# RADIO & TV ALIGNMENT HANDBOOK

by WARREN J. SMITH

Everything you need to know to properly align any radio or TV receiver—including how to set up and use equipment, interpret instructions, and gauge the results.

# RADIO & TV

# ALIGNMENT

# HANDBOOK

BY WARREN J. SMITH

# RADIO & TV ALIGNMENT HANDBOOK

# PREFACE

Although most service manuals include step-by-step alignment instructions, the average service technician often hits a snag because he does not know how to use alignment equipment properly. Moreover, even though capable of following the manufacturer's instructions to the letter, he does not fully understand the exact purpose behind each step in the alignment procedure. As a result, he usually bogs down at some step along the way—or, more commonly, employs someone else to do the job and thus cuts down on his profits.

This book has been written with the assumption that the reader knows very little about alignment. At the beginning, you'll learn why alignment is needed. Following this, the material describes TV receiver response, alignment equipment needed, how to interpret response curves, and step-by-step instructions—*with the reason for each step*—on how to align TV receivers, VHF and UHF tuners, color TV receivers, and AM and FM radios. Thus, by the time you finish the book, you should not only have a good idea of why alignment is necessary, but should also be able to properly align 99% of the sets that come into your shop. Moreover, you'll understand the reasoning behind each step, so that alignment will no longer be a hit-or-miss proposition. By acquiring this background, you will then be able to apply practical alignment procedures intelligently, quickly, and profitably.

WARREN J. SMITH

March, 1961

# TABLE OF CONTENTS

## CHAPTER 1

## CHAPTER 2

Vestigial-Sideband Transmission—Receiver
Response Curves — Effect of $Q$ Factor on
Tuned-Circuit Response — Method of Reducing Circuit $Q$—Meaning of Alignment—
Effect of Misalignment in Receiver Response—Method of Compensating for Vestigial-Sideband Transmission

## CHAPTER 3

Oscilloscope — Sweep Generator — Marker
Generator—Vacuum-Tube Voltmeter—Bias
Box—Alignment Tools—Alignment Data—
Equipment Operation — Effect of Scope
Sweep Rate on Response Indication —
Method of Obtaining Horizontal Sweep in
an Oscilloscope—Method of Obtaining Vertical Sweep in an Oscilloscope—Setting Up
Alignment Equipment — Alignment Preparations—Interconnecting the Equipment—
AGC Considerations

# CHAPTER 1

# The Need

# For Alignment

There are many reasons why a receiver may need realignment. In the past, normal aging of components and mishandling were the most common; but in the present era of "do-it-yourself," it is rather commonplace to encounter receivers in which experimental adjustments have been made by the set owner. This generally makes a complete realignment job necessary, and a strong warning against such further tampering should be given. Finally, in order to achieve optimum receiver performance, it is approved service practice to completely realign a receiver after a component or tube is replaced in a tuned circuit.

Occasionally a receiver may exhibit symptoms which appear as improper alignment but actually are not. Conditions such as poor sensitivity or selectivity, distortion, and oscillation can generally be traced to defective components. On the other hand, effects of misalignment are not always immediately evident, or are confused with poor reception. In a TV receiver, the most obvious result of RF or IF misalignment is poor picture quality. Misalignment will always produce a degraded picture, displaying such defects as limited frequency response, ringing, smear, or overload in one or more amplifiers because of high response
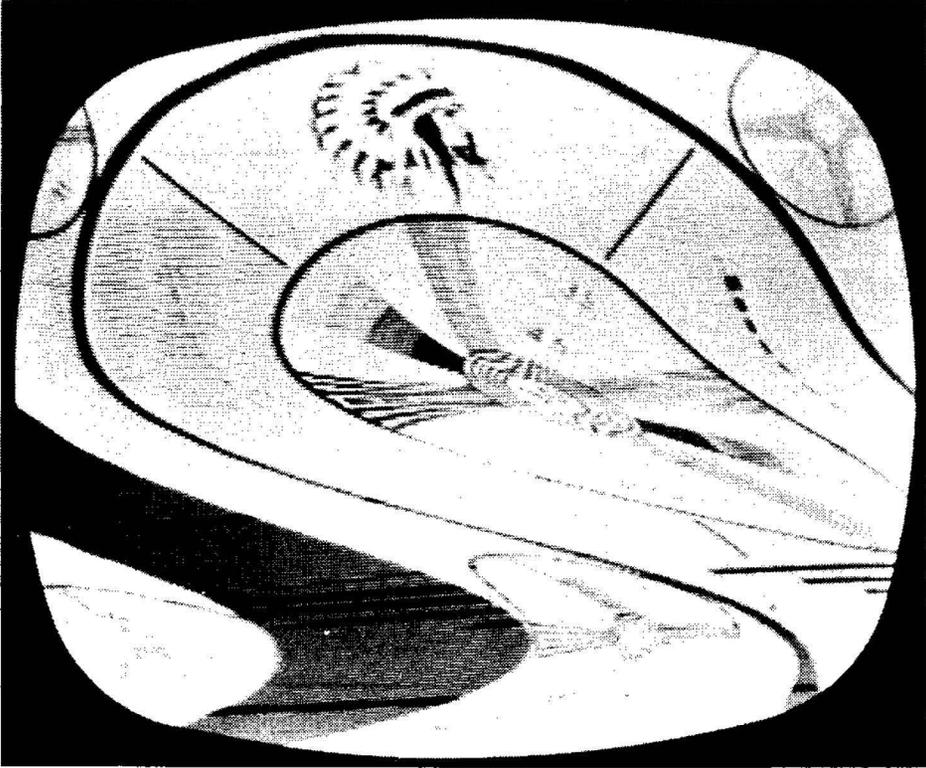
(A) Overloading.
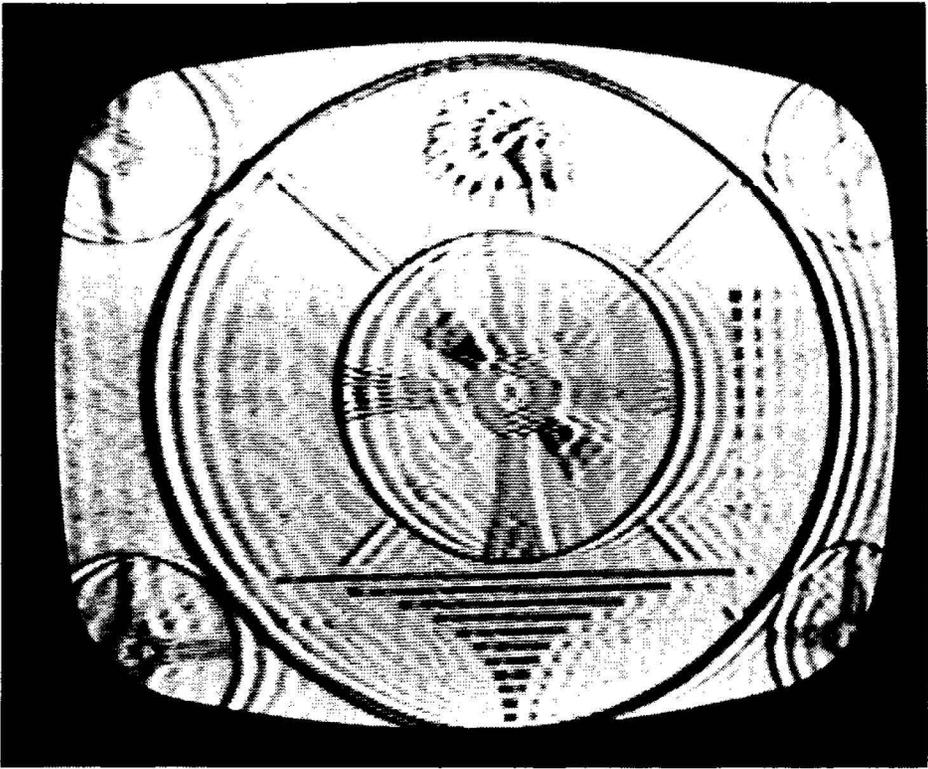


(B) Ringing.

Fig. 1-1. Various effects of
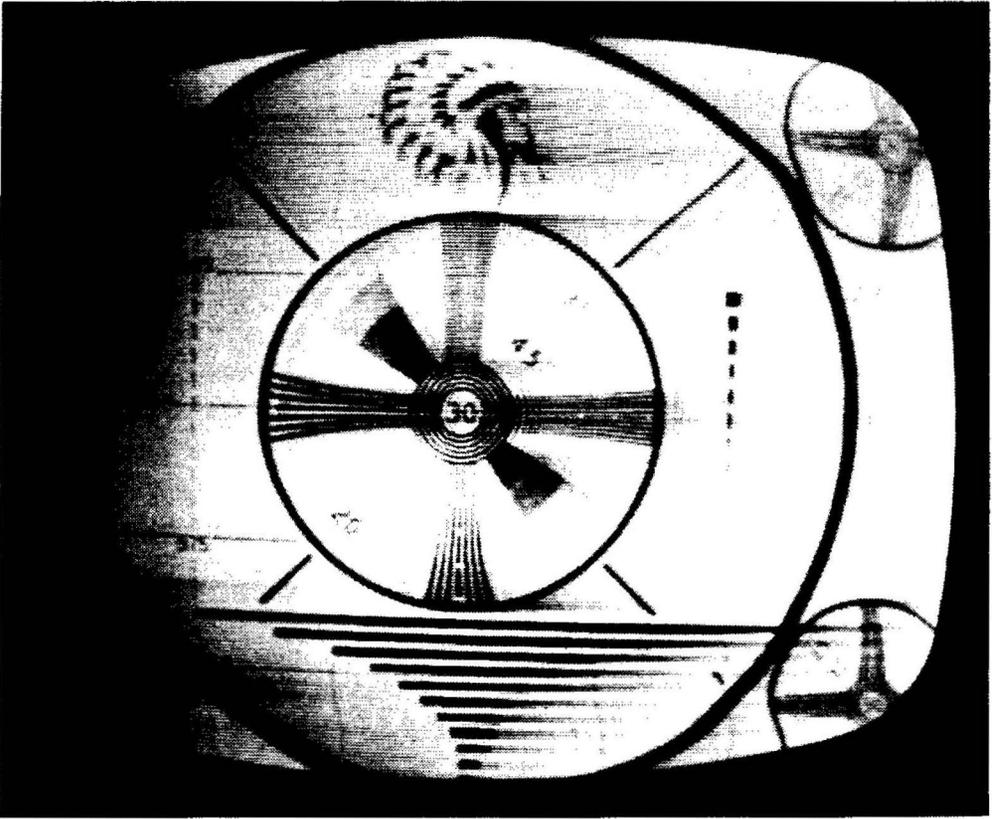
(C) Smear.
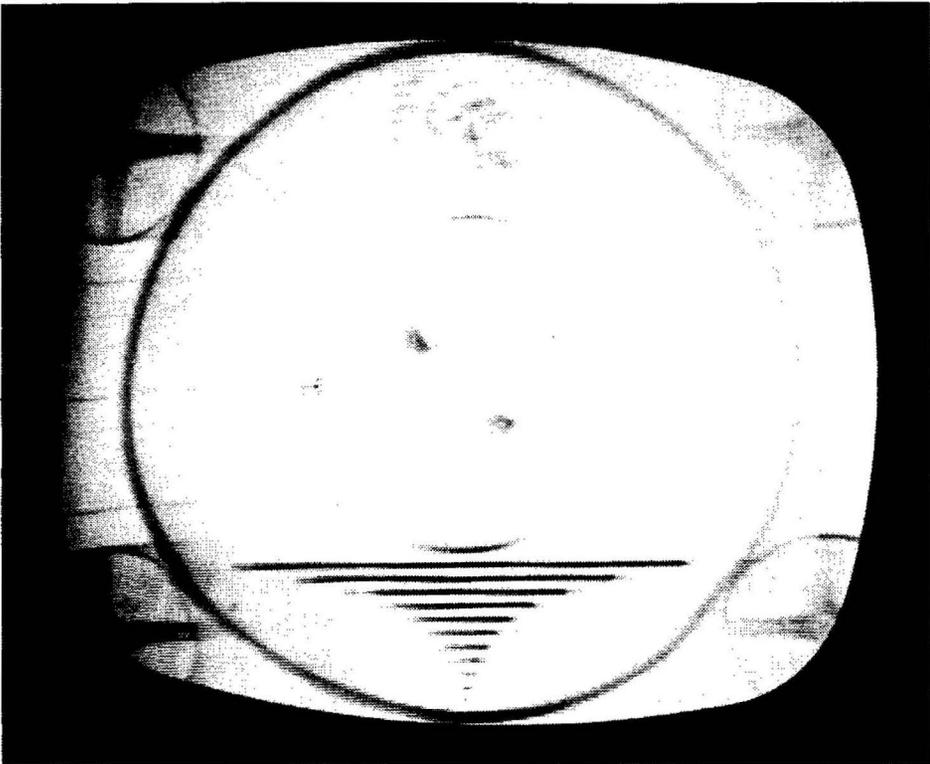


(D) Limited frequency response.

misalignment on the picture.

peaks in some part of the frequency range. Fig. 1-1 shows the results of some of these conditions. A very common indication of misalignment is multiple images; which at first glance appear as "ghosts" caused by multipath reception, but are actually the result of phase shift in the RF or IF amplifiers. Other less obvious defects which can result from misalignment are unstable sync, improper AGC action, and interference from signals which normally would not affect a properly aligned receiver. To further complicate the situation, any one of the defects mentioned may be due to conditions external to the receiver; multipath reception, for example, can produce many of them.

The resolution of the TV picture often indicates whether a receiver needs alignment, or circuit repairs are in order. As a rule, tuner and video IF alignment should be checked if any of the following conditions appear.

*Tunable ghosts*—Varying the fine-tuning control changes the spacing between images and ghosts if the set needs aligning. Ghosts caused by multipath reception maintain a fixed spacing.

*Tunable smears*—Sharp edges, particularly on the blacks, are blurred. Appears as a white smear trailing off the black edge, and can be varied by adjusting the fine-tuning control (Fig. 1-2).

*Weak-signal reception*—This condition causes regeneration in the RF or IF amplifiers and appears as horizontal smearing in the wedges of a test pattern.

*Poor low-frequency response*—Horizontal wedges in test pattern appear gray, in contrast with darker or black vertical wedges. To check video response, roll picture downward out of vertical sync. Adjust brightness and contrast controls until sync pulse appears darker than blanking bar, which should be at least as dark as any gray in the picture (Fig. 1-3). Sync pulse should remain same shade of gray as it moves downward. If conditions other than those described appear, video amplifier is probably defective or the set is misaligned.

*Poor resolution*—Appears on all received channels as loss of fine detail, or fuzziness, that cannot be corrected with fine-tuning control or focus adjustment. A test pattern provides the most accurate resolution check. Adjust operating controls for best possible picture and observe the wedges. (Fig. 1-4).

Resolution, or definition as it is sometimes called, is very important to the over-all quality of the picture since it determines the amount of individual detail that can be distinguished by the viewer. When the receiver is not properly responding to all video frequencies, either the vertical or the horizontal wedges of the test pattern appear gray while the others remain
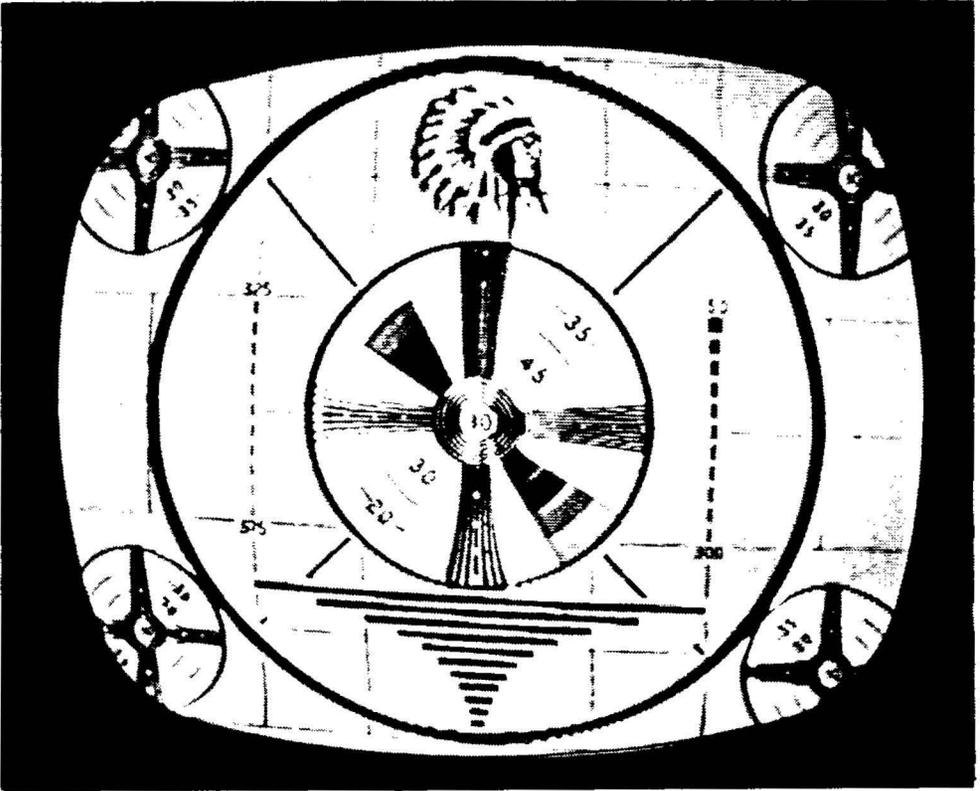
Fig. 1-2. Pattern showing white smear trailing off the black.
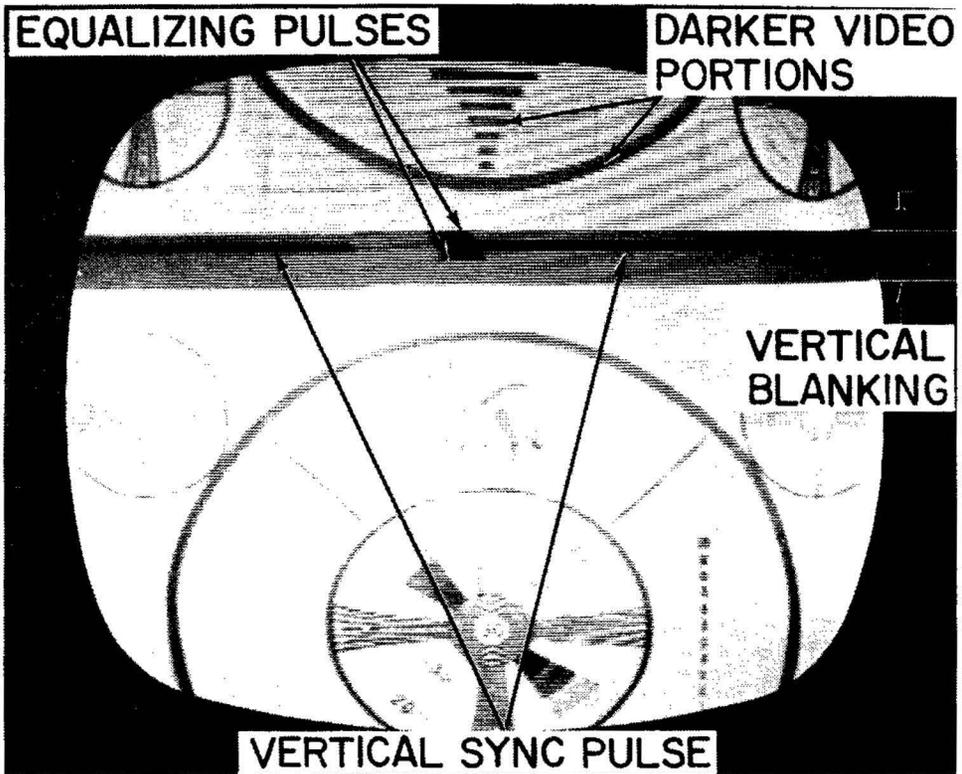


Fig. 1-3. Location of vertical-sync pulse in blanking bar.

DIAGONAL LINES FOR
INTERLACE CHECK.

CALIBRATION NUMBERS
TO READ RESOLUTION
IN LINES.

VERTICAL WEDGE TO
CHECK HORIZONTAL
RESOLUTION.

HORIZONTAL WEDGE
TO CHECK VERTICAL
RESOLUTION.

SINGLE RESOLUTION
LINES TO CHECK FOR
HIGH FREQUENCY RINGING.

SHADING BLOCKS TO
CHECK SETTING OF
BRIGHTNESS, CONTRAST,
AND AGC.

CIRCLES TO CHECK PICTURE
SIZE, LINEARITY, AND CENTERING.

BARS TO CHECK FOR
LOW-FREQUENCY PHASE SHIFT.

Fig. 1-4. A typical test pattern.

a normal black. In the case of poor high-frequency response the vertical wedge turns gray, whereas poor low-frequency response results in a gray horizontal wedge. Generally the majority of receivers exhibiting symptoms of limited frequency response are in need of RF and/or IF alignment.

Conditions which may indicate alignment of the sound section is necessary are as follows:

(a) Distortion which cannot be corrected with the fine-tuning control.

(b) Weak sound.

(c) Noise (ignition or electrical) in the output of split-carrier receivers, which cannot be nulled out with the fine-tuning control.

(d) Buzz. Normally there is a small amount of buzz, due primarily to intermodulation between the video and sound carriers. However, this condition is aggravated when the sound carrier is too high on the response curve. In a correctly aligned receiver this residual buzz can be nulled or minimized with the fine-tuning control. Accurate alignment of the sound IF and detector is important, but buzz can often be eliminated by touching up the sound detector and sound take-off coils slightly.

A few words of caution are appropriate here. Do not attempt random experimental alignment adjustments. This practice is often resorted to by the more venturesome service technicians of limited experience. Such unorthodox adjustments could be disasterous, to the point where the receiver would have to be completely realigned at considerable cost in lost time.

