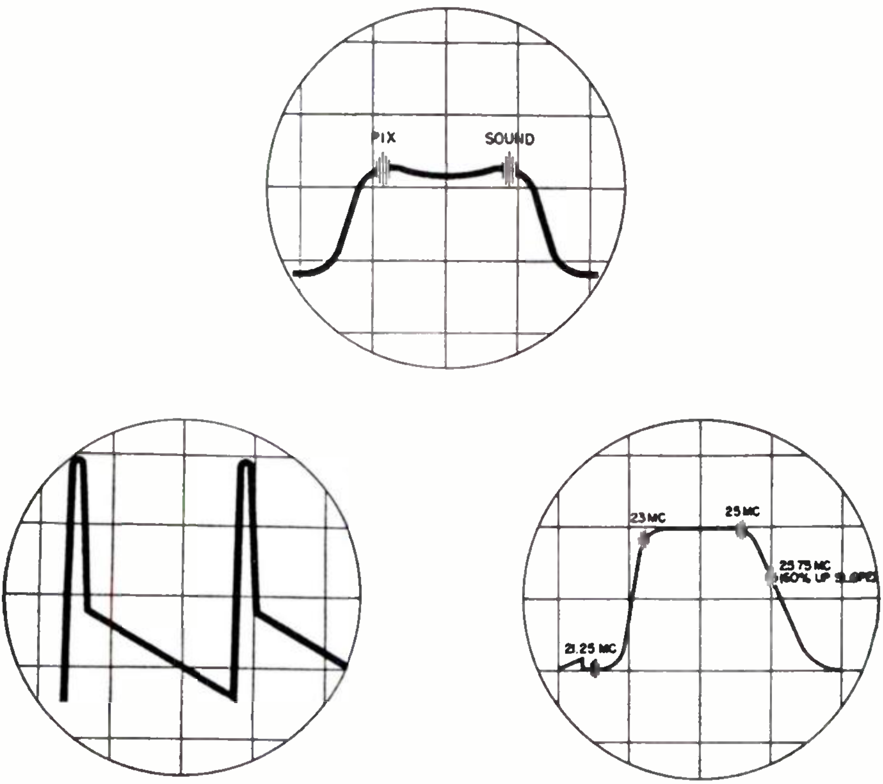


FIGURE 104 TYPICAL RESPONSE CURVES IN TELEVISION RECEIVERS

Another important characteristic of a good television alignment generator in regard to marker frequencies is the ability to provide for either the absorption type of marker or the "blip", or oscillator, type of marker. When using an external signal generator to supply markers it is impossible to obtain the absorption type markers.

Complete control of the amount of marker signal is imperative.

Another use for the self-contained marker oscillator is made possible by circuits which permit it, when used as an oscillator, to be either modulated or unmodulated at 400 cycles. This permits this oscillator to be used independent of the main FM oscillator for the accurate alignment of traps and also for the preliminary alignment of stagger-tuned intermediate stages of television receivers. In the case of such stagger-tuned receivers, the manufacturer will give definite frequencies at which each stage should be aligned. By using this marker oscillator set for these various frequencies, the various stages can be preliminarily aligned, either with a modulated or unmodulated signal as specified by the manufacturer of the receiver, using as an output indicator an AC or DC voltmeter or oscillograph.

To align the oscillator section of a television receiver to any of the twelve channels best requires some form of crystal controlled frequency as this adjustment should be done very accurately. It is distinctly advantageous to have the crystal oscillator built into the television alignment generator, thus eliminating the necessity for additional equipments to provide for crystal controlled frequencies. The crystal oscillator should have provisions so that it may be either modulated or unmodulated in accordance with the manufacturer's service instructions for the receiver under test. This crystal oscillator can also be used where desired in connection with crystals ground to any of the IF frequencies, although this is not, in general, necessary due to the high degree of accuracy of the marker oscillator.

The output impedance of a television alignment generator should be equal to or lower than the circuit into which the generator is connected.

In many alignment procedures of television receivers it is imperative that a relatively high signal voltage be available. This is due to the fact that many stages in television receivers, as a result of their wide band pass characteristics, have inherently low gain. Where a single stage is to be aligned, independent of other stages, the output of the generator must be quite high to provide a sufficient signal that the output of the stage under alignment will give satisfactory deflection on the oscillograph screen being used as an indicator. In conjunction with this high output requirement, very good attenuation or low minimum signal is also required. Television receivers, in many cases, have very high overall sensitivity and it is important to be able to attenuate the signal to such a low level that it will not overload the receiver being aligned. Such an overload could easily cause erronous alignment. Stability in a television alignment generator is also important since we are operating at relatively high frequency and making alignments by a visual method. Nothing is so disconcerting as to have frequency drift or instability.

Another important feature is that the main tuning dial of the generator be directly calibrated in terms of megacycles. It is very confusing and often very erroneous results will occur in cases where the generator has no direct calibration as all the information known about a particular band is that it covers from . . . to . . . megacycles.

Briefly summarizing the requirements of a completely equipped television service shop, these might be as follows. In addition to a good cathode ray oscillograph and television alignment generator, such other equipments as kilovoltmeters for measuring the high voltages found in the cathode ray tube supply, and a cross-hatch or grating generator such that linearity adjustments may be made on the horizontal and vertical deflecting circuits during the time that the test pattern from a TV station is not available for this purpose. Since most television manufacturers give voltage information on wave forms found in the deflecting circuits, a voltage calibrator which can be used in connection with the cathode ray oscillagraph is very helpful in determining the peak to peak voltages in these circuits.

NOTES

NOTES

NOTES

OSCILLOGRAPH CONTROL SETTINGS VS. POSITIONS

POSITION	VERTICAL	HORIZONTAL	RETURN ELIMINATOR	DEMODULATOR OR DETECTOR
1	AMP IN	60 ~	Not used.	Not used.
2	AMP IN	SWEEP CIR. OSC.	Not used.	Not used.
3	AMP OUT (NOTE 1)	60 ~	Not used.	Not used.
4	VIDEO (NOTE 2)	60 ~	Not used.	Not used.
5	AMP IN	60 ~	Not used.	Used. See NOTE 3.
6	AMP IN	60 ~	Used.	Not used.
7	AMP IN	SWEEP CIR. OSC.	Not used.	Used. See NOTE 3.
8	AMP IN	120 ~ (NOTE 4)	Not used.	Not used.
10	AMP OUT	SWEEP CIR. OSC.	Not used.	Not used.
11	VIDEO (NOTE 2)	SWEEP CIR. OSC.	Not used.	Not used.

NOTE 1—In case the oscillograph being used does not have provisions for direct connection to the vertical plates, its vertical input circuit will probably be such that the signal can be attenuated sufficiently that direct connection will not be necessary.

NOTE 2—Video or wide band vertical amplifiers should be used to obtain the signals referenced. The frequency range of the amplifier should be sufficient to pass the frequencies being observed.

NOTE 3—Some oscillographs do not have self-contained demodulator or detector circuits. If this is the case, a demodulator probe or detector circuit may be connected externally to obtain the signals referenced under this position.

NOTE 4—Some oscillographs do not have provisions for a synchronized 120 cycle horizontal sweep. If the oscillograph does not have such provisions but does have provisions for synchronizing a 120 cycle sweep from an external source, it is generally possible to obtain the proper synchronizing voltage by making a connection to the input of the full wave power supply filter of the receiver under test where a 120 cycle frequency will be available.