CHAPTER 2

# Response of

# TV Receivers

In order to interpret the various presentations shown by an oscilloscope during visual alignment, it is imperative that you have a thorough understanding of modulation, sidebands, and response curves.

The process of varying the transmitter carrier wave is known as modulation. The information necessary to produce a picture or sound may be impressed on the RF carrier wave in any one of several ways, the most common being amplitude modulation (AM). This is the method used in transmitting the TV picture (video) information. The amplitude of the RF carrier is varied in step with the variations in the information being transmitted. Fig. 2-1 illustrates this process. The RF carrier wave (A) is modulated with the sine-wave signal (B), and the resulting amplitude-modulated signal appears as shown in (C). During the amplitude-modulation process, two changes occur. First, the height (amplitude) of each cycle of the RF carrier wave is changed; and secondly, new RF frequencies are generated on each side of the original RF carrier. If we draw an imaginary line along the peaks of the modulated RF carrier wave, we will have two modulation envelopes as in Fig. 2-1C, one above the zero axis and the other below. The new RF fre-

(A) Unmodulated RF carrier.



(B) Modulating sine-wave signal.



RF CARRIER
WAVEFORM NOW VARIES
IN AMPLITUDE

LINES DRAWN THROUGH PEAKS SHOW
AMPLITUDE VARIATIONS FOLLOWING
WAVEFORM OF MODULATING SIGNAL

(C) Amplitude-modulated carrier.
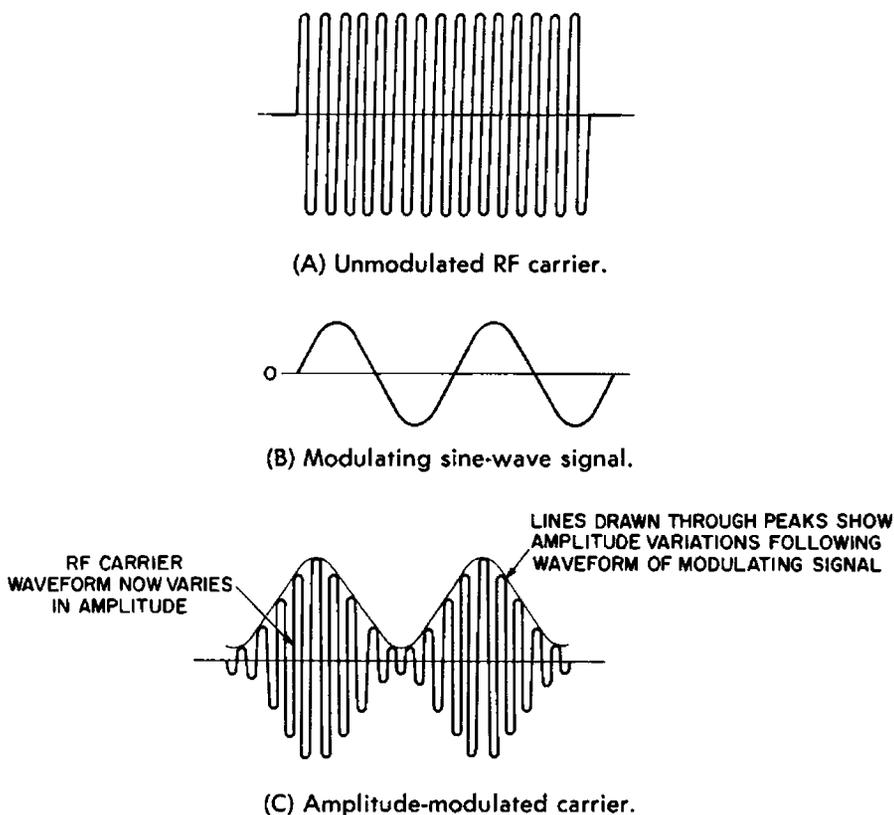
Fig. 2-1. Amplitude-modulation process.

quencies, called sidebands, extend above and below the carrier frequency by an amount equal to the sum and difference of the modulating frequency. This can be better understood by referring to Fig. 2-2A. The frequency of the RF carrier in this case is 10 mc, and the modulating signal is a 10-kc sine wave. The modulated RF carrier still has a frequency of 10 mc, but each cycle is varying at a rate equal to the frequency of the 10-kc modulating signal. This produces the two new side frequencies:

$$10 \text{ mc} + 10 \text{ kc} = 10.01 \text{ mc} \quad \text{(upper sideband)}$$
$$10 \text{ mc} - 10 \text{ kc} = \phantom{0}9.99 \text{ mc} \quad \text{(lower sideband)}$$

Therefore, the complete modulated signal consists of the 10-mc RF carrier plus the upper and lower sidebands of 10.01 and 9.99 mc respectively. These are the only frequencies present when the carrier is modulated by a fixed-frequency sine wave. All the 10-kc sine-wave information is contained in each sideband (Fig. 2-2B). The amplitude of a sideband cannot be greater than one-half the amplitude of the carrier. Assuming a carrier wave is modulated 100 per cent, each sideband will have an amplitude of exactly 50 per cent. In other words, one-half the total energy of the modulating signal is present in

either sideband, but each contains all the modulation information. None of the modulating signal appears in the carrier signal alone. If an AM receiver with an extremely sharp bandpass (Fig. 2-3A) were tuned to exactly 10 mc, sidebands could not get through to be reproduced. The receiver bandpass must



(A) Location of sidebands.



(B) Modulating information.
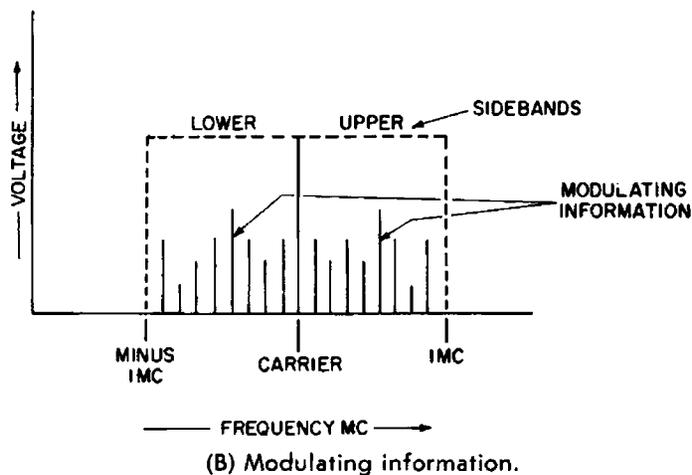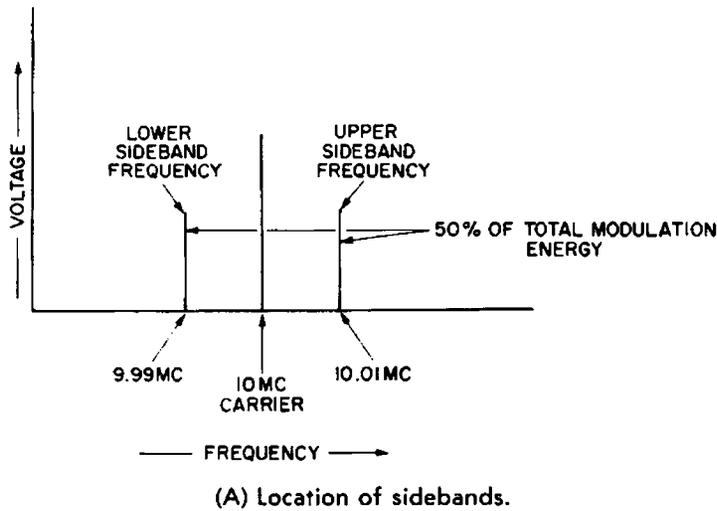
Fig. 2-2. Sidebands produced during modulation process.

be wider, as in Fig. 2-3B, to accommodate at least one sideband if successful reception is to be accomplished. Notice that only one sideband is required for reception, and that it may be either the upper or lower.

When the modulating signal is a complex waveform as in music or video signals, a great number of frequencies are encountered, ranging from about 30 to 10,000 cycles or higher for the audio signals and 30 cycles to 4 megacycles in the video range. Each of these particular frequencies produces two side frequencies during the modulation process, so there is a large band of various frequencies on either side of the RF carrier.

EXCESSIVELY
SHARP RECEIVER
RESPONSE CURVE

9.99 MC
LOWER SIDEBAND

10.1 MC
UPPER SIDEBAND

10 MC
CARRIER

(A) Sharp response.

IDEAL
RESPONSE
CURVE

9.99 MC
LOWER SIDEBAND

10.1 MC
UPPER SIDEBAND

10 MC
CARRIER

(B) Ideal response curve.
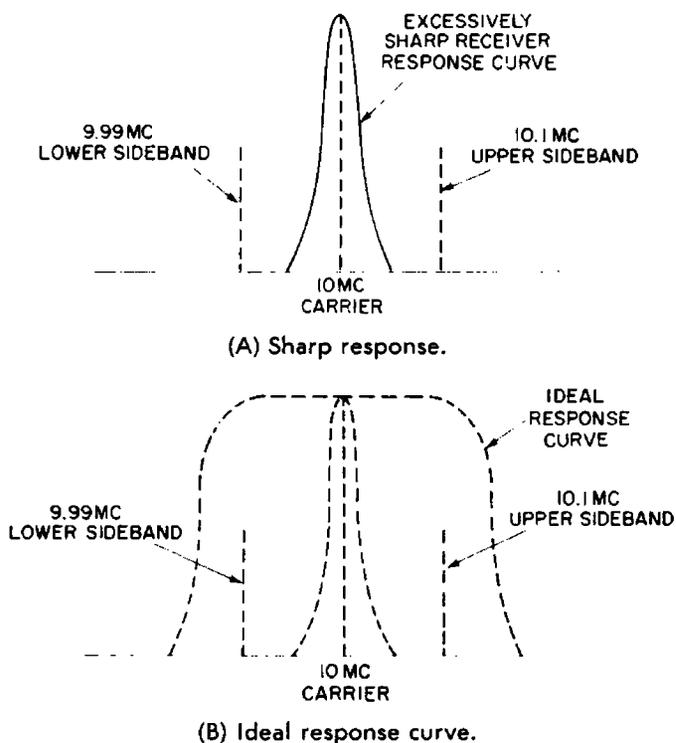
Fig. 2-3. Effect of receiver response on sideband
reception.

Fig. 2-2B illustrates the result when the carrier wave is modulated with a complex waveform extending from 0 to 1 mc.

Since each sideband carries all the information and half the total modulation energy, an AM receiver need respond to only one sideband for complete reproduction. (Because only one-half the bandwidth of double-band transmission is required, it is possible to filter out one sideband before transmission and thus allow more transmitters to operate without interference in a given frequency range; hence, single-sideband.)

## VESTIGIAL-SIDEBAND TRANSMISSION

From the foregoing discussion it was determined that the bandwidth of an RF carrier plus both sidebands is two times the highest modulating frequency. In the composite TV video signal, the highest frequency is approximately 4 mc, which would seem to dictate a bandwidth of 8 mc for the video signal alone. However, the bandwidth allotted to each television channel is only 6 mc, and this includes 50 kc for the frequency-modulated (FM) audio signal. Single-sideband transmission of the video is prohibited by practical difficulties: If the entire lower sideband were suppressed, serious phase distortion would result. So only frequencies more than 1.25 mc below the car-

rier are filtered out; the entire upper sideband to 4 mc is transmitted, along with the remaining portion of the lower sideband. This method, termed vestigial-sideband transmission, is a combination of single- and double-sideband transmission. For video frequencies to 1.25 mc it is double-sideband; but for those in the 1.25- to 4-mc range, it is single-sideband. This is illustrated in Fig. 2-4. Because the highest frequency which could pass in
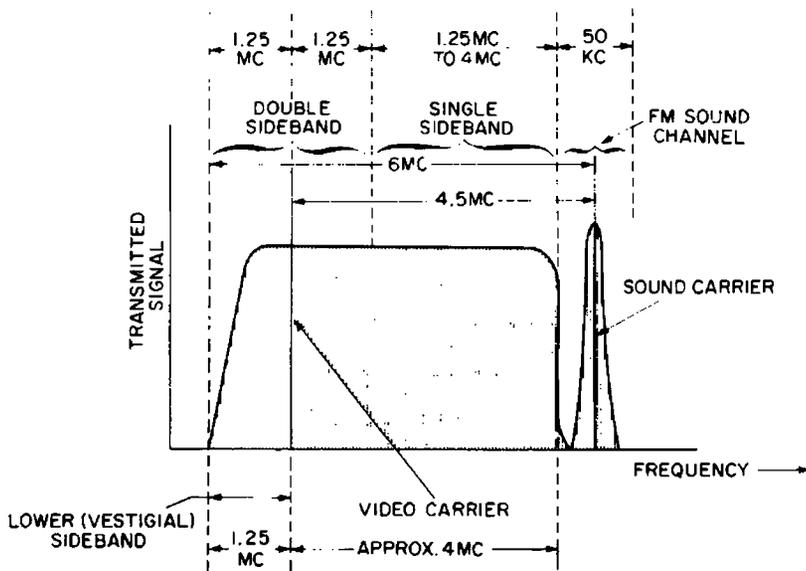
Fig. 2-4. Vestigial-sideband signal.

a 6-mc channel is 3 mc, double-sideband transmission of the complete video-modulating signal would result in loss of horizontal detail.

## RECEIVER RESPONSE CURVES

The following discussion on receiver response curves is intended to show graphically the relative amplitude with which signals of different frequencies pass through tuned circuits.

Assume we have a parallel-resonant circuit as in Fig. 2-5A, the resonant frequency of which is determined by the values of L and C. Maximum impedance is offered to signals at resonance, permitting the signal to build up to a relatively large voltage. The amount of this voltage depends primarily on how close to resonance the signal is, and also on the Q of the tuned circuit. When the Q is high, the tuned circuit will be sharply resonant, and the signal must be very close to resonance to develop a voltage of appreciable magnitude. Suppose the tuned circuit has a resonant frequency of 10 mc and a very high Q. If signals of equal amplitude but different frequencies around
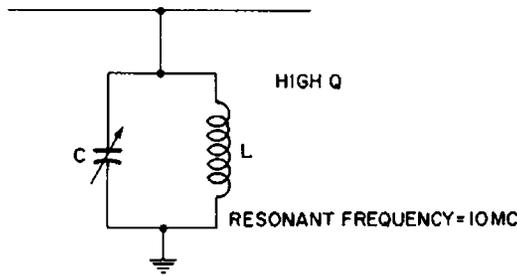
(A) Parallel-resonant circuit.
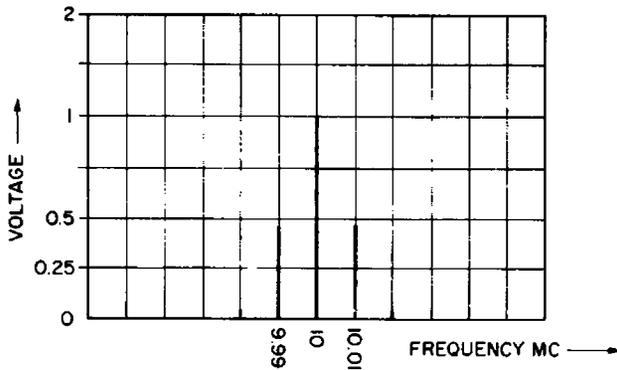


(B) Graphic representation of voltage versus frequency.
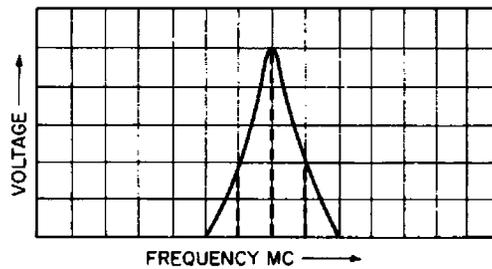


(C) Response curve after plotting.

Fig. 2-5. Effect of "Q" factor on tuned-circuit response.

10 mc are injected into the circuit and the resulting voltages measured, a graph can be plotted showing the relative ease or difficulty with which these signals will pass through. Fig. 2-5B illustrates this point. A test signal of exactly 10 mc produces an output of 1 volt, and so a vertical line representing 1 volt is drawn on the chart. The process is repeated at 9.99 and 10.01 mc, and the resulting voltage reading also plotted on the chart. At some frequency both above and below resonance, the output voltage will drop to zero. A small mark corresponding to these frequencies is placed along the base line. After all the lines representing the voltage developed by different frequencies have been charted and an outline drawn through their tips, we will have a picture of the circuit response. The completed curve, shown in Fig. 2-5C, is the response required of a receiver

intended to reproduce the modulated signal of Fig. 2-2. Note that the distance from the base line to any point on the curve is the relative amplitude a signal of that frequency should develop in the circuit.

A tuned circuit of extremely high $Q$ has little value other than as a trap circuit. With its sharp bandpass, it is not capable of passing signals carrying information in the sidebands. The circuit $Q$ can be reduced, or the circuit broadbanded, by in-



LOW Q
RESONANT FREQUENCY STILL
10 MC

RESISTANCE ADDED TO
REDUCE Q OF CIRCUIT
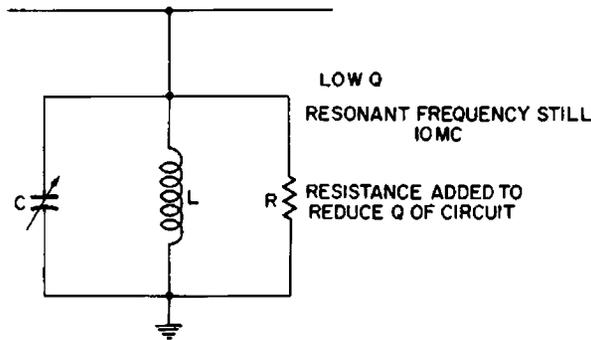
(A) Resistance added in parallel with tuned circuit.
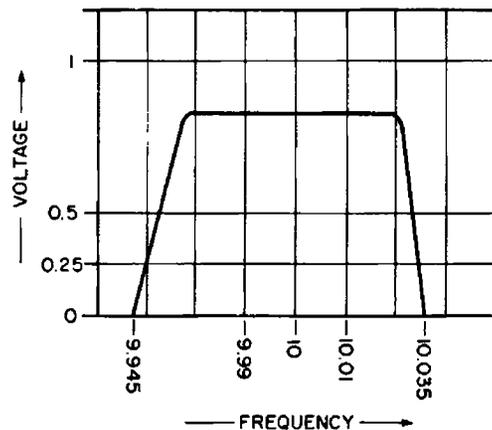


(B) Result of reducing circuit "Q".

Fig. 2-6. Method of reducing circuit "Q".

troducing resistance (R) as illustrated in Fig. 2-6A. The sharpness of the response decreases if the circuit is loaded by a shunt resistor, rectifier, absorption trap, or any other device which takes power from it. If the response of this tuned circuit is plotted on a graph as before, we will find that many more frequencies are able to develop a greater voltage and that the response curve has become essentially flat-topped, indicating response to a much wider band of frequencies.

This series of illustrations demonstrates two basic facts of prime importance. First, the response curve visually shows the

technician how well signals of different frequencies within a band are passed by a particular tuned circuit or series of circuits. Secondly, to correctly reproduce all the modulation information present on an RF carrier, the response of a receiver must be sufficiently broad to accept at least the carrier and one complete sideband. In other words, the response must be adjusted to pass the range of frequencies contained in the received signal, whether the modulation be audio or video.

From the foregoing it can be seen that in an AM receiver designed to receive stations transmitting double sidebands totaling 15 kc wide, the circuits must be tuned broadly enough
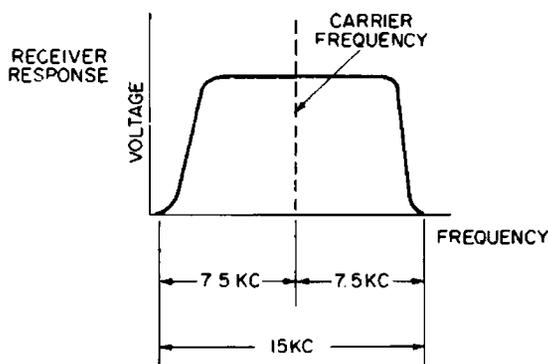


Fig. 2-7. Ideal receiver response curve.

to accept all the frequencies in the full 7.5-kc bandwidth. In addition, all the tuned circuits must be adjusted to the same 7.5 kc, as we shall soon see. If the tuned circuits have broad response and the receiver is properly aligned, all the audio modulating frequencies from 0 to 7,500 cps will develop the same amount of voltage at any given point in the passband, and any signals above 7,500 cps will be attenuated by a sharp drop in response, as shown in Fig. 2-7. AM radio receivers designed for broadcast-band reception have tuned circuits which accept both sidebands. The voltage at the output of the tuned circuits should theoretically be twice that attained with single-sideband signals, because each sideband contains 50 per cent of the modulation energy. This does not hold true, however, since broadening the response of an amplifier circuit reduces the over-all gain and thus offsets any increase in total signal voltage at the output.

Inadequate bandwidth results in a loss of modulation information. For example, the response curve of a receiver in which the tuned circuits are misaligned and respond only to 2,800 cps while attenuating the remaining modulation frequencies would mean the higher audio frequencies would not be reproduced,

and as a result, the sound output from the speaker would be distorted.

For reception of most broadcast signals, a bandpass of 7.5 kc on either side of the carrier is sufficient, since most stations do not transmit program material having higher sideband components. However, some stations are licensed to transmit up to 10 kc or more for high-fidelity performance. Hence, a tuner or receiver designed for high-fidelity reception will employ a tuned circuit of broader-than-average bandpass.

## MEANING OF ALIGNMENT

Alignment is the process of adjusting the tuned RF and IF circuits of a receiver to (1) make the response broad enough to accept all necessary sidebands of the signal, and (2) to adjust all tuned circuits to the correct band of frequencies.
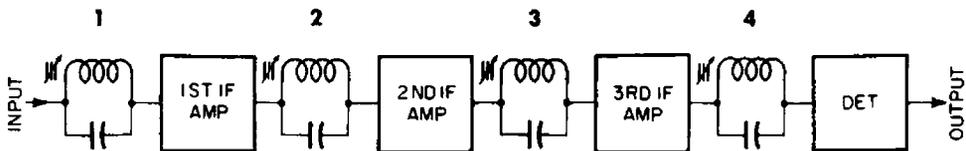


Fig. 2-8. Typical cascaded IF strip with four tuned circuits.

A cascaded amplifier circuit consisting of three stages and four tuned circuits is illustrated in Fig. 2-8. A signal must pass through each stage in turn, so misalignment in any one of the stages could distort the signal appearing at the detector. Fig. 2-9 illustrates some of the conditions which prevail when the different stages are misaligned. In Fig. 2-9A all tuned circuits are properly aligned and each stage responds to the same 7.5-kc band. In Fig. 2-9B the last two tuned circuits are misaligned— the third is tuned too low and the fourth too high. The shaded portion of the curve shows the range of frequencies cut off. If a sweep generator is connected to the input and an oscilloscope to the detector output, a waveshape similar to the unshaded portion of (B) will be seen. As the fourth tuned circuit is re-adjusted toward the proper frequency, the right side of the waveform will move to the left. Upon reaching the proper position relative to the rest of the curve, the waveshape on the scope will appear as in Fig. 2-9C. Adjusting the third tuned circuit in Fig. 2-9B will move the left side of the waveform to the right and produce the desired over-all response curve. In Fig. 2-9C only one stage is misaligned, but the result is almost as pronounced as in B since all frequencies above 3,500 cps are cut off. By judiciously adjusting the tuned circuit, we can
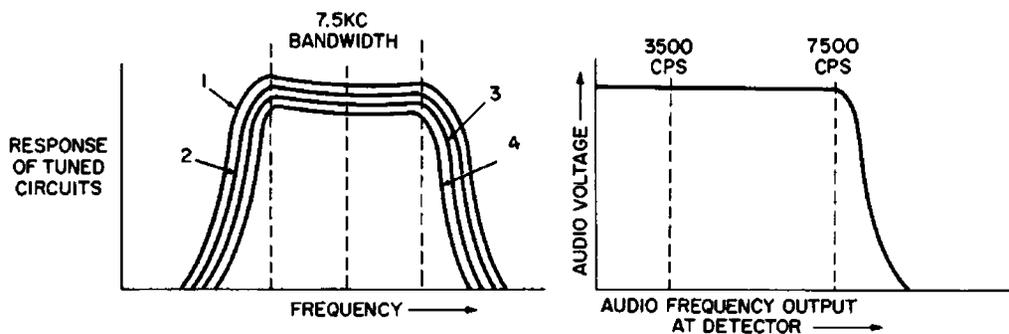
(A) All tuned circuits properly aligned.
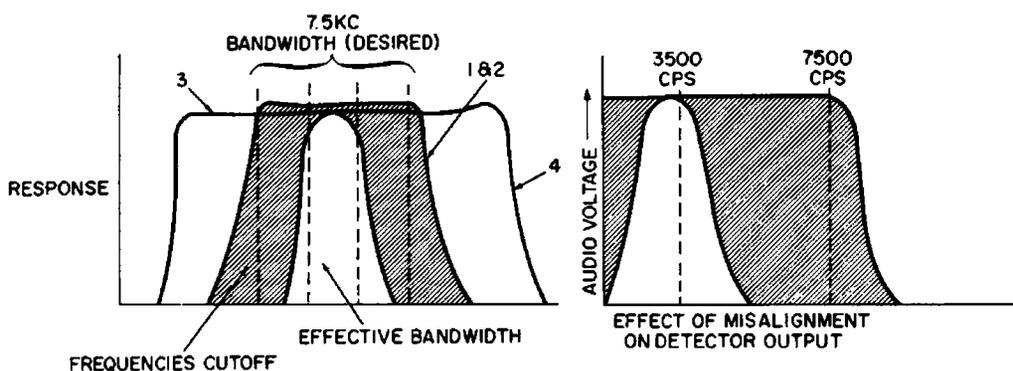
(B) Tuned circuits 3 and 4 misaligned.
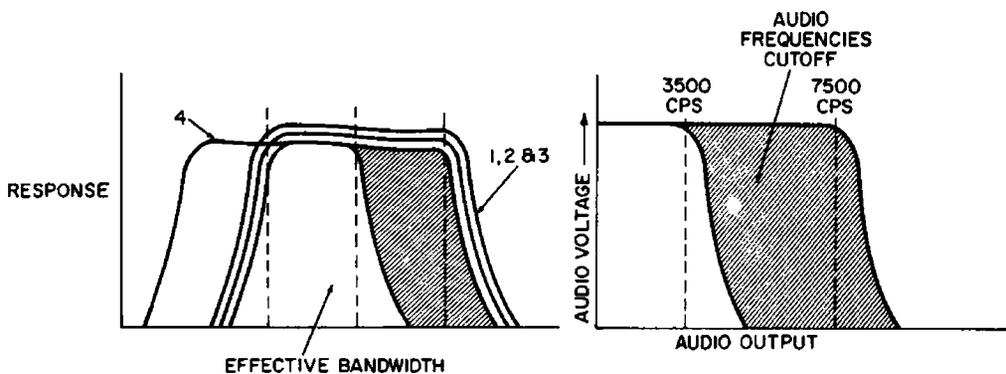
(C) Tuned circuit 4 misaligned.

Fig. 2-9. Effect of misalignment on receiver response.

move the response curve up in frequency until it coincides with the others as in A.

When readjusting tuned circuits it is very easy to move a curve too far and overshoot the desired position. For this reason it is very important to keep a close check on the frequency of the waveforms (as well as their shape and amplitude). As in the illustrations, the base line on the scope represents frequency. When the frequencies the sweep generator is producing are known, it is possible to estimate the frequency of any point on the base line with acceptable accuracy. With the addi-

tion of a marker generator these frequencies can be pinpointed more accurately.

It has been shown that the tuned circuits of a receiver must respond to a certain frequency range which depends on the modulating frequencies of the carrier. All the information transmitted is reproduced only when all these modulating frequencies develop equivalent amplitudes in the receiver.
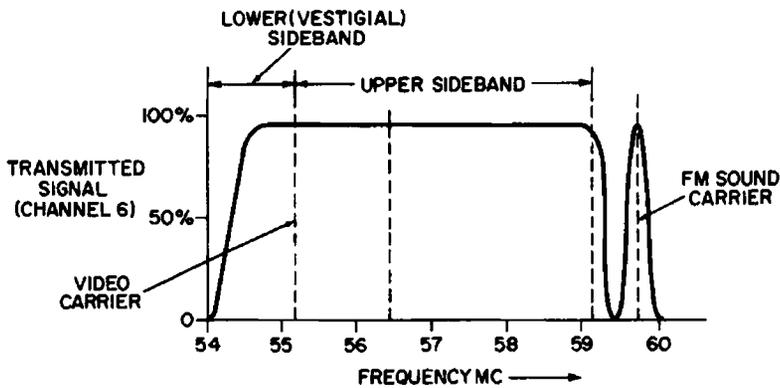


(A) Channel-6 transmitted signal.
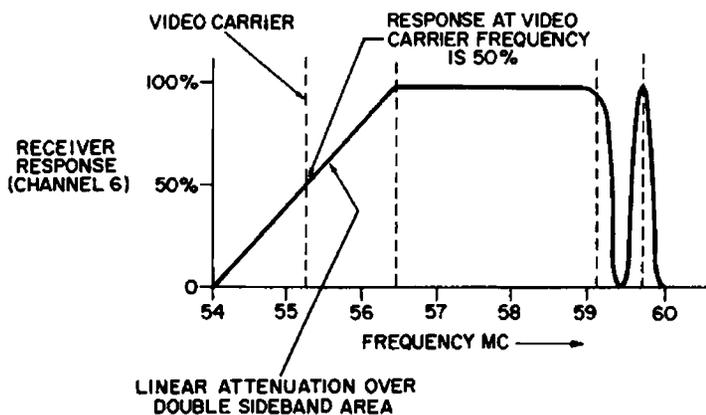
(B) Channel-6 receiver response.
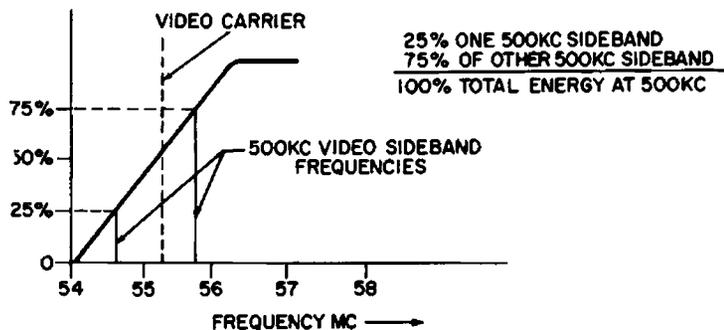
(C) Energy distribution at receiver.

Fig. 2-10. Method of compensating for vestigial-sideband transmission.

Examine the detailed TV transmitter output curve in Fig. 2-10A. As mentioned previously, eliminating one sideband completely would result in detrimental phase distortion, therefore, vestigial-sideband transmission is used. The complete upper sideband and a small portion of the lower sideband are transmitted; the remainder of the lower sideband is suppressed at the transmitter. Since each sideband in an AM signal contains 50 per cent of the modulation energy, the lower video frequencies have 100 per cent modulation; but the higher frequencies have only 50 per cent. Thus the lower frequencies in effect are boosted considerably. In Fig. 2-10B we have the over-all response curve of a receiver tuned to Channel 6. The tuned circuits are arranged so that the response is nearly linear on the video-carrier side of the curve. Therefore, in a properly aligned receiver the video-carrier frequency develops only half the signal voltage developed by the higher video frequencies. Because the double-sideband, or low-frequency, range of the transmitted signal has twice as much modulation energy as the rest of the signal, the attenuation of this range by the receiver corrects for differences in sideband strength introduced at the transmitter. This point is clarified by Fig. 2-10C. Here we are considering a single video frequency of 500 kc (0.5 mc), which lies in the double-sideband area of the response curve. Two such side frequencies are transmitted, one 500 kc above the carrier and the other 500 kc below. In the receiver, the 500-kc signal above the carrier develops approximately 75 per cent of the voltage of the signals above 1.25 mc, and the 500-kc signal below the carrier develops only 25 per cent. Together, the two side frequencies develop the total voltage of 100 per cent. In other words, the total signal voltage at this frequency is the same as the voltage developed by any video frequency in the single-sideband region.

Fig. 2-10B illustrates the ideal over-all receiver response curve, showing the response from antenna to detector. Its shape compensates for the distortion introduced by vestigial-sideband transmission. The shape of a receiver response curve is determined primarily by the IF amplifiers. Fig. 2-11A illustrates the receiver RF response. It obviously is not the same as for the IF systems in B and C; the shape of the IF response curve is the same as the over-all curve of the receiver.

To minimize interference from adjacent television channels, tuned traps are inserted in the IF amplifiers. Being tuned circuits, these traps affect the IF response and thus the over-all IF response curve. The RF response is of course unaffected by traps in the IF's.

Sound signals are handled by the IF amplifiers in intercarrier receivers, and so the shapes of both the RF and the IF response curves differ slightly from those of the split-carrier receiver. This can be seen by comparing Figs. 2-11B and C. In the split-carrier receiver curve, there is no response at the sound-carrier frequency, whereas in the intercarrier receiver the response extends to appoximately 5 per cent above zero.



(A) RF and converter response.



(B) IF-amplifier response in a split-carrier receiver.



(C) IF-amplifier response in an intercarrier receiver.
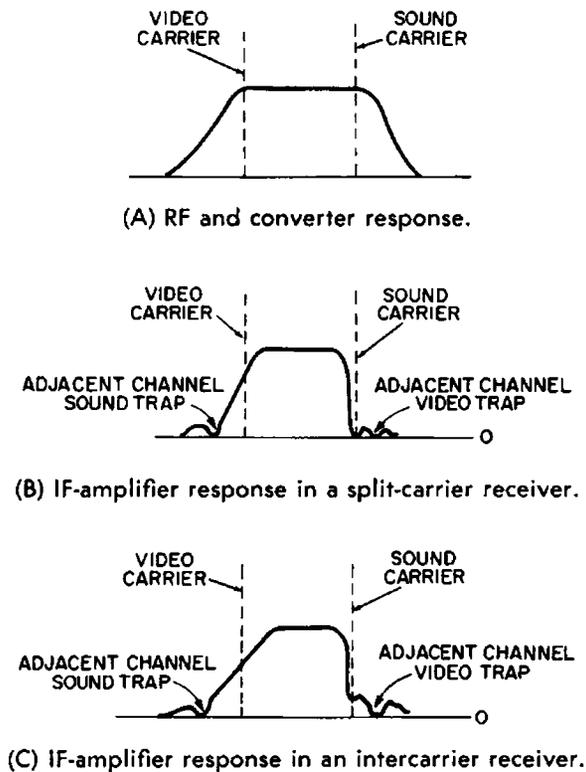
Fig. 2-11. Typical receiver response curves.

In Fig. 2-12A you will note that the RF frequency increases from the video carrier to the sound carrier, and that the IF frequency increases from the sound carrier to the video carrier. This is always true whenever the local oscillator operates above the frequency of the received signal. Video response is shown in Fig. 2-12C; zero corresponds to the video carrier. The sound carrier is located in the area of the high video frequencies in the RF and IF response curves. The over-all characteristic curve shown in Fig. 2-12D always has this shape, regardless of calibration. If calibrated as RF or video frequencies, the frequency increases from video carrier to sound carrier; if calibrated in IF frequencies, the increase is from sound carrier to video carrier.

Certain bandwidths are required in a receiver to pass all the frequencies in the transmitted signals. First, the entire signal

VIDEO
CARRIER

SOUND
CARRIER

FREQUENCY INCREASE

83.25
MC

87.75
MC

(A) RF front-end response.

VIDEO
CARRIER

SOUND
CARRIER

FREQUENCY INCREASE

45.75
MC

42.75
MC

(B) IF-amplifier response.

VIDEO
CARRIER

SOUND
CARRIER

FREQUENCY INCREASE

0

4 MC

(C) Video-amplifier response.

VIDEO
CARRIER

SOUND
CARRIER

FREQUENCY INCREASE

83.25
MC

87.75
MC
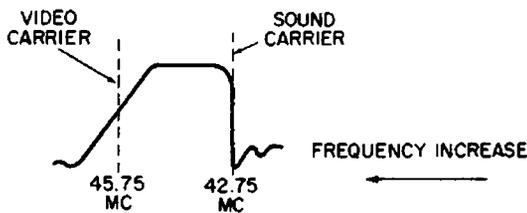
(D) Over-all response.

Fig. 2-12. Direction of frequency increase.

must pass unaltered through the RF amplifier; so it must have a bandwidth equal to the transmitted signal, or 6 mc.

The IF bandwidth required depends on the receiver system being used. In a split-carrier arrangement the sound signal may pass through a stage or two of video IF before being taken off. In such a case, the IF"s which pass both the video and the sound signals must have a larger bandwidth than IF"s which pass video alone. As a rule a video-IF amplifier should have a bandwidth sufficient to cover all frequencies in the video region. In split-carrier receivers this would be 4 mc.

In intercarrier receivers the entire video plus sound signals pass through all IF stages, and for this reason the IF"s must

have a very large bandwidth. It is common design practice to make the bandwidth of intercarrier receivers at least equal to the frequency separation between video and sound carriers, or 4.5 mc.

The total width of the sound signal is only about 50 kc, so the sound-IF bandwidth need not be as great as the video IF's. In split-carrier receivers the bandwidth may be comparatively broad, however, to compensate for local-oscillator drift, which may cut off or distort the sound signal. The actual bandwidth varies from one receiver to another, but we can safely assume it is in the range of 150 to 250 kc. Local-oscillator drift is of no consequence in intercarrier receivers because the IF is determined by the separation between carriers, and this is held within ±.004 at the transmitter. However, maintaining a broad bandwidth is desirable since it provides a linear operating slope at the detector. As a rule, the sound-IF bandwidth is about 200 kc. Of course the IF bandwidths described are simply optimum—some receivers may use wider or narrower ones.

# Alignment Equipment and Its Application

Certain test equipment is required before you can satisfactorily align TV and radio receivers. In addition, each piece of equipment must have certain characteristics if it is to perform adequately. The equipment and some of the basic requirements are as follows:

## OSCILLOSCOPE

The characteristics required in a scope are not particularly critical. The vertical-deflection amplifier should, however, have good low-frequency response down to 10 cps or less, because the input signal from the sweep generator is usually 60 cps. In addition the vertical amplifier should have reasonable sensitivity, on the order of .05 volt peak-to-peak per inch (.018 volt rms) to provide usable deflection from low-voltage signal sources. The screen should be large enough for comfortable viewing and easy identification of markers; 5 inches is generally considered ideal.

A matching RF probe is a desirable scope accessory. The probe is not needed for tuner or IF alignment, where the scope input signal is taken from the mixer or detector. However, it

is required when viewing the response of one or two IF stages, and also for observing the video-amplifier response during the sweep-signal method.

## SWEEP GENERATOR

The sweep generator should have an output voltage of at least 10,000 to 20,000 microvolts over its entire range. It must have a continuous attenuator to control output amplitude, and a phase control if the scope is not so equipped. A sweep-width control with a controllable range of a few hundred kilocycles to approximately 15 megacycles is required. The smaller sweep width is useful in checking sound-IF response and alignment.

Normally two different test cables are used with a sweep generator. A single-ended output cable is used primarily for TV and FM tuners employing coaxial line inputs and for IF-amplifier signal injection. The other cable, designed for a balanced output, is used to feed the signal into a balanced input circuit.

Most generators have an output impedance of 30 to 300 ohms. To maintain proper output stability, the test cable must be terminated correctly. This is important both to stable generator operation and to the receiver under test. The low output impedance of the generator must be matched to the high input impedance encountered in practically all receiver circuits. The antenna terminal impedance of TV and FM receivers is 72 or 300 ohms, whereas the input impedance of grid circuits is on the order of thousands of ohms. Three common methods of coupling unlike impedances are illustrated in Fig. 3-1. Where a very loose coupling is desired, the methods shown in Figs. 3-1A or B are used. Most receiver manufacturers recommend A because it is simpler and does not disturb critical circuits. The tube shield is raised slightly and the generator lead connected to it. Capacitance between the tube elements and shield provides the coupling. The method illustrated in B is similar, but uses a few turns of insulated wire around the tube itself, rather than direct connection to a tube shield. (It is actually a combination of capacitive and inductive coupling.) The third method, illustrated in Fig. 3-1C, employs a small capacitor in series with the generator cable. The capacitor should be small in order to maintain a relatively high impedance at the test frequency, although any value from 5 to 100 mmf is generally adequate. Sometimes sufficient coupling can be accomplished by simply connecting the generator cable to an insulated component or lead in the circuit.

34

Three important factors concerning generators and test cables must be adhered to: (1) the generator must be properly loaded so that its output remains stable, (2) the output cable must be properly terminated, and (3) the generator output cable must be coupled to the circuit under test in such a manner that their unlike impedances are not unduly disturbed.
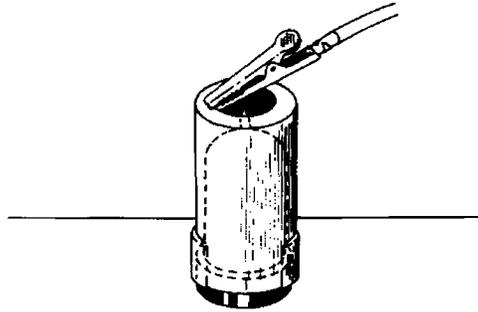


(A) To a floating tube shield.
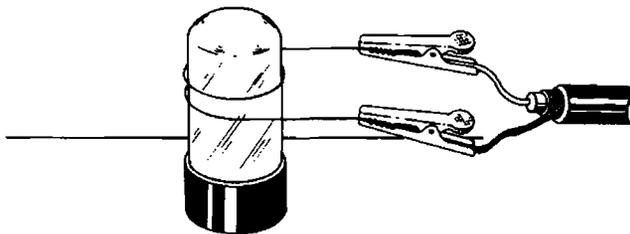


(B) Inductive coupling through a wire loop around tube.
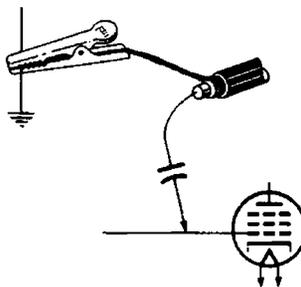


(C) Through a series isolating capacitor.

**Fig. 3-1. Methods of coupling unlike impedances.**

## MARKER GENERATOR

A marker generator is simply an RF signal source used to "mark" various frequencies on the response curve. Its requirements are not critical, other than accuracy and proper frequency range. Some additional features, such as provision for

external crystal control, are desirable but not absolutely essential. Many commercial sweep generators have built-in absorption-type markers or marker generators, or both.

## VACUUM-TUBE VOLTMETER

Any reasonably accurate voltmeter can be used for alignment purposes, but a VTVM is more desirable. In addition to the decreased circuit loading it produces, a VTVM usually has a center-zero arrangement, which is useful in alignment work.

## BIAS BOX

In some receivers it is practically impossible to obtain the proper response curve unless the AGC voltages are maintained at a fixed level during alignment. This is so because the sweep-generator signals do not develop normal AGC voltages. The bias voltages required will vary from receiver to receiver (and sometimes from one circuit to another.) Construction of a bias box is relatively simple; Fig. 3-2A illustrates one type recommended by receiver manufacturers. Since the current drain is low, a 9-volt mercury battery can be employed, as shown in Fig. 3-2B. A switch disconnects the battery from the output control when not in use, and the 1,000-ohm resistor limits current drain in event of a short in the leads or AGC circuit.

## ALIGNMENT TOOLS

You will need a wide variety of special alignment tools for the various adjustments in receivers. Insulated tools with metal tips or blades are preferred. Keep in mind that you must have the correct tool; otherwise, breakage may result and make further adjustment difficult or impossible.

## ALIGNMENT DATA

Up to this point, only the equipment essential for alignment or receiver response checking has been discussed. However, before undertaking the actual alignment it is important that you have on hand all available data on the receiver to be aligned. This data can be obtained directly from the manufacturer or from a publisher of servicing information. Study this data carefully before making any adjustments. It is much easier to first determine in your mind where the various adjustments are to be made, than to search them out after the alignment
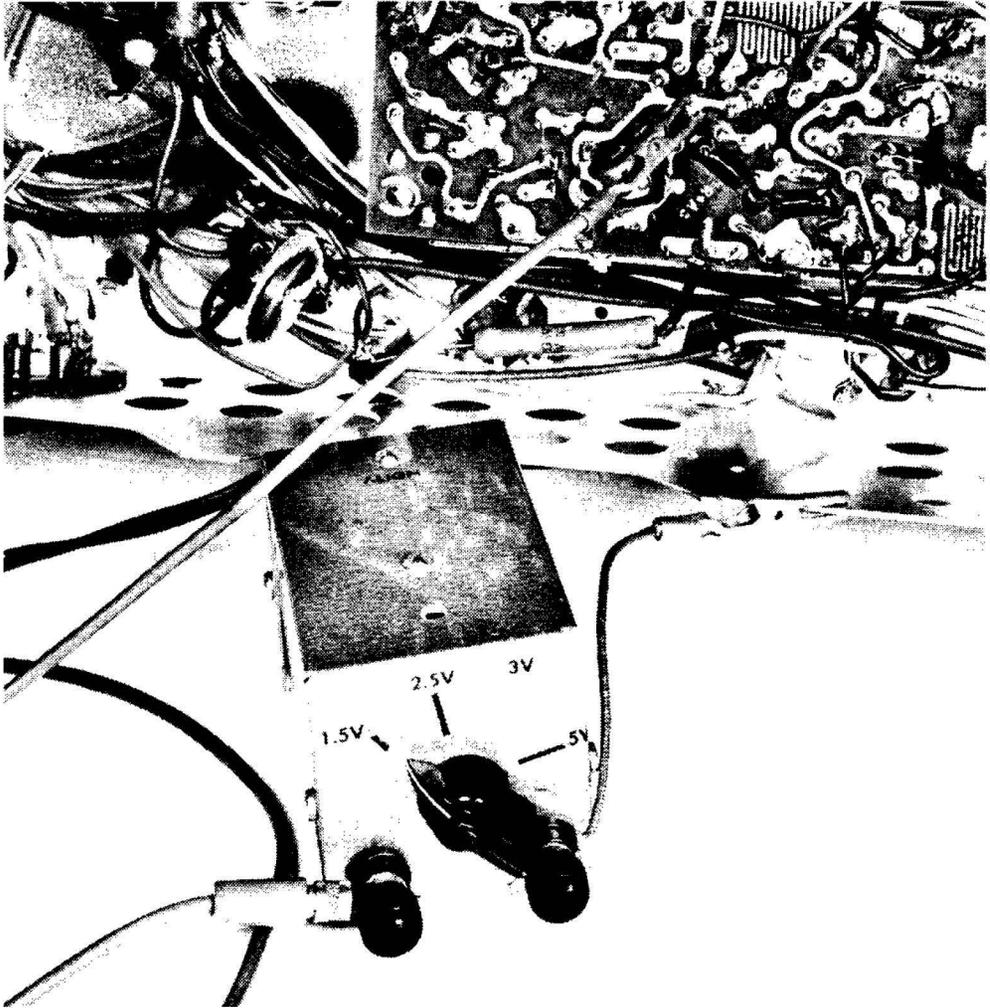
(A) Physical appearance.
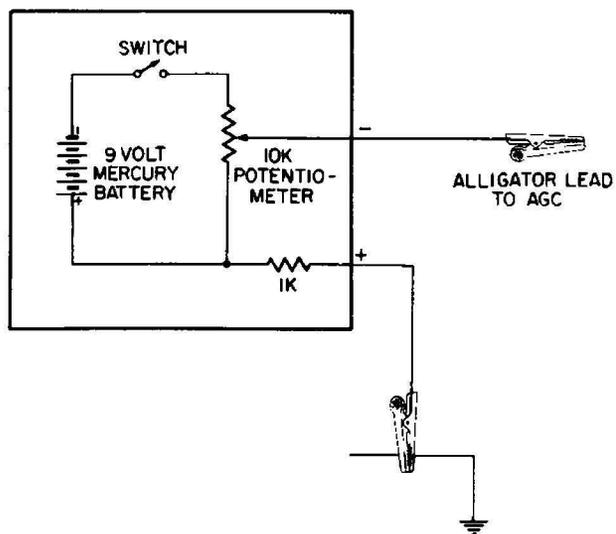


(B) Circuit.

Fig. 3-2. One type of bias box.

procedure has begun. Receivers of recent manufacture often include convenient test points on the chassis for connecting the signal generator and scope. Using these points minimizes much of the time and trouble usually wasted in alignment work. In addition to providing the alignment procedure for a particular receiver, service data provide such information as bias voltage required, response curve desired, exact frequencies marked, and permissible tolerances.

## EQUIPMENT OPERATION

There are two basic methods of determining the response characteristics of a circuit. The first, touched on in Chapter 2, is the step-by-step method. A signal of a frequency within the expected bandpass is injected into the circuit, and the output voltage is then measured and recorded on a graph. The signal level is maintained and the process is repeated for a large number of frequencies, in increments, until the output drops to zero at two points. Connecting the various lines, representing voltage *versus* frequency, produces the response curve. Obviously, such a method is time consuming and therefore of no practical value in a service shop. Moreover, if the response plotted is off, the process will have to be repeated each time an adjustment is made—an impossible situation to be sure.

In the second method, termed *sweep analysis,* the scope presents a continuous picture of what is going on in a circuit, so that the effect of each adjustment can be seen as it is made.

To best understand this process, let's consider individually the different steps required to form the response image on the scope screen. The first step is understanding basic sweep-generator operation.

The sweep generator, or more properly the frequency-modulated signal generator, generates a signal which varies periodically above and below a chosen center frequency. As an example, a sweep generator set to 57 mc, with a sweep width of ±10 mc, will generate a sequency or frequencies from 47 to 67 mc. Furthermore it will sweep, or repeat, this sequence at intervals. By connecting a scope at the video detector, we can thus observe the over-all response of a TV receiver tuned to Channel 2.

Of all the sweep generators manufactured, the simplest was the rotating-capacitor type. Although it has long since faded into the oblivion, this generator is nevertheless simple in operation and will be used here to demonstrate the principle of sweep modulation. It is well to understand that there are

many means of sweep generation, some mechanical and others electronic. They differ only in method, not in results.

In the rotating-capacitor generator, a synchronous motor rotates at a fixed speed of 3,600 rpm (60 cps). The motor is coupled to a small continuously-variable capacitor in parallel with the tuned circuit of an oscillator (Fig. 3-3). With the continuously-variable capacitor half-meshed, the oscillator center frequency is adjusted by C. As the motor unmeshes the small variable capacitor, the total circuit capacity is reduced and the output frequency of the oscillator shifts upward. As the capacitor begins to mesh again, the opposite occurs—the
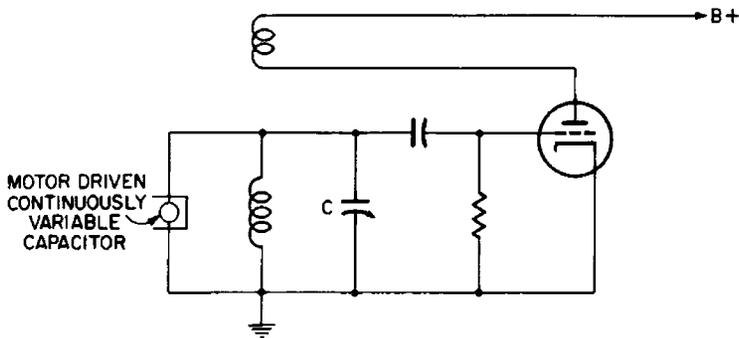
Fig. 3-3. A rotating-capacitor type sweep generator.

total circuit capacity is increased and the output frequency shifts downward to the nominal, or center, frequency. When the capacitor is completely meshed, the frequency shifts downward still further until it reaches maximum below the center frequency. Additional rotation returns the output frequency to the center value, from whence the cycle begins again. Fig. 3-4 illustrates this operation in detail. In Fig. 3-4A we have the response curve of a single frequency; the motor-driven capacitor is at rest at 50 per cent of its maximum capacity, and the center frequency of the oscillator is set to 57 mc. In Fig. 3-4B the variable capacitor has rotated to maximum (100 per cent of capacity), shifting the frequency from 57 to 47 mc and tracing the response curve shown. This curve is nothing more than the single frequency curve of Fig. 3-4A displaced to the left. If the capacitor were stopped at the maximum capacity position, the curve would be identical to A except it would appear at 47 mc. As the capacitor continues to change from maximum back to the starting point, the oscillator output frequency retraces the curve just generated, only in reverse. As the variable capacitor rotates toward minimum capacitance, or fully unmeshed, a similar curve is generated starting at 57 mc and extending to 67 mc (Fig. 3-4C). Rotating the capacitor

back to its original half-meshed starting position causes the output frequency to retrace in reverse the curve just generated. Fig. 3-5A illustrates the over-all output curve for a complete cycle of the motor (360-degree rotation in 1/60th of a second). As can be seen, there are two complete response

OSCILLATOR
OUTPUT

POSITION
OF ROTOR

FREQUENCY MC —

47          57          67

(A) Capacitor at mid position.

OSCILLATOR
OUTPUT

POSITION
OF ROTOR

FREQUENCY MC —

47          57          67

(B) Capacitor fully closed.

OSCILLATOR
OUTPUT

POSITION
OF ROTOR

FREQUENCY MC —

47          57          67

(C) Capacitor fully open.
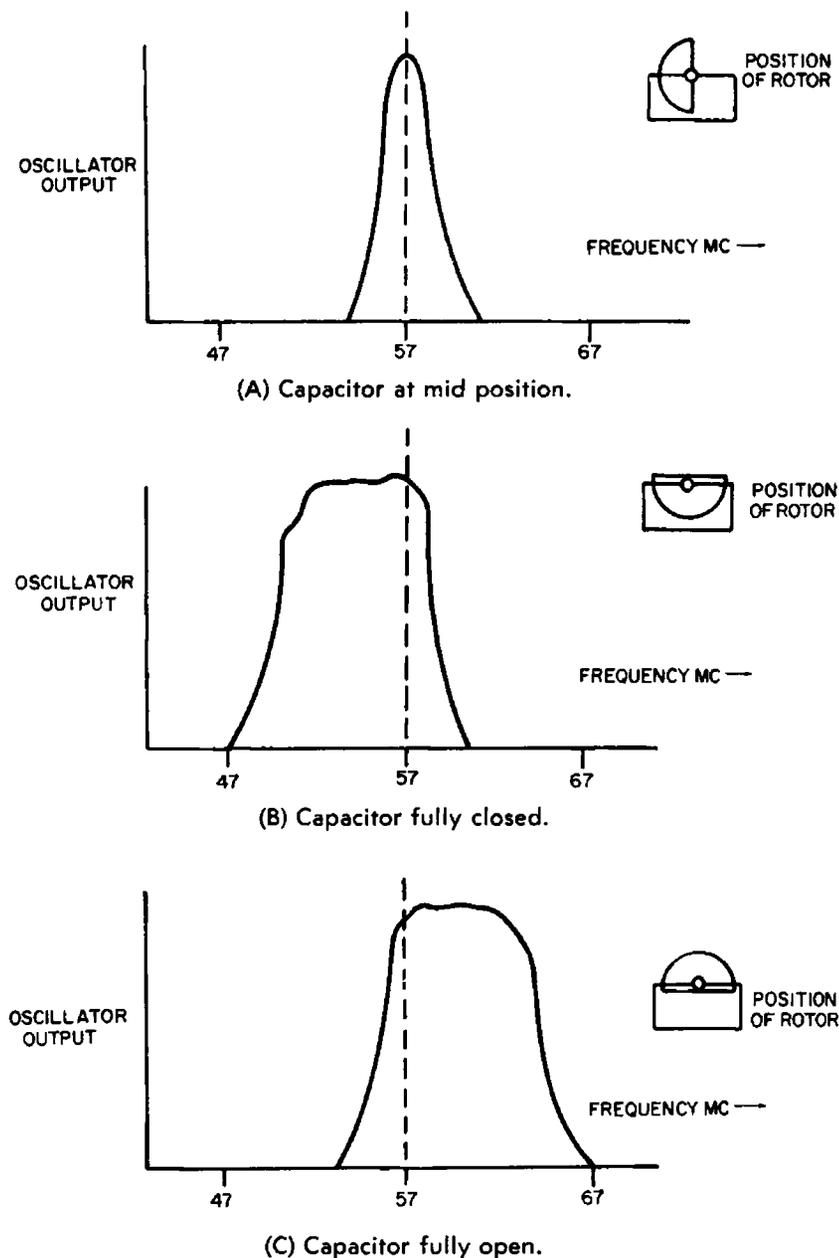
Fig. 3-4. Operating sequence of a rotating-capacitor sweep generator.

curves, and for alignment we need only increase the scope sweep frequency to superimpose the two curves. In other words, the scope beam will scan across the screen twice in 1/60th of a second, during which time the sweep oscillator generates two complete response curves. The resulting single-

image response curve will appear as shown in Fig. 3-5B. You may have noticed that the response curves are not symmetrical, but have a hump on one side. First, it is almost impossible to make the output of a sweep generator perfectly flat over its entire range; and secondly, rarely is scope response perfectly linear over its rated frequency range. Therefore, the two super-
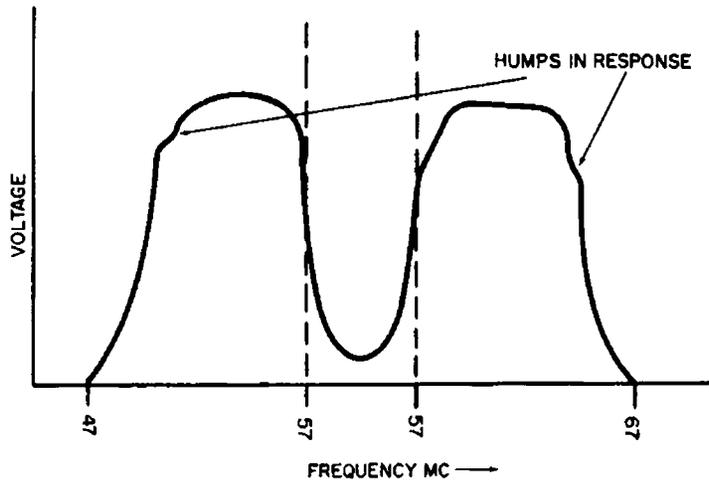


(A) Double curves at 60 cycles.
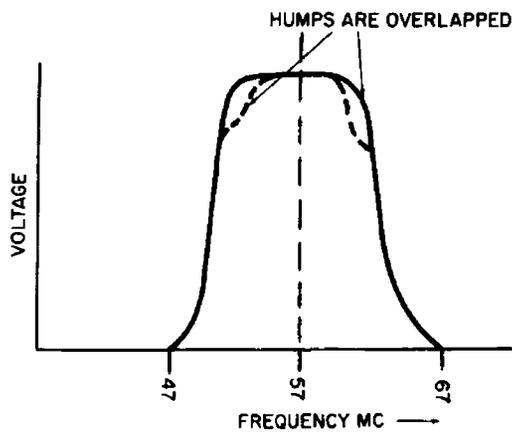
(B) Single curve at 120 cycles.

Fig. 3-5. Effect of scope sweep rate on response indication.

imposed response curves in Fig. 3-5B do not completely overlap, but they are close enough for all practical alignment purposes.

We have considered the basic principle of sweep-frequency generation. Next, let us take a look at the oscilloscope. The first phase of scope operation is the horizontal-sweep deflection of the beam and its relation to the frequency coverage of the sweep oscillator. As we have seen, the sweep oscillator sweeps the output signal throught a range of frequencies over and over again in a rapid and definite pattern, from the lowest frequency

to the highest and then back. The same voltage which produces the frequency sweep is available at a terminal (usually labeled "Sync") on the panel of the sweep generator. This operates the horizontal-deflection system of the scope (Fig. 3-6), moving the beam back and forth horizontally across the screen. This back-and-forth motion is synchronized with the frequency variation of the sweep oscillator. For example, when the sweep output frequency is about to sweep from the low end of its width, the scope beam is at the extreme left of the screen, ready to scan toward the right. When the scope and sweep oscillator are properly synchronized, each point along the path to be traced by the beam represents some instantaneous oscillator frequency. We can see, then, that the distance
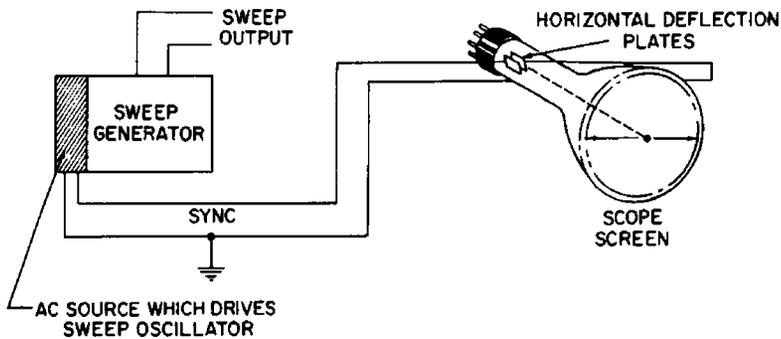


Fig. 3-6. Method of obtaining horizontal sweep in an oscilloscope.

between the left and right extremes of beam travel is directly proportional to the frequency of the sweep-oscillator output. As the sync voltage shifts from maximum in one polarity to maximum in the opposite polarity, it sweeps the oscillator output frequency to the maximum value at the high-frequency end of its width. At the same time, the same sync voltage applied to the horizontal input of the scope deflects the beam toward the right of the screen. When the sync-voltage polarity reverses the oscillator output frequency, the scope beam also is reversed and follows in step.

The direction of beam travel may be opposite from that just described; that is, the beam may be at the extreme left of its scan at the highest instantaneous frequency of the sweep and at the extreme right at the lowest instantaneous frequency. The frequency would then increase from right to left along the horizontal axis. This condition could be caused by a change in polarity of the sync voltage occurring in the scope horizontal amplifier. The response curve in this case may seem to be "flopped over," however, its shape actually remains unchanged. In any event, the direction the frequency increases should first

be determined with a marker generator, to assure correct interpretation of the response curve.

To summarize, the first step in producing a visual response curve is to establish a horizontal trace and retrace which corresponds to the sweep-oscillator output frequency. Each point along the horizontal trace corresponds to some instantaneous oscillator frequency.

Now we will analyze the action produced in the vertical-deflection process of the scope. Its vertical terminals are connected to the output of the receiver, and the sweep oscillator to the input as in Fig. 3-7. The higher the voltage at the ver-
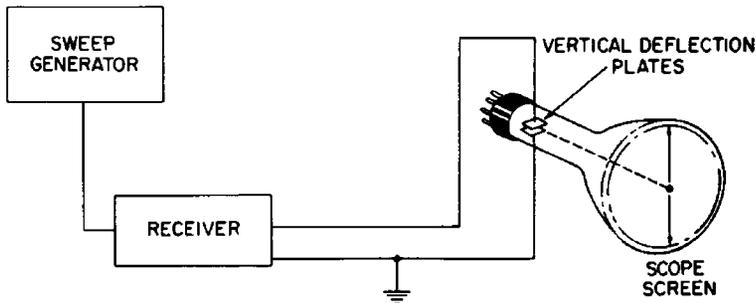


Fig. 3-7. Method of obtaining vertical sweep in an oscilloscope.

tical input of the scope, the greater the vertical deflection of the beam. Therefore, the height of the beam above the horizontal reference line at any given instant is directly proportional to the output voltage from the receiver. The output voltage results from the signal voltage at the receiver detector and thus is directly proportional to the response of the receiver.

Combining the vertical and horizontal actions described, gives the result in Fig. 3-8. The scope beam scans the screen horizontally in step with the oscillator frequency sweep; at the same time, the beam is deflected vertically by the instantaneous
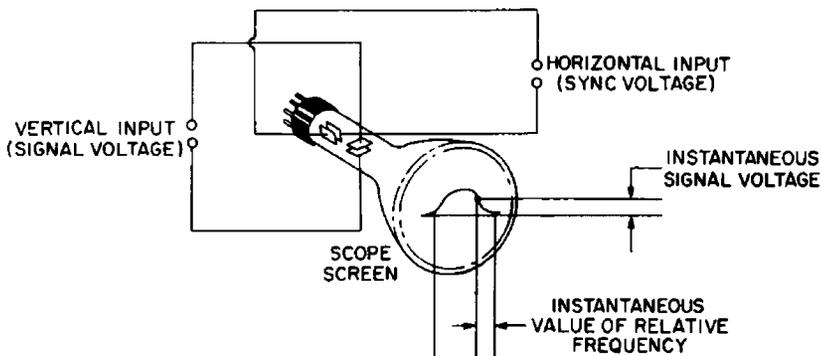


Fig. 3-8. Resultant pattern obtained from combination of horizontal and vertical sweep. Its height indicates the voltage; its width, the relative frequency.

voltage at the output of the receiver. Thus, the scope beam moves up and down and across the screen, and as it does, traces the response characteristics of the receiver. Whether the response curve is right side up (Fig. 3-9A), or upside down (Fig. 3-9B), depends on the polarity of the voltage at the receiver output and the direction of vertical deflection for a given signal polarity. Except for being inverted, the response curve will have the same shape for either polarity.
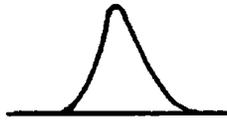


(A) Curve right side up.
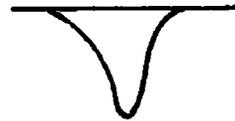
(B) Curve upside down.

**Fig. 3-9. Waveform aspect on scope depends on polarity of voltage at receiver output.**

In service-type sweep generators, the sweep action of the output frequency is produced by an AC voltage taken usually from a transformer winding in the power supply. Since this synchronizing voltage has a sine waveform, the output frequency varies at a sine-wave rate. The change in frequency is slow near the upper and lower extremes of the sweep width, but very rapid in the middle. In spite of this nonlinear action, however, a linear relationship exists between the scope presentation and the sweep-oscillator output because the same sync voltage is applied to both. The horizontal axis is therefore linear, and each equal interval represents an equal change in frequency. The variation due to the sync-voltage waveform causes the scope beam to scan over the middle portion more rapidly than over the left and right extremes. However, the sweep rate is fast enough to produce what our eyes perceive as a fixed trace.

In the discussion of sweep-oscillator operation, we determined that the output frequency starts at some nominal value and sweeps to maximum. From here it then reverses and returns to the starting point, retracing the curve just generated. If the trace and retrace curves do not coincide, the points which represent the lowest and highest oscillator frequencies will not be at the ends of the scope trace. Instead, they will appear as two nearly identical traces but in different horizontal positions, as illustrated in Fig. 3-10. This is due to a phase difference between the voltages producing the frequency sweep and and horizontal-beam scan. A phasing control on the generator or scope adds reactance to a circuit, thereby changing the phase of one voltage with respect to the other and producing a single trace.

44

Fig. 3-10. Scope pattern when phasing is incorrect.

When the phasing is correct, only one response curve is observed, with nothing to indicate a base line under the curve. At times, however, it is desirable to have such a base line. One can be produced by blanking, or cutting off, the sweep-oscillator output during retrace. In other words, the scope beam traces out the response curve during the forward scan, but during retrace the beam is not deflected and it produces a horizontal line. This is illustrated in Fig. 3-11.

Fig. 3-11. Type of response pattern obtained with blanking. Note that base line serves as reference point.
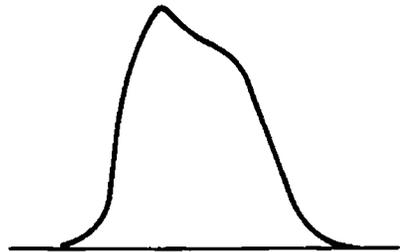


## SETTING UP ALIGNMENT EQUIPMENT

The exact arrangement to be used in setting up the alignment gear is up to you. There are, however, several important factors to consider in its placement:

1. To minimize leakage and spurious-output effects, space the sweep generator and receiver as far apart as possible, preferably the full length of the generator leads. A word of caution: these leads are designed for the generator, to be used as they are, and any attempt to lengthen them may introduce such hard-to-remedy troubles as excessive signal leakage and spurious output.

2. Accessibility of power connections for the scope, receiver to be aligned, and sweep and marker generators.

3. Accessibility of a good common-ground connection. The alignment bench should be equipped with a large ground plate upon which all alignment gear and the receiver can be placed. Sheet copper which covers the entire working area is preferable. This establishes a common-ground potential for all equipment, and also provides some shielding against interference. The ground plate cannot be considered a substitute for an earth ground, since it is merely an extension of an existing ground connection. The refer-

**45**

ence point for true ground is generally accepted as the earth itself. For this reason, an underground water pipe makes an excellent connecting point for the ground plate (and any other ground connections). The importance of good grounding cannot be overemphasized. Points which are supposed to be at ground potential, but are not, will develop an RF voltage above ground and interference with the accuracy of alignment.

4. Order of alignment progress. It is often easier to arrange the equipment in the order the signal travels through it, so that the alignment process will be orderly and thus less confusing. One way is to place the receiver in the middle, with the sweep and marker generators to the left and the scope to the right.

5. Sweep alignment is by no means a simple operation, but it is often made unnecessarily more complicated by an undersized, cluttered workbench. Your bench should be of sufficient size to hold all the equipment and still have considerable space to spare.

## ALIGNMENT PREPARATIONS

One of the cardinal rules of good alignment is to allow a suitable warm-up period for the equipment. This is to assure stable operation by minimizing heating effects before actual alignment begins. Experienced technicians often turn all the gear on first, and then take advantage of the warm-up time to make necessary connections and rechecks, study adjustment locations, and so on.

Connecting the equipment for alignment invariably poses the problem of lead termination. There are several methods and each has its own application. As stated earlier, generator leads must be properly terminated if alignment is to be accomplished without the troublesome effects of standing waves. Standing waves at higher frequencies, say above 30 mc, affect alignment results greatly: They cause double trace lines on the scope, and subsequent difficulty in obtaining a sharp, stable response curve. They also alter the shape of the response curve by producing peaks and valleys and other misleading indications not actually in the receiver. Standing waves may even be present on the outside of shielded but improperly terminated leads, causing them to be touchy to any change in position or connection. In any event, keep in mind that the only way to eliminate standing waves is to terminate leads in their own characteristic impedance.

The original generator leads may or may not be equipped with a self-contained termination network. If not, you are expected to add the external termination required. Since all signal generators differ somewhat, you are urged to consult the manufacturer's instruction manual before attempting such termination. In the final analysis, the ultimate authority on proper lead termination is the manufacturer himself; the examples given here are not intended as substitutes, but rather as a guide when no other information is available.



RI = 47 OHMS
R2,R3 = 120 OHMS

R1

R2

R3

300 OHM OUTPUT

RI = 100 OHMS

RI

LOW IMPEDANCE OUTPUT

RI,R3 = 68 OHMS
R2,R4 = 82 OHMS

SHIELDED TWO
CONDUCTOR CABLE

R1

R3

R2

R4

300 OHM OUTPUT

RI = 150 OHMS
R2 = 75 OHMS

300 OHM SOURCE

R1

R2

75 OHM OUTPUT
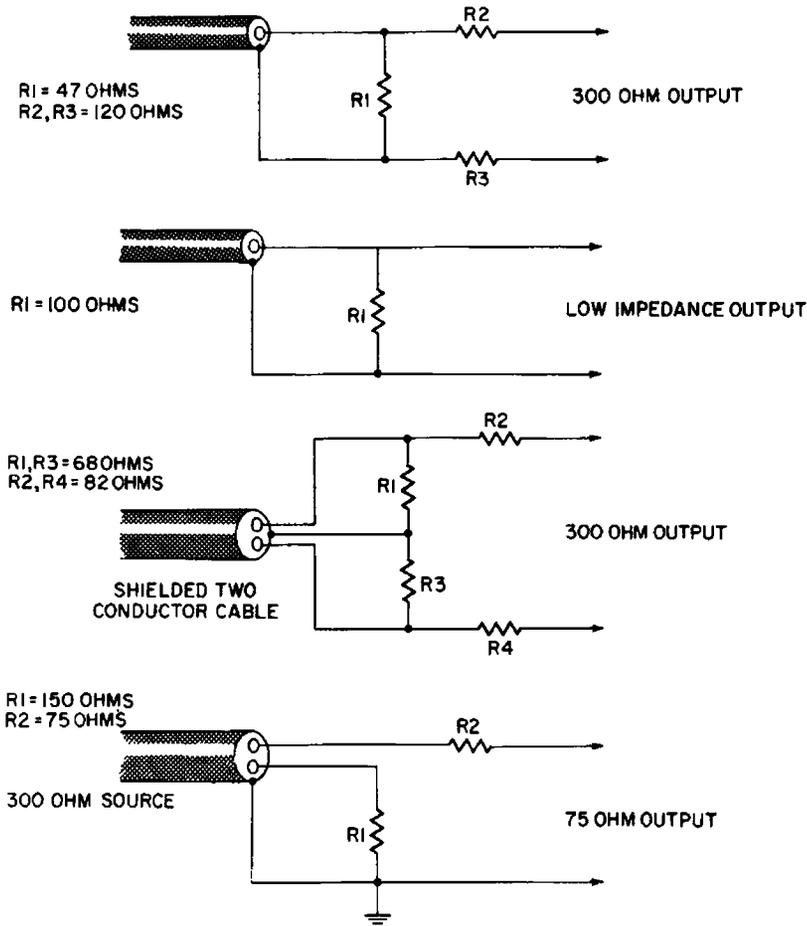
**Fig. 3-12. Typical networks for terminating generator leads.**

Typical terminating networks, like those which often appear in generator operating manuals, are illustrated in Fig. 3-12. Fig. 3-13 shows examples of self-contained networks.

Fig. 3-14 shows two dummy antennas like those often used to connect a signal generator to the antenna circuit of a radio receiver. The impedance the antenna circuit "sees" will then be the same as that offered by the antenna itself. The dummy antenna of Fig. 3-14A is the standard adopted by the Institute of Radio Engineers (IRE). It has an average terminal imped-

ance suitable for use with practically all AM radio receivers in the 500-kc to 30-mc range. The simpler dummy antenna in Fig. 3-14B is suitable for receivers tuning the 500- to 1700-kc band, since at these frequencies it has almost the same terminal impedance as the network in Fig. 3-14A.

## Interconnecting the Equipment

Certain problems arise in interconnecting alignment equipment. One is marker insertion—the marker signal may be in-
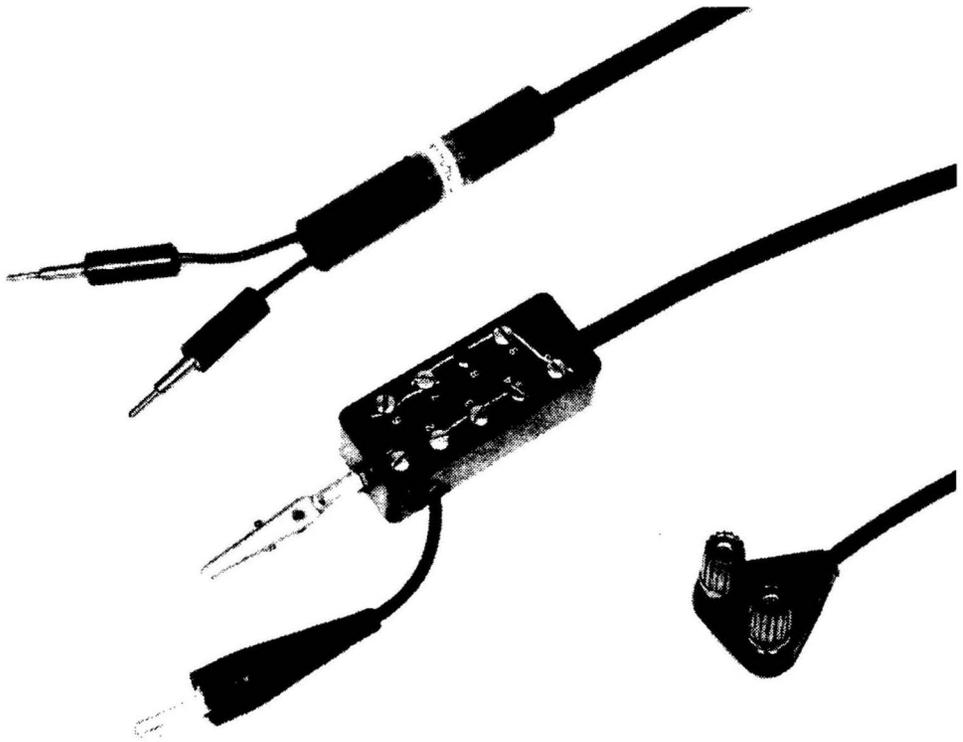


Fig. 3-13. Examples of self-contained terminating networks.

serted in several ways, but not all of them are equally satisfactory for the many marker generators in use. Experience shows that it is often difficult, if not downright impossible, to insert a marker without adversely affecting the response characteristics of a receiver. The main concern is that the marker be easily seen on the scope. At the same time, the marker signal cannot be so great that it overloads the circuits and affects the response curve. Regardless of the marker-injection method used, the response will change slightly in any receiver. As long as this change does not occur in the shape of the response curve,

METAL SHIELD BOX



GENERATOR
INPUT

OUTPUT TO ANTENNA
INPUT

C1 = 20 MMF
C2 = 400 MMF

R1 = 400 OHMS
L1 = 20 MICROHENRY COIL

(A) Circuit.

GENERATOR
INPUT

OUTPUT TO RECEIVER
ANTENNA CIRCUIT

C1 = 200 MMF          R1 = 25 OHMS          L1 = 20 MICROHENRIES

(B) Simplified variation.
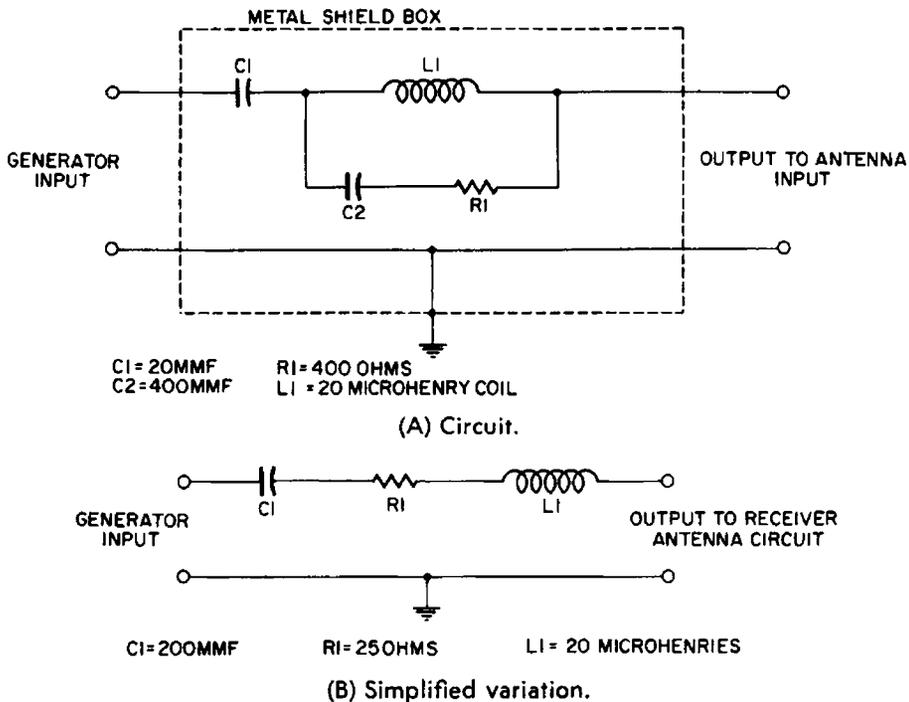
**Fig. 3-14. Standard dummy antenna for coupling a signal generator to an AM receiver.**

it is not detrimental to good alignment. Any peaks and valleys in the curve prior to marker insertion should remain constant when the marker signal is applied. In addition, their relative amplitudes must not change, although the over-all amplitude may do so.

One common method of marker insertion is illustrated in Fig. 3-15A: the output of the marker generator is coupled to the sweep signal by winding a few turns of insulated wire around the "hot" sweep lead, near the feedpoint, and connecting the "hot" marker-generator lead to the wire. Fig. 3-15B shows a second method which, oddly enough, seems to work well. Here both marker leads are connected to the receiver chassis, but are three to five inches apart. The marker signal appears across the resulting ground loop and is radiated to the receiver circuits, where it heterodynes (beats) with the sweep signal to produce a marker pip on the scope.

One other acceptable method of marker insertion may be resorted to if necessary. This is to couple the generator, through a very small isolating capacitor (up to 12 mmf), to one of several points in the IF strip—such as certain sections of the AGC circuit, and to the screen grids or the B+ end of transformers in the IF stages.

Methods of coupling the sweep-generator output to the receiver were covered earlier in this chapter; but other, lesser-used methods will be shown where they apply.

For video-IF alignment it is always safest to connect the oscilloscope directly across the video-detector load resistor, as illustrated in Fig. 3-16. One other scope connection is permissible, and that is across both the load resistor and series peaking coil L1 together. Never take the detector waveform from the output side of coupling capacitor C1; this will cause a low frequency phase shift which varies with the value of the
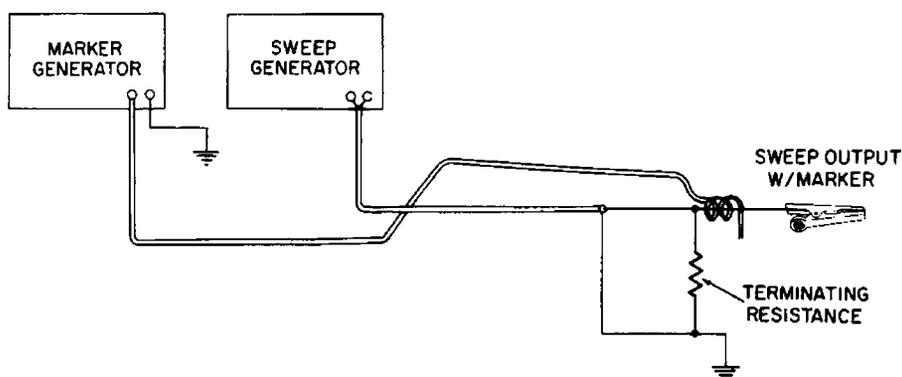


(A) Inductive loop.
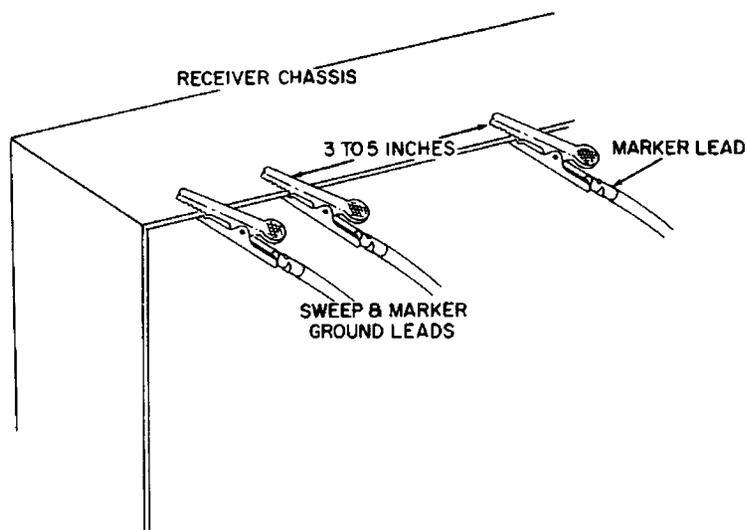


(B) Chassis ground loop.

Fig. 3-15. Method of coupling marker in with sweep signal.

coupling capacitor. As a result, the trace and retrace will not coincide on the scope, and if blanking is used, serious and misleading distortion will occur. Unless the manufacturer's alignment data specifically states otherwise, always take the scope signal from across the load resistor.
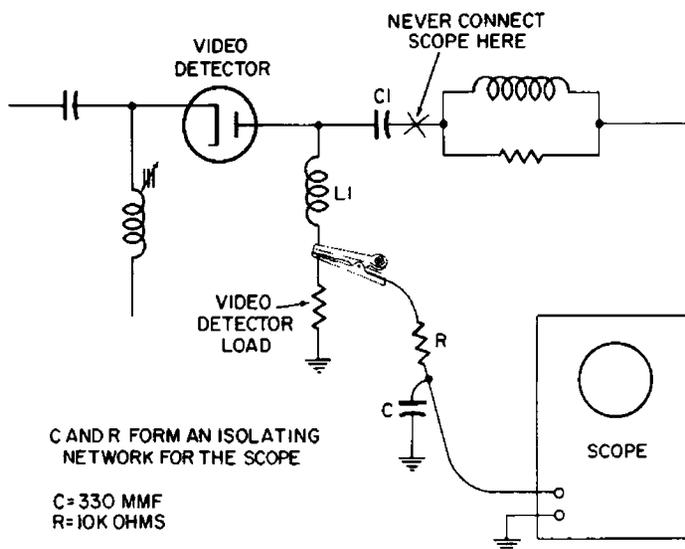
Fig. 3-16. Scope connections for video-IF alignment.

## AGC Considerations

Few technicians are aware of the consequences of permitting the AGC circuit to function during alignment. Let's review a few facts covered earlier in this chapter, to see how the AGC fouls up alignment.

The output of the sweep generator is frequency-modulated with a 60-cycle sine wave, and the same 60-cycle signal is applied to the scope horizontal amplifier to insure perfect synchronization of the response curve. Since retrace is visible on the scope with sine-wave deflection, two effectively superimposed response curves appear on the scope screen. These two curves are rarely perfectly superimposed and a base or reference line is often desirable. To produce such a line, blanking of the retrace is often used. It is this blanking of the sweep-oscillator output that introduces alignment inaccuracies if the AGC circuit is permitted to function. The reason for these inaccuracies becomes obvious when all contributing factors are considered. An AGC filter network must have a time constant large enough to eliminate the 15,750-cycle horizontal-sync pulses, but small enough to respond to changes in signal strength within a few frames of the change. During the alignment process a signal is present only half the time, so the AGC filter charges and discharges to follow the presence and absence

Fig. 3-17. Voltage waveform on AGC line when sweep generator is used and AGC voltage is not clamped.



I/60 SECOND
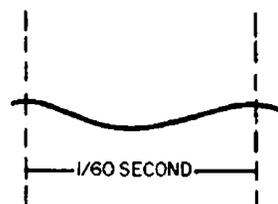
of this signal. The resulting voltage on the AGC line has a waveform somewhat like the one in Fig. 3-17. This varying voltage biases the AGC-controlled amplifiers at a higher level during one portion of the sweep than during the remaining portion. This is illustrated in Fig. 3-18. The effect is even more pronounced if the receiver employs a gated AGC circuit, because of the amplification of the AGC voltage. Service technicians have been known to attempt to realign a receiver because the seemingly improper curve led them to believe the IF alignment was off. Actually the receiver was being misaligned, for an external bias applied to the AGC line would have shown the response curve to be normal and readjustment unnecessary. It can be stated without reservation that a TV receiver cannot be properly aligned with the AGC system operating. Discon-



Fig. 3-18. Variation in IF-amplifier response due to
change in AGC bias.

necting the AGC circuit will not help matters any, because the voltages developed under actual operating conditions may vary anywhere from contact potential (a fraction of a volt) to as high as 10 or 12 volts. Hence, the importance of manufacturer's data in alignment work. The manufacturer's engineering department determines the average bias value for alignment of its particular receiver. The need for correct bias can be seen by varying it over a wide range while observing the response curve on a scope. The curve will shift around considerably over the 1- to 10-volt range, and in some high-gain receivers it may become a single sharp peak on a low bias value. This is due primarily to the Miller effect, and in some instances, to regeneration. The Miller effect is the detuning of circuits due to variations in tube interelectrode capacitance as the applied bias changes. Regeneration is the result of a feedback path between the first and third video-IF amplifiers.

As a rule, in an area with both primary (strong) and fringe (weak) signals, the receiver should be aligned with the exact bias recommended by the manufacturer. After such alignment, however, it is good practice to vary the applied bias above and below this value to make certain the response characteristics do not vary too much. If they do, realignment with a lower or higher bias voltage may be required.

If a receiver is used in a fringe area only, it should be aligned with the bias voltage nearest the actual AGC voltage developed during reception, say 2 or 3 volts. For best results, measure the AGC voltage developed by a number of receivers on signals in the area; then use the average as a guide to the most effective bias value.

# Interpreting

# Response Curves

Having seen what response curves are and how they are reproduced on the scope screen for observation, it's time to examine some of the common difficulties faced in obtaining a good response curve. The manner in which the receiver response is adjusted will be discussed subsequently. Although it
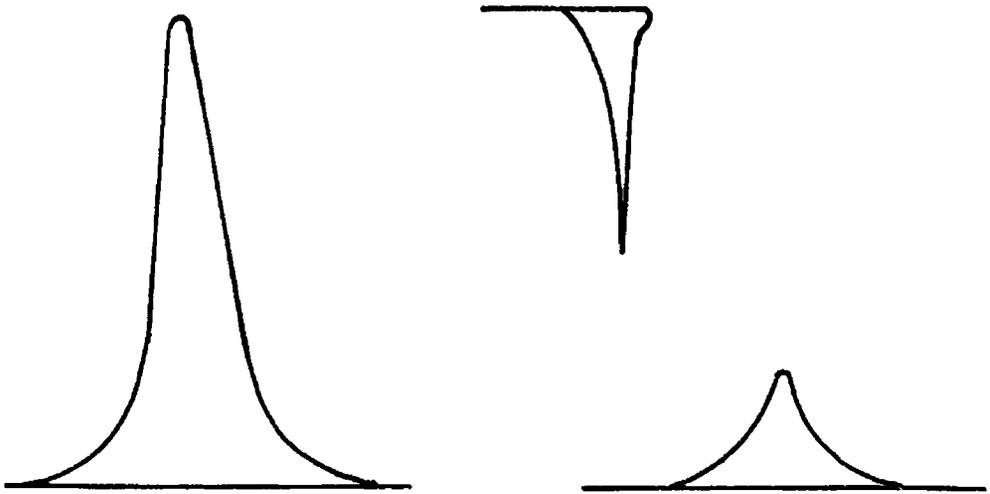


Fig. 4-1. Typical examples of clear, stable response curves.

is obviously impossible to analyze all the myriad troubles which could develop, we can provide examples of the most frequent ones and show you what to watch for in the response curve.

Your first concern is to become thoroughly familiar with the response characteristics you must obtain. Because the shape of the response curve will vary from one receiver to another,

there can be no set rule on shapes in general. You must develop a sixth sense for recognizing the actual response of a receiver —and this can be accomplished only if you know what you are doing and have confidence in your ability.

Typical examples of clear, stable response curves are shown in Fig. 4-1. A good curve is stable and is unaffected by movement of the test leads or your body. Nor should it change in shape as the input-signal level is raised to the point of receiver overload.

Some of the difficulties which may develop in obtaining this desired curve are shown in Fig. 4-2.

**Fig. 4-2. Trouble chart.**

| CONDITION | CAUSE AND REMEDY |
|---|---|
| No horizontal-sweep deflection on scope screen (Fig. 4-2A). | Switch the scope horizontal amplifier from external to internal deflection. If the trace does not change, then trouble is indicated in the horizontal-deflection amplifier. If switching produces horizontal deflection, there is discontinuity in the sync signal from the sweep generator. Check interconnecting leads for open or short with an ohmmeter. Check for sync voltage at generator-output terminals with an AV voltmeter or VTVM. |
| No vertical deflection on scope screen (Fig. 4-2B). | Either the sweep generator or scope vertical amplifier is inoperative, or there is discontinuity between the sweep oscillator output and scope vertical input. A defect in the test cables or receiver, or an incorrect connection, is the cause. First, recheck to make certain all equipment connections are correct. Check all test leads for opens or shorts with an ohmmeter. Check sweep generator for RF output with a VTVM and RF probe (or place an operating AM radio receiver near the generator. A raspy buzz will be heard in speaker if the generator is functioning). If the generator is all right, the receiver itself may be defective and is blocking the signal. This must be traced and it can be repaired by using ordinary servicing methods. If the generator and receiver are both all right, check out the scope. Disconnect the vertical-input lead from the receiver, turn the vertical gain wide open, and place your hand on the "hot" lead. Some vertical deflection should occur; if not, the vertical-amplifier section is defective. |

| CONDITION | CAUSE AND REMEDY |
| --- | --- |
| Nonlinear base line with ripple (Fig. 4-2C). | Generally caused by lack of proper grounding. Make certain all points which are supposed to be grounded, are grounded, and the ground connections are good. Sometimes, AC pickup on the leads is the difficulty. Proper shielding is the only remedy. |
| An erratic response or rough base line (Fig. 4-2D). | Generally due to an interfering signal or to excessive marker-signal level. Interference can usually be eliminated by proper grounding and lead shielding. Difficulty due to marker signals can be eliminated by reducing the signal level with the generator attenuator or, in case of excessive generator leakage, by reducing the coupling between generator and receiver. |
| Base-line tilt or distortion (Fig. 4-2E). | A very common condition during tuner alignment. It is caused by signal reflections from the IF-amplifier strip, and can be prevented by removing the first IF tube (or by shorting out the IF grid load in a series-string filament). |
| Distortion in RF response curve (Fig. 4-2F). | This is an example of the Miller effect, and it often occurs when the oscillator tube is removed during tuner RF alignment. The only solution is to not pull the oscillator tube. If the condition remains unchanged after this tube is reinserted, some other tuner trouble is causing the distortion. |
| Overload distortion (Fig. 4-2G). | This is a very tricky condition which may not even be apparent at first glance. The sweep-generator output attenuator should be adjusted over its range to make certain the signal level is not overloading the receiver, thereby changing the shape of the response curve. (In varying the attenuator from minimum output to the overload point, its *height* will change but its *shape* must not.) |
| Fuzziness which distorts the response curve (Fig. 4-2H). | Almost always due to reception of a strong signal from a local station. Switch the channel selector to one of the unused high-frequency channels (10, 11, 12, or 13). The setting of the channel selector often has a great influence on response-curve distortion, and for this reason it is best to follow the receiver manufacturer's recommendations on the channel-selector setting during alignment. |
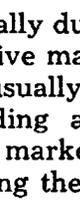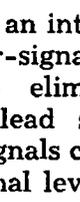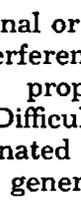
Up to this point all response curves have been shown in the conventional manner—that is, with the low-frequency end at the left, and upward deflection. In actual practice, however, response curves are often seen upside down or with their frequency increasing from right to left. Therefore, you must learn to read curves no matter what their position. This is not as difficult as you might imagine, since a good response curve is usually very distinctive. The polarity of a response curve can-
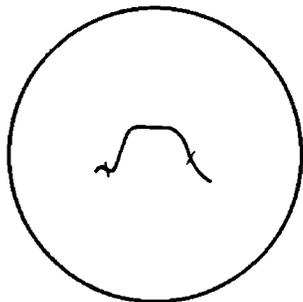


(A) Pattern up and low frequency at left.
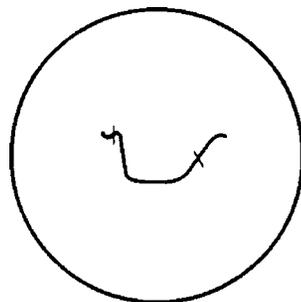


(B) Pattern down and low frequency at left.
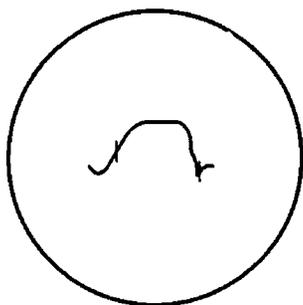


(C) Pattern up and low frequency at right.
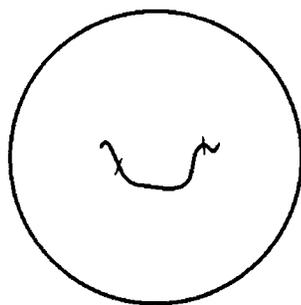


(D) Pattern down and low frequency at right.

Fig. 4-3. Various presentation of an IF-response curve, seen with different brands of equipment.

not be readily controlled, a point which really doesn't matter as long as you recognize or can identify what the scope is showing. Fig. 4-3 illustrates the different presentations of an IF response curve which you might see with different brands of equipment.

## RF RESPONSE CURVES

To check the RF response of a receiver: connect the sweep generator, through a matching pad or network, to the receiver antenna terminals along with the loosely-coupled marker generator; and connect the scope vertical input to the mixer grid.
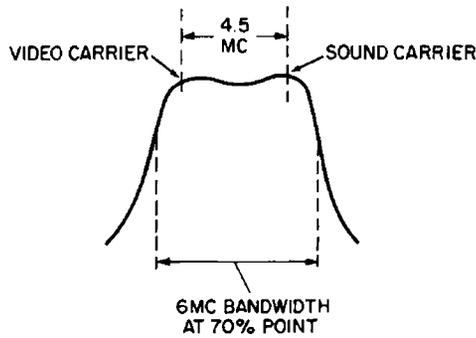
Fig. 4-4. Normal position of the carriers when the response curve is narrow.

The sound- and video-carrier frequencies, located by setting the marker to first one frequency and then the other, should fall on the peaks of the curve. The peaks should be the same height, and the dip between should be shallow. The curve must be symmetrical, and the bandpass at the 70% points of the curve must be 6 mc wide. See Fig. 4-4. Keep in mind that the curve actually viewed may be upside down or reversed from the one shown. Not all RF curves will look like (or in some receivers, even approach) the ideal curve illustrated here. Often the response will even vary from one channel to the next because RF curves are usually a set of compromises. This is due to interaction: the setting of the high-frequency channels



(A) Channel 2.

(B) Channel 5.

(C) Channel 9.

(D) Channel 13.
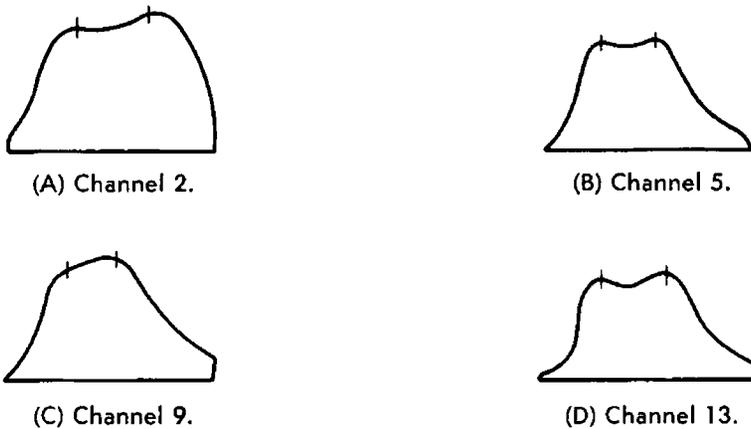
Fig. 4-5. Typical tuner RF-response curves.

normally affects the low-frequency channels. And of course there are other variables, such as different alignment equipment, which affect the results obtained. The service data should always be used as a guide whenever possible, since it gives the proper response curves for the particular receiver.

Fig. 4-5 shows a set of typical tuner RF response curves. Note the differences between channels and the way the carriers fall

on the different peaks. One reason why a great deal of accuracy is not necessary in shaping RF response is that the compensation for vestigial-sideband transmission takes place in the IF amplifiers. The two main factors of importance are proper bandwidth and flat response over each entire channel.

Even though there are wide (but normal) variations in RF response curves, certain definite limits must be adhered to, as illustrated in Fig. 4-6. As a rule we can say:

1. The dip between peaks on the curve must not drop more than 30% below the peaks unless otherwise specified by the receiver manufacturer.

2. The peak at the sound carrier on flat-topped response curves (dotted line) must not drop more than 30% below the video-carrier peak unless otherwise specified by the receiver manufacturer.

Normally the sound and video carrier should fall either on the peaks or on the flat portion of the curve. If the bandwidth is on the narrow side, the carriers may be near the top of the slope as in Fig. 4-4, but should never be lower than 70%. The lower portions of tuner RF curves usually overlap both adjacent channels. In order to make the top portion of the curve broad enough for both carriers, a certain amount of overlap is necessary. However, the gain may be seriously reduced if the lower portion of the curve is too wide.

To further simplify response-curve analysis, look over the curve of Fig. 4-6 carefully. The lower video frequencies are represented by the curve in the area of the video carrier, and the high video frequencies are in the region toward the sound carrier. If the curve were slanted downward as in Fig. 4-7A, the high video frequencies would be attenuated. A standard test pattern would then display weak vertical wedges and a
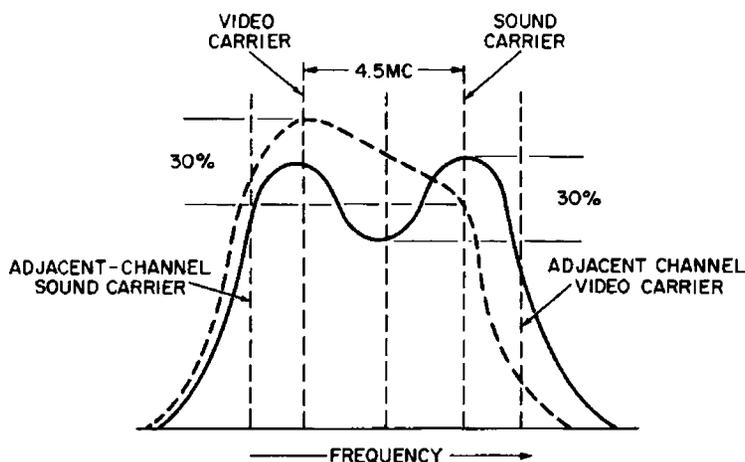


Fig. 4-6. RF response-curve limits.
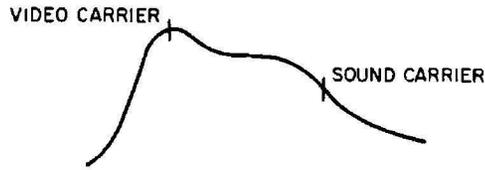
(A) Response curve.
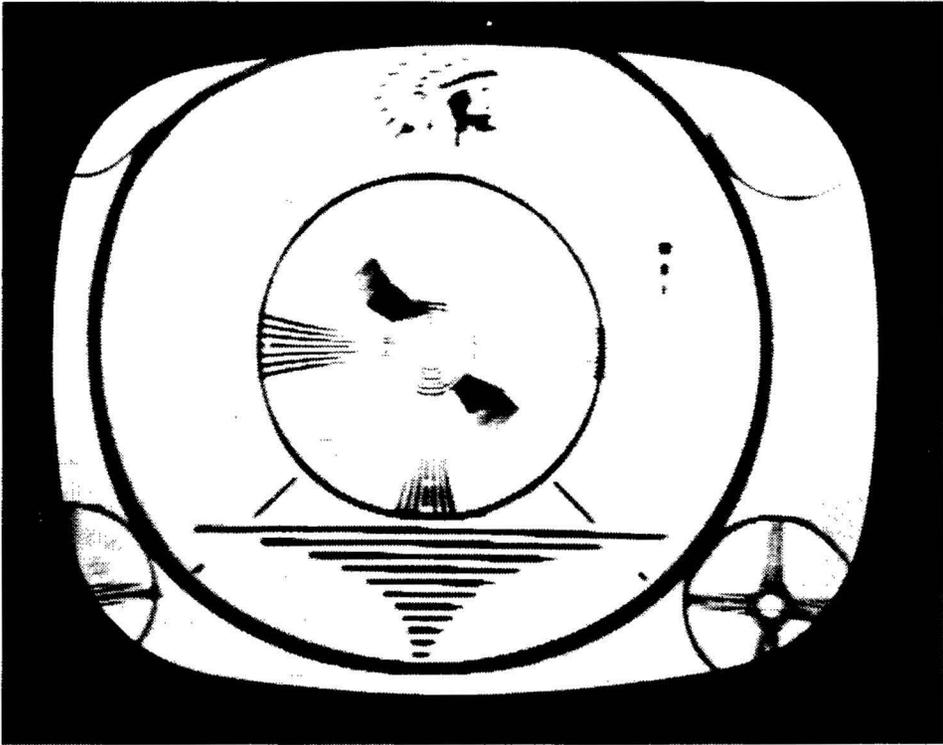


(B) Effect on test pattern.

Fig. 4-7. Effect of excessive response-curve slope toward the sound carrier.

loss of resolution, as illustrated in Fig. 4-7B. If the curve slants downward in the opposite direction (i.e., toward the video carrier) as shown in Fig. 4-8, the low frequencies will be attenuated. A standard test pattern would display washed-out or gray horizontal wedges and a poor over-all black-to-white ratio. If the low frequencies are seriously attenuated, ghosting (whites trailing blacks) or loss of sync could result.
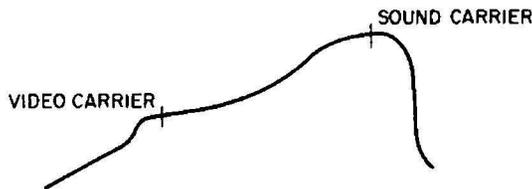


Fig. 4-8. This response will attenuate the lower video frequencies.

In checking receiver RF response, don't jump to the con-
clusion that complete RF alignment is required, merely because
a curve is outside the specified limits. Check *all* channels first.
Quite often a receiver must be factory-aligned with a compro-
mise curve before satisfactory results can be obtained on adja-
cent channels. Because local channels are the only concern,
alignment of unused channels is comparatively unimportant.

Any adjustments made in tuner circuits will produce an
important change in the response curve, and often secondary
effects as well. As an example, in adjusting for increased am-
plitude (gain), the tilt or frequency of the curve may be thrown
off, making necessary an additional adjustment for the best
compromise curve. For this reason, experienced technicians
sometimes use a pair of alignment tools on two interacting ad-
justments at the same time. By adjusting both simultaneously,
it is easier and quicker to find the best compromise setting of
each.

A tuner is generally well-aligned when it leaves the factory,
and as a rule does not get badly out of alignment. However,
minor adjustments are sometimes necessary for best reception
on local channels. When such a touch-up is indicated, it usually
makes little difference in what order you make the adjustments.
But if complete realignment is required for some reason, the
procedure recommended in the manufacturer's alignment data
must be followed to the letter.

## VIDEO-IF RESPONSE CURVES·

For split-carrier video-IF response checks or alignment, the
sweep and marker signals are coupled to the receiver at the
video-IF input (or, in some receivers, to the grid of the mixer
stage), and the scope is connected across the video-detector
load resistor as described earlier. An ideal response curve is
illustrated in Fig. 4-9 for a receiver with a video-IF center fre-
quency of 25.75 mc. The video carrier should normally fall on
the 50% area of the slope unless the receiver is used in an area
of very strong or weak signals. Then it should be nearer the
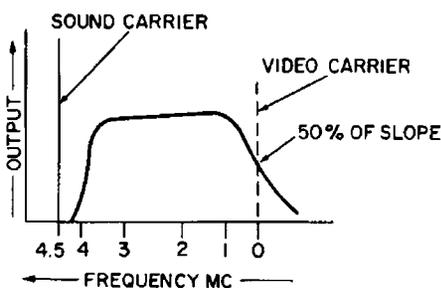


Fig. 4-9. An ideal IF response curve.

70% mark to improve sync action in fringe areas, and more toward the 30% point in primary signal areas, to improve resolution. If the carrier is made too low, however, poor black-to-white ratio and loss of sync and blanking may occur because of the reduced low-frequency response.

The fine-tuning control has a tendency to move the video carrier up and down the curve slope, since it varies the IF frequency to which the RF is converted. The characteristic shape of the IF response curve does not change because it is determined by the adjustment of the IF transformers and is not affected by changes in the carrier frequency occurring in the converter stage. In split-carrier receivers there is invariably a tracking problem between the sound and video carriers on weak signals. The best compromise between good sound and picture occurs near the center setting of the fine-tuning control. Tuning away from this setting produces a better picture but a loss of sound. This condition is normal on weak signals and is easily explained: As the fine-tuning control shifts the RF oscillator frequency, the video carrier is shifted further up the slope. The gain increases at low video frequencies, but at the expense of the highs. However, as the RF oscillator shifts the video carrier, it also moves the sound-IF carrier out of the sound-detector passband, resulting in distorted or weak sound. If the frequency shift is great enough, there may be no sound at all. On a strong signal, changing the fine-tuning control would cause a noticeable loss of detail in the picture. Therefore, the best sound coincides with the best picture on strong signals.

The sound-IF carrier must be at zero on the over-all curve to prevent sound from appearing in the picture. In many receivers, traps are included in the IF strip to reject the video carrier above and the sound carrier below on adjacent channels. This is necessary to prevent interference from stations on adjacent channels.

We can set down a few rules for good response-curve characteristics which would help the technician decide whether receiver response is adequate or not. They are:

1. The top of the response curve should be reasonably flat.
2. The video-carrier slope should rise gradually.
3. The curve slope (on the sound-carrier side) which represents the high video frequencies should rise sharply from the region of the sound-carrier frequency.
4. The high video-frequency response marker should be near or above 90% of the curve slope for the best high-frequency response and resolution.

Any change in the slope of the video-IF curve or in the location of the video carrier and traps will cause trouble. Poor picture quality always shows up as the first symptom of misalignment, followed by such other troublesome signs as poor blanking, unstable sync, regeneration, snow, and interference. Fig. 4-10 illustrates several different video-IF response curves that might be encountered in a TV receiver. These curves are typical of the difficulties experienced from misalignment. Test-



Fig. 4-10. Various video-IF response curves that might be encountered in a TV receiver.

pattern analysis will always help in pinpointing alignment defects if you recognize the symptoms. (This of course applies to component failures as well.) When you encounter an obscure fault in the RF or IF sections, take a few minutes to hook up the alignment equipment and check the over-all response. This will often aid you in locating the faulty stage.

## INTERCARRIER RESPONSE

The IF response curve for intercarrier receivers differs slightly from that of a split-carrier receiver. The reason is that the sound IF passes through the video-IF amplifiers, along with the video signal, and appears in the output of the video-detector circuit.

To couple in the sweep and marker signals, connect the leads to the grid circuit of the first IF, to a floating tube shield over the converter tube, or to the antenna terminals. The latter produces an over-all response curve, but the curve seen on the scope is actually that of the IF response. This will be explained shortly.

Fig. 4-11 illustrates the intercarrier IF response curve. We can set down a few rules on what constitutes a good response curve:

1. The top should be reasonably flat.
2. The video carrier should fall near the 50% point on the slope.

3. The sound carrier should fall near the 5% point on the opposite slope (not zero as in split-carrier receivers). Its position is very critical; if much higher than 5% on the slope, a buzz will be heard from the speaker, and some-

Fig. 4-11. The intercarrier IF response curve seen on the scope.
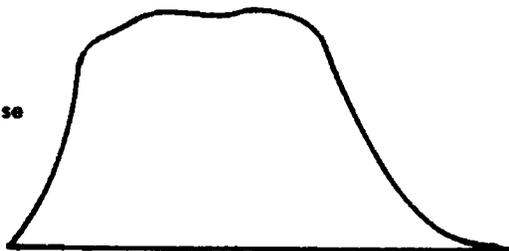
times sound bars will appear in the picture as well. When the sound carrier is too low, the sound usually becomes noisy or weak.

The curve should always have the general shape illustrated in Fig. 4-11.

## OVER-ALL RF-IF RESPONSE

The over-all RF-IF response curve seen on the scope is actually the response of the video-IF amplifiers, and its shape should be the same as that of the IF curve alone. The only difference is in the method of feeding the signal into the receiver. This is done by connecting the sweep generator to the antenna terminals and feeding in an RF signal of the correct frequency for the RF channel being checked. This signal passes through the RF amplifier first, and since the scope is connected across the video-detector load, the signal must be converted in the mixer and continue through the IF stages to the detector before we can see it. Therefore, what we actually see is the curve shape produced in the IF strip, the last receiver section to handle the signal. The marker signal is coupled in at the grid of the first IF and thus does not move on the curve when the channel selector is changed. This method is often used to check video-IF response because it is an easy way to interconnect the equipment. It is also a quick check that will show up inadequate RF bandwidth.

## SOUND-IF RESPONSE

The sound-RF carrier is frequency modulated and has a maximum frequency deviation of ±25 kc at 100% modulation (±75 kc for FM radio). In the transmitted signal the sound-RF

carrier is 4.5 mc above the video-RF carrier; but after conversion in the receiver front-end, the sound-IF carrier is below the video-IF carrier frequency. This transition takes place because the local-oscillator frequency is above both of the RF carriers.

In split-carrier receivers the sound-IF signal is either taken off ahead of the video IF's, or else is amplified in one or more video-IF stages and then taken off. Regardless of the take-off point, one or more sound-IF amplifier stages follow, feeding either a discriminator or ratio detector. The output of the sound detector feeds a conventional audio amplifier.

In intercarrier receivers, the sound-IF carrier is amplified in the video-IF stages along with the video signal. The sound-IF carrier heterodynes with the video-IF carrier in the video detector to produce a second sound-IF carrier of 4.5 mc, the difference frequency between carriers. This 4.5-mc signal is taken off after the video detector and then fed to a sound-IF strip and sound detector.

In split-carrier receivers the sound-IF frequency is either 21.25 or the standard 41.25 mc. The intercarrier sound-IF frequency is 4.5 mc, as we said earlier.

The response of the sound-IF channel can be checked by connecting the sweep and marker generators to the input of the first sound-IF stage, and connecting the scope across the grid
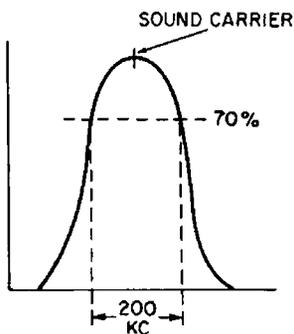


Fig. 4-12. A typical sound-IF response curve.

of the final IF amplifier. The signal is rectified at this point because the stage is biased to produce a current flow from the cathode to the control grid. A DC voltage proportional to the strength of the sound-IF signal therefore appears across the grid load. Fig. 4-12 illustrates a typical curve. Keep in mind that sound-IF curves may vary considerably depending on the type of coupling employed between stages. However, certain characteristics are desirable. They are as follows:

1. The curve should be symmetrical around the center or sound-carrier frequency.

2. The bandwidth between the 70% points should be approximately 200 kc.
3. The curve should have sufficient amplitude.

Although the bandwidth of the transmitted sound signal is only 50 kc at most, the 200-kc receiver bandwidth is desirable to compensate for local-oscillator drift. As explained earlier, if allowances were not made for normal oscillator drift, it may distort the sound output or even cut it off entirely.

## DISCRIMINATOR RESPONSE

The discriminator can be aligned, or its response checked, by connecting the sweep and marker generators to the grid of the second or third IF stage and the scope to the ungrounded output cathode of the discriminator stage. (See Fig. 4-13.) An ideal discriminator response curve is illustrated in Fig. 4-14. Here are some important factors to watch for in discriminator response curves:
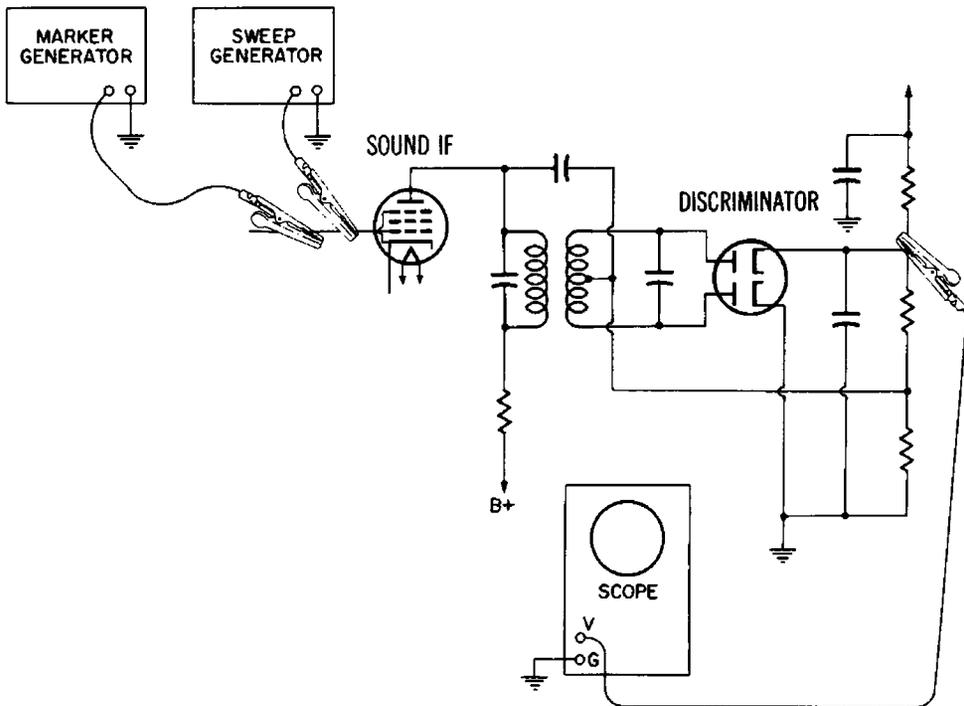


Fig. 4-13. Test setup for aligning discriminator or checking its response.

1. The curve must be linear over at least 25 kc on both sides of the center frequency. The best curve is one which is linear over the entire slope. A nonlinear curve is illustrated in Fig. 4-15A. Under these conditions the sound output will probably be distorted and possibly noisy because of AM interference.

Fig. 4-14. Ideal discriminator response curves.
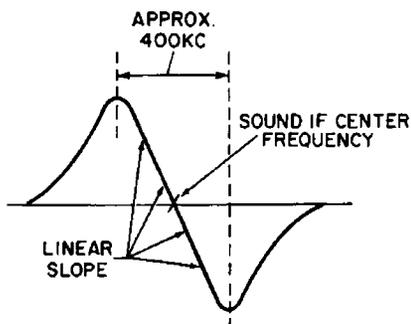
2. The bandwidth between peaks of the curve should be not less than 250 kc. (In some split-carrier receivers the bandwidth may be as great as 500 kc; intercarrier receivers average around 400 kc.) Too narrow a bandwidth (Fig. 4-15B) causes distortion or loss of sound. In split-carrier sets the picture quality may fall off at the point of best sound on the fine-tuning control. But don't be deceived by this condition—it is perfectly normal. If it occurs on stronger signals, however, check the discriminator center frequency and bandwidth for discrepancies. (It is a good idea to consult the manufacturer's data for the correct bandwidth.)

3. The sound-IF frequency should fall at the center of the slope. The curves in Figs. 4-15C and D illustrate the lack of symmetry when the sound-IF carrier frequency is too high and too low on the slope.

Fig. 4-16 shows some of the conditions in a misaligned discriminator circuit. Realignment can be accomplished quickly in two simple steps, using sweep and marker signals:

1. Adjust the secondary so the carrier falls at the intersection of the curve and reference trace. The discriminator output will then be zero at the center frequency.



(A) Nonlinear slope.



(B) Bandwidth too narrow.



(C) Sound carrier too high on slope.



(D) Sound carrier too low on slope.
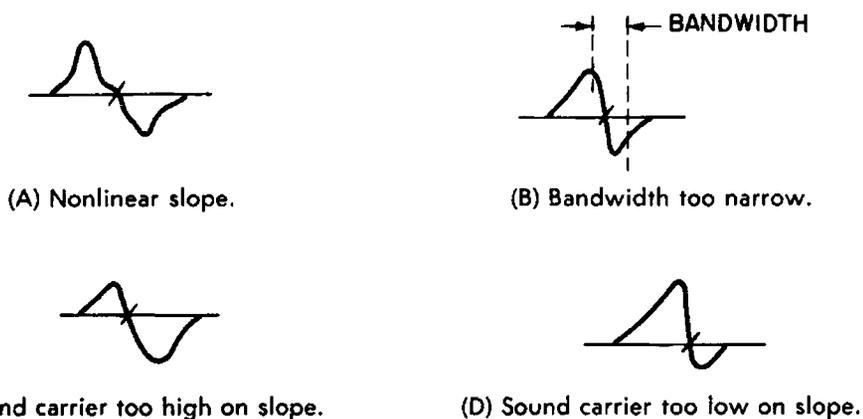
Fig. 4-15. Faults to watch out for in discriminator response curves.

2. Adjust the primary for equal curve amplitude above and below the carrier frequency.

The response curve of a ratio detector is generally the same as the discriminator's, except that in some receivers its high- and low-frequency slopes may be steeper and drop sharply to zero just past the peaks.



(A) Secondary tuned above carrier frequency

(B) Secondary tuned below carrier frequency.

(C) Primary tuned above carrier frequency.

(D) Primary tuned below carrier frequency.
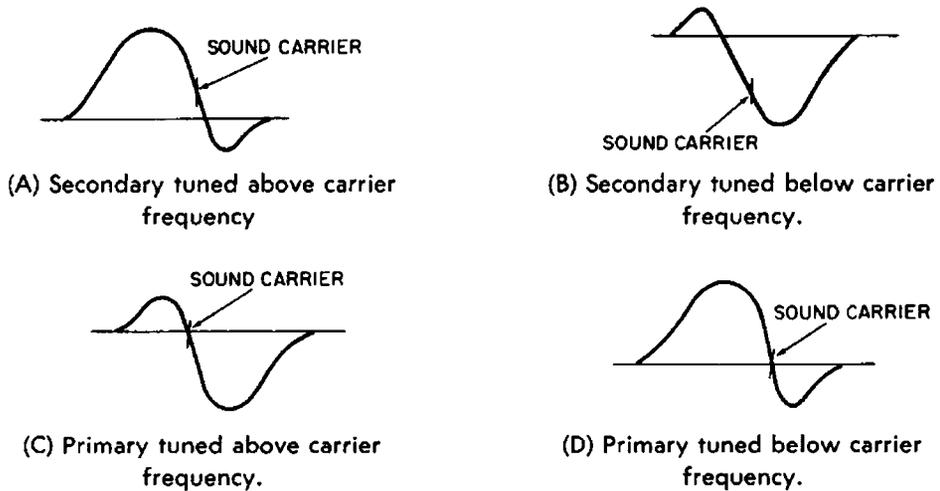
Fig. 4-16. Curves often encountered in misaligned discriminators.

# CHAPTER 5

# TV

# Alignment

The individual alignment steps for any receiver are given in the manufacturer's service data. However, these brief instructions presume the service technician has some prior knowledge and experience in alignment techniques. The purpose of this chapter is to provide you with the additional information needed to really understand the reason behind each step in the alignment procedure.

In the beginning, it is best to follow the manufacturer's alignment instructions to the letter. As you gain experience and learn the short cuts, the service data then becomes a valuable working guide.

## ALIGNMENT DIFFICULTIES AND PRECAUTIONS

Even after observing all precautions in connecting and adjusting the alignment equipment, you may run into trouble. One problem is that various oscillations and small waveforms sometimes appear on the response curve. One type of spurious response, termed "hash" (Fig. 5-1), is a very common occurrence. This is simply a poor signal-to-noise ratio in the receiver, caused by using a sweep signal of too low a level. Normally the
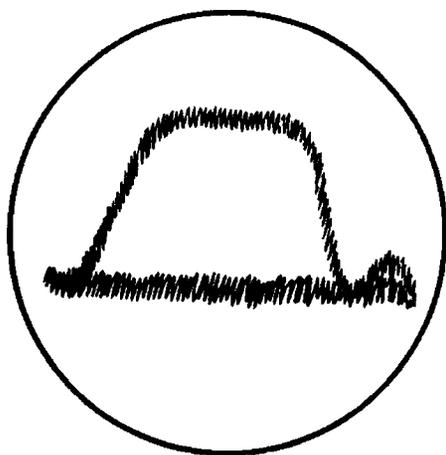
Fig. 5-1. A spurious response, called "hash," caused by too weak a signal or by pickup from receiver's deflection oscillators.

sweep output signal should be kept low, but if "hash" shows up, try increasing the sweep signal level and reducing the vertical gain of the scope. (Be careful not to increase the signal to the point of overload.)

Another type of curve interference resembling hash is pickup from the vertical- or horizontal-deflection amplifiers of the receiver itself. The solution is the same as before—or as an alternative, disable the offending oscillator.

In the service shop, oscillation resembling a marker pip sometimes occurs because of stray radiation from the local oscillator of a nearby TV receiver. The obvious solution is to change channels or turn off the offending receiver.

Oscillation in the video-IF strip — caused by two stages aligned to the same, or nearly the same, frequency—produces the pattern in Fig. 5-2. Other possible causes are poor grounding, feedback through a test lead, stray coupling, or an open bypass capacitor.

As in most high-gain circuits, the video-IF amplifiers are highly susceptible to regeneration, a condition of in-phase
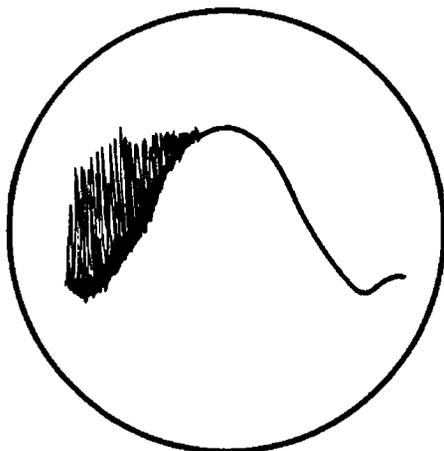


Fig. 5-2. Pattern produced by oscillation in the video-IF strip.

(positive) feedback from the output to the input circuits. Regeneration greatly increases circuit selectivity and gain, and when it occurs, the normally rectangular IF response curve breaks down into a badly distorted waveform having one or more very high voltage peaks. (A VTVM connected across the video-detector load resistor may read as high as 50 volts.) Even slight regeneration will peak the response curve at some frequency.

Because regeneration greatly changes the shape of the IF response, this in turn produces many effects on the screen. Some of these can be very misleading—loss of picture detail, ghosts, weak picture, smearing, negative picture, and herringbone stripes are just a few. The pattern varies with the frequency and amplitude of the regeneration. In many instances you can pinpoint the oscillating stage by bringing your hand close to each circuit and watching for changes in the over-all waveshape.

Since oscillation is most often caused by two IF stages tuned to approximately the same frequency, the first step in correcting the trouble is to align the entire IF strip. Follow the manufacturer's instructions, because there's a good chance someone before you didn't.

The first step is to disable each IF stage, except the last, by temporarily soldering a .005-mfd capacitor between the grids and ground. With the VTVM connected across the video-detector load resistor, connect the marker generator to the grid of the last IF stage and peak-align it to the correct frequency. Remove the shunt capacitor from the grid of the next-to-last stage, connect the marker generator in its place, and align to the correct frequency. Repeat this procedure for each IF stage, working back from the video detector to the converter.

### Misaligned Traps

Off-frequency traps can distort the resposne curve badly, as illustrated in Fig. 5-3. Here, a 27.25-mc trap is misaligned to a
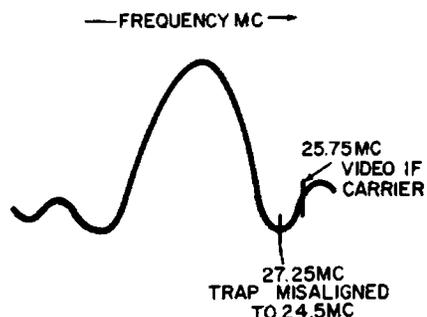


Fig. 5-3. Effect of a misaligned trap on the response curve.

—FREQUENCY MC—

25.75MC
VIDEO IF
CARRIER

27.25MC
TRAP MISALIGNED
TO 24.5MC

point below the video-carrier frequency. If some other factor such as narrow bandwidth were to further distort the response, the curve would probably be totally unrecognizable. If a curve similar to this appears, you can quickly identify the trap points by touching each trap with your finger. The added body capacitance will shift the trap frequency and cause the dip to move. Of course you won't know if the trap is off-frequency or not until the marker signal is injected. One effect of an off-frequency trap is illustrated in Fig. 5-4.
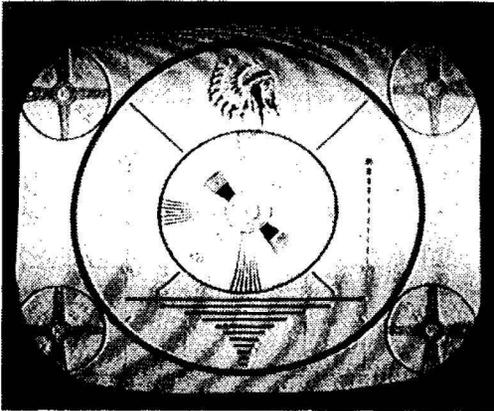


Fig. 5-4. Effect of an off-frequency trap on picture quality.

When aligning an IF amplifier using overcoupled transformers, you may notice an unidentifiable dip, resembling that produced by a trap, on the response curve. This often baffling effect is produced when the sweep generator swamps out the effectiveness of the IF transformer secondary, while the primary (a resonant circuit) acts as an absorption trap. At the resonant frequency of the primary, some of the sweep signal is absorbed. This reduces the signal reaching the detector, and a dip therefore appears in the response curve. The position of the dip depends on the resonant frequency of the primary, and the exact effect on the curves varies as shown. By shunting the primary with a capacitor of 200 mmf or so, the resonant frequency is lowered sufficiently to remove the trap effect and restore the curve to normal.

## Miscellaneous

Regeneration, oscillation, or response-curve instability is sometimes the result of inadequate grounding, as mentioned previously. The most common of these is due to power-line coupling. This is caused by the receiver and alignment equipment being at different ground potentials, so that feedback occurs between the equipment through the power line. Proper grounding is the only remedy.

Before tuner RF alignment is undertaken, two preliminary preparations—usually ignored or overlooked—should be made. First, to prevent curve distortion caused by hum and trap reflections from the IF strip, disable the video-IF input stage by pulling the tube or shunting the grid to ground with a .005-mfd capacitor. The second step, though not always necessary, is to load the primary of the first IF transformer by connecting a resistor of approximately 270 ohms across it, to damp out resonance in the converter plate circuit. Always keep the oscillator tube in the socket when the RF front-end is being aligned. Otherwise, misleading curve distortion occurs if the oscillator bias is removed from the converter.

## PRACTICAL ALIGNMENT PROCEDURE

The following circuits and procedures are intended as a working guide to practical alignment methods, and may be adopted to any TV receiver. Keep in mind that the response curves encountered may differ considerably from the examples presented here, but the basic methods and the results obtained do not.

### Checking RF-IF Response

1. Interconnect the alignment equipment as illustrated in Fig. 5-5, using the proper matching networks and an isolating resistor of approximately 10K in series with the scope's vertical-input lead, shunted by a 330-mmf capaci-
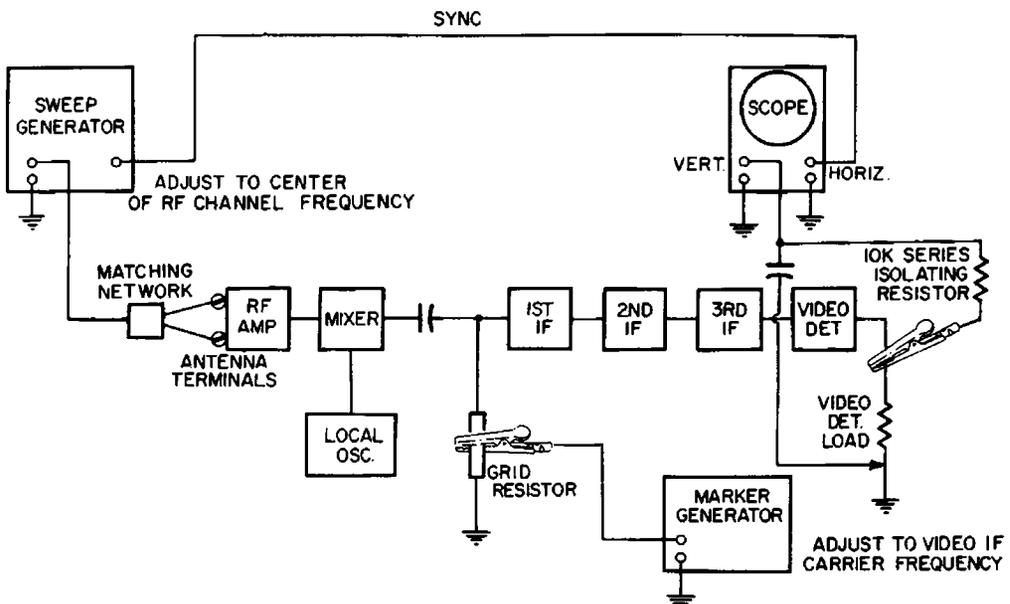


Fig. 5-5. Method of connecting equipment for checking RF-IF response.

tor. (The marker is coupled to the circuit by connecting the "hot" generator lead to the insulated body of the grid resistor.)

2. Turn the channel selector to the highest local channel and the fine-tuning control to a midrange setting.
3. Set the sweep generator to the same channel center frequency, and the marker to the video-IF carrier frequency.
4. Clamp the IF-RF AGC bus line with the bias voltage recommended by the manufacturer.
5. Adjust the operating controls of the alignment equipment until you obtain a response curve of the proper shape and amplitude. Be careful to keep the sweep and marker signals low in order to prevent overloading. The video-IF carrier marker pip should fall between the 40 and 60 per cent points on the slope.
6. Readjust the marker to the sound-IF carrier frequency. The marker pip should now appear on, or disappear into, the sound-trap dip on the curve. After the bandwidth of the first response curve has been checked, the marker can be readjusted to the video-IF carrier frequency and left there throughout the remainder of the response check. The width of the other curves on other channels will indicate whether the bandwidth is satisfactory or not.

Check the response on each local channel, changing the sweep-generator frequency at each step. Remember that the response will be different on each channel, but must always be within the limits outlined earlier. If the response is not up to par on one particular channel, make a mental note to check its RF response later. If the video-carrier marker is outside the specified limits (40 to 60 per cent of the slope) on one channel, check the local oscillator by varying the trimmer slug slightly. This will usually bring the marker pip into line.

When the over-all response curve has the general shape of the IF curve on most of the channels checked, you can assume the video-IF alignment is satisfactory. If not, check the video-IF response by moving the sweep-generator lead to the grid of the converter stage and adjusting the generator frequency to sweep the IF bandwidth. This circuit will probably be out of alignment.

## Traps

Image and sound interference in the picture is a common problem, because of the position of the carriers in the channels, the circuit design of TV tuners, and the very nature of TV channel allocations themselves. To eliminate these problems,

traps coupled to the IF circuits and tuned to the frequencies of the interfering signals are used. The traps absorb these signals from the IF signal before they reach the video detector. The procedure to use in trap adjustment is as follows:

1. Set up the equipment as in video-IF alignment. (See Fig. 5-5.)
2. Adjust the marker generator to the exact frequency indicated for the trap to be aligned (this value usually appears on the circuit diagram, next to the trap symbol).
3. Adjust the trap for minimum indication on the scope or VTVM. If more than one trap is tuned to the same frequency, adjust each one for minimum output.
4. Increase the marker-generator output slightly, and retune the trap (or traps) for minimum output.
5. Repeat the process at all trap frequencies, increasing the generator signal level at each until you have obtained the lowest output. Usually there are at least two different trap frequencies; nevertheless, the procedure for each is always the same.

## Peak Alignment

If a receiver is too far out of alignment for ordinary sweep-alignment touch-up, a procedure known as stage-by-stage sweep, or peak, alignment will be required. The setup for peak-aligning the video-IF strip is illustrated in Fig. 5-6. Either the
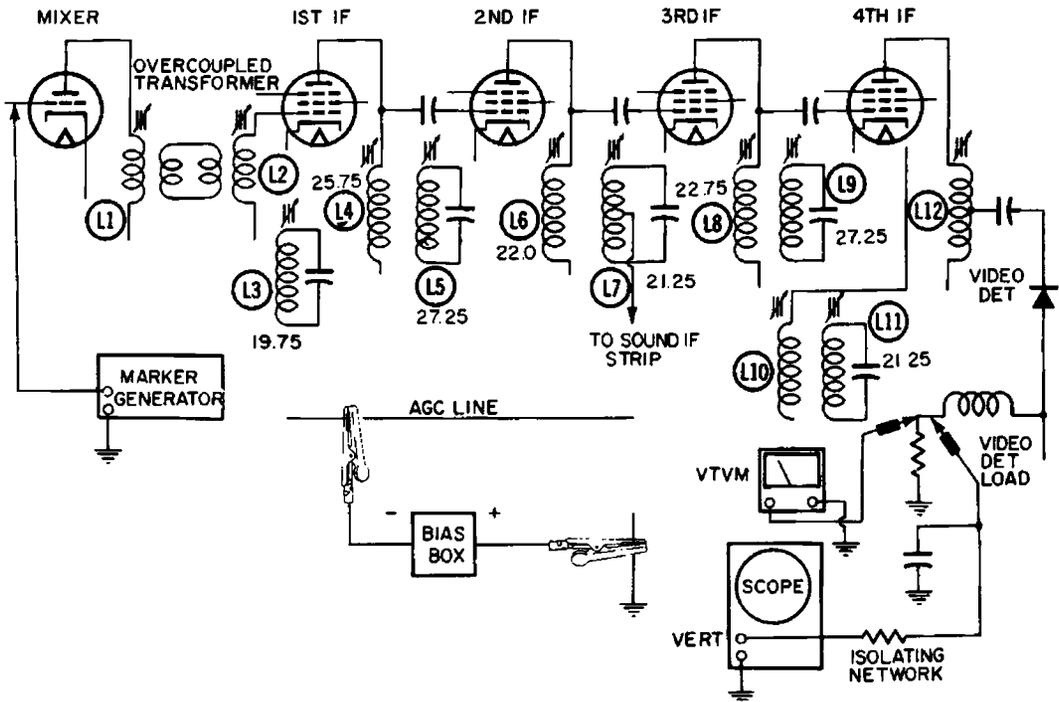


Fig. 5-6. Test setup for peak alignment of video-IF strip.

scope or the VTVM may be used as a peak indicator, or both may be used together. Using both provides a decided advantage: when you are making adjustments for minimum or maximum meter deflection, a look at the scope pattern will indicate the presence of any signal overload. However, the input signal must be modulated to provide the necessary scope deflection. Modulation is not needed when the VTVM is used alone, because it indicates only the DC voltage developed by the video detector.

Sound traps are generally aligned first. An important point to keep in mind, when aligning traps, is to use a reasonably strong signal. Switch the VTVM to the second lowest scale (3 or 5 volts) and adjust the marker-generator output for nearly a midscale reading. In our hypothetical receiver of Fig. 5-6, we would adjust the first sound trap L7 for a minimum indication on the meter, and then adjust the second sound trap, L10. If you have trouble obtaining a definite dip on the meter when adjusting the first trap, detune the second trap until the meter indicates a higher reading, and then adjust the first for a minimum. If difficulty is still experienced, move the marker-generator lead to the IF grid just ahead of the second trap and adjust it for a minimum reading. Reconnect the marker lead to the mixer stage, and then adjust the first sound trap. The meter should now indicate a definite dip in resonance.

Image traps L5 and L9 are adjusted next, using the same procedure. This should be followed by adjustment of adjacent-channel video trap L3.

Before making any IF-transformer adjustments, set the generator output to minimum and make certain the bias box is set at the bias value recommended by the manufacturer.

The service data for any TV receiver will specify that the coils be aligned in a certain order—usually the same as for our typical circuit (L8, L11, L6, and L4). Adjust the marker-generator output frequency to that of L8 (Fig. 5-6), and increase the signal output until you obtain a legible meter indication. Then adjust L8 for maximum output. Repeat the procedure for remaining coils L11, L6, and L4. This completes the alignment of the traps and stagger-tuned coils.

However, overcoupled mixer–first-IF transformer L1 still remains. The simplest method of aligning L1 is from its response curve, using an RF probe as illustrated in Fig. 5-7A. The desired response curve is shown in Fig. 5-7B. Time and trouble can be avoided by using two alignment tools and simultaneously adjusting the overcoupled-transformer primary and secondary while observing the response curve. With a little
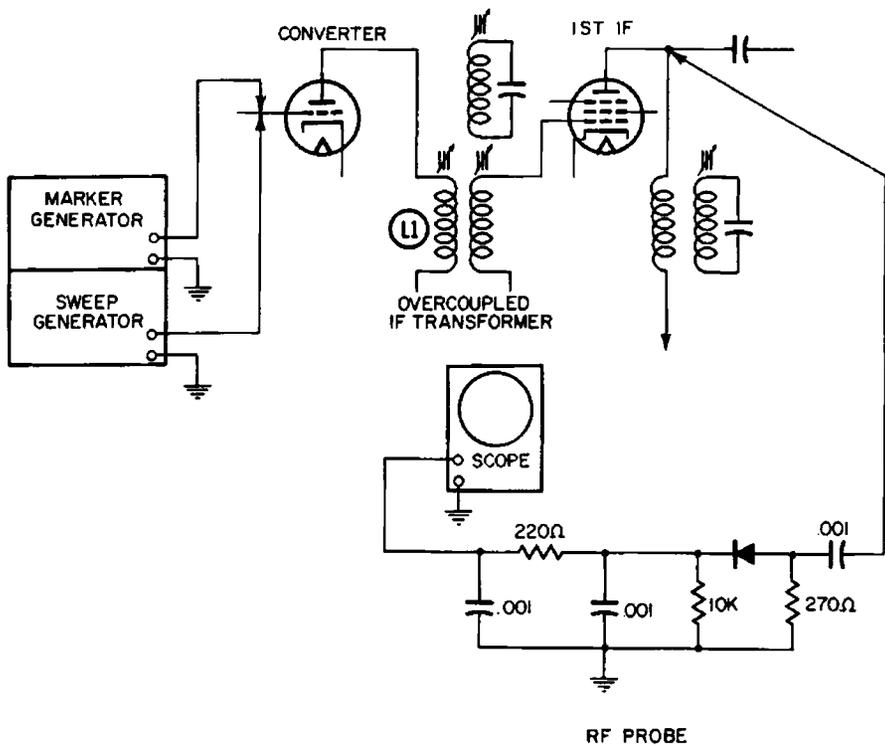
(A) Circuit connections.
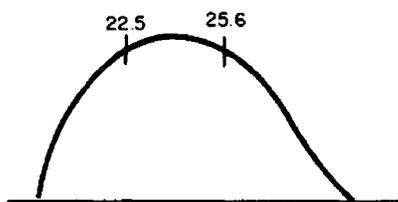


(B) Curve seen with RF probe.
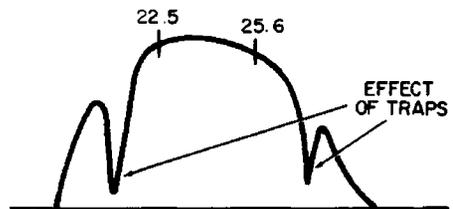
(C) Effect of traps.

Fig. 5-7. Using an RF probe to check the response of an overcoupled IF stage.

patience and practice you will be able to tell if the curve is shaping up properly, and if not, which direction to make each adjustment in order to obtain the desired response.

A 270-ohm resistor is needed across the RF probe input to swamp out the first video-IF plate coil because we do not want to see its response. The probe is connected to this point to isolate it from the first IF grid circuit and prevent loading, which would alter the resonant frequency of the transformer. The transformer response curve can be taken off the video detector without an RF probe, but first it is necessary to disable the other IF stages by shunting all coils with a 390-ohm resistor. The traps need not be similarly disabled because their only effect is to add dips in the curve, as shown in Fig. 5-7C.

The response curve of any IF stage or combination of IF stages can be viewed by disabling the others with shunting

resistors. Thus, stagger-tuned IF amplifiers can be sweep-aligned if alignment data showing reference curves are available.

## Step-Sweep IF Alignment

Step-sweep alignment is a little more complicated than peak alignment, but it is sometimes required in order to obtain the desired result. The equipment is interconnected as illustrated in Fig. 5-8. The marker signal is injected at the mixer stage, and the scope is connected across the video-detector load resistor. The sweep-generator lead, terminated with a series ca-
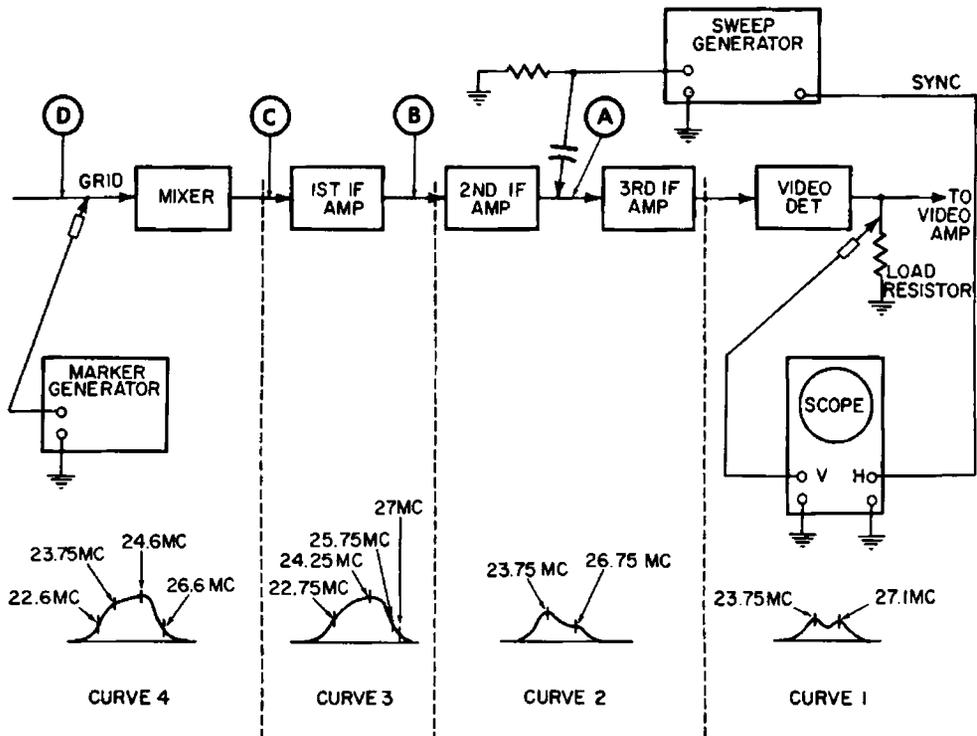


Fig. 5-8. Method of connecting equipment for step-sweep IF alignment.

pacitor and shunt resistor, is connected to point $A$ (the grid of the last video-IF amplifier). The sweep-generator output frequency is adjusted to sweep the entire IF bandwidth, and the marker is adjusted to 27.1 mc (the first frequency to be checked). The video-IF carrier frequency in this example is 26.6 mc. To obtain the scope response shown by curve 1, adjust the last IF output circuit for a peak at the 27.1-mc marker frequency. Set the marker output frequency to 23.75 mc and adjust the trimmer capacitor, between the detector and last IF stage, until you obtain a second peak. The curve on the scope should now resemble curve 1.

Readjust the marker generator to the frequency of the trap just ahead of the third video-IF stage. Remove the sweep lead and turn on the 400-cycle internal modulation of the marker generator. Adjust the trap for minimum modulation amplitude on the scope screen.

Reconnect the sweep lead to position $B$ at the grid of the second video-IF stage. Turn the sweep-generator output attenuator to zero and increase the output until a usable curve is obtained without overloading. Turn the marker modulation off and readjust the output frequency to 23.75 mc. Adjust the circuits between the second and third IF stages for a response resembling curve 2 but having the main peak at the marker frequency.

Again disconnect the sweep lead, retune the marker frequency to that of the first IF plate trap, turn the internal marker modulation on, and adjust the trap as before.

Most receiver manufacturers recommend aligning the sound-IF strip at this time, because of interaction of the sound take-off transformer with the video-IF coupling network. After completing the sound-IF alignment, connect the sweep lead to point $C$ and align the circuits between the first and second IF stages for a response similar to curve 3. There are no traps to be adjusted, so connect the sweep lead to point $D$ and make final adjustments at the mixer output and at the input of the first IF stage for the over-all response of curve 4. The video-carrier marker should fall near the 40 per cent point on the slope of the curve.

### Discriminator Alignment

As a rule the discriminator can be aligned by using either the sweep or the peak method. The sweep method was discussed in detail in another chapter. Now let's look at the peak method.

The marker signal is injected at the grid of the last sound-IF stage, and the VTVM is connected to the center of the discriminator load resistors as in Fig. 5-9. A large-value isolation resistor is generally added in series with the VTVM lead to compensate for the small shunt capacitance of the probe. Connect the VTVM to point $A$ first. Adjust the marker generator to the sound-IF carrier frequency, and tune the discriminator-transformer primary (top slug) for maximum reading on the VTVM. Reduce the marker-signal level and readjust the primary for maximum meter swing. Remove the VTVM lead and zero-center the meter. Then reconnect the VTVM lead to point $B$ (the discriminator output cathode). Adjust the
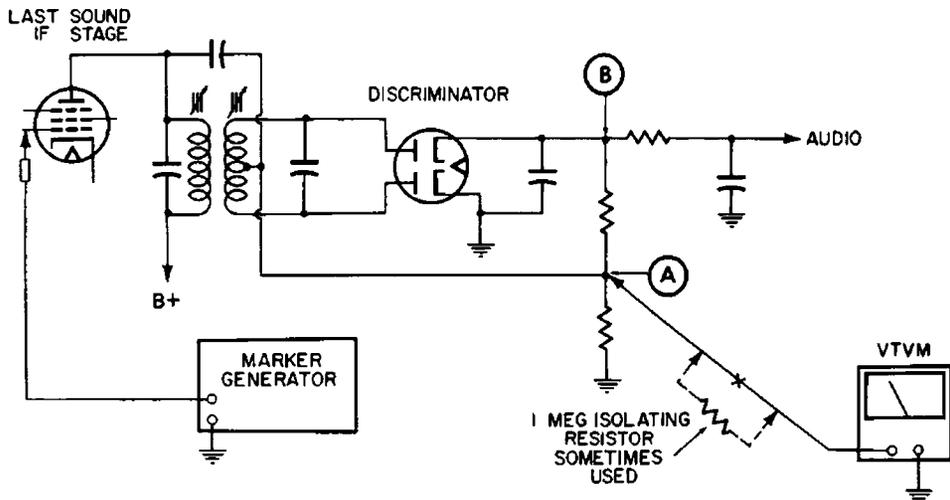
Fig. 5-9. Equipment connections for peak-discriminator alignment.

discriminator-transformer secondary (bottom slug) for zero output on the meter.

Check out the discriminator alignment (response), using the zero-center of the VTVM as a reference. Adjust the marker frequency away from the sound-IF carrier frequency until the meter indicates a peak positive or negative voltage. Readjust the marker output back through the IF frequency and on, until a peak voltage of the opposite polarity is reached. The peak-voltage readings should remain almost the same. If not, turn the primary slug in a turn or so, and readjust the secondary for zero output at the sound-IF carrier frequency. Check the peak voltages again; if farther apart, turn the primary slug two or three complete turns out, and again zero the secondary. Repeat this procedure until the peak voltages are at least within 10% of each other.

If you have difficulty obtaining normal discriminator response, even after the primary and secondary windings have been correctly tuned, the reason may be other than misalignment. Use the sweep check described earlier to pinpoint the trouble. Curves like those in Fig. 5-10 indicate a defective transformer, which must be replaced before the desired response can be obtained.

## Ratio Detector Alignment

The ratio detector (distinguishable from the discriminator by the fact that it has a tertiary transformer winding and an electrolytic capacitor in the load circuit to provide a constant reference voltage) is sweep- or peak-aligned like the discriminator. A typical circuit and the connection points for the alignment equipment are illustrated in Fig. 5-11.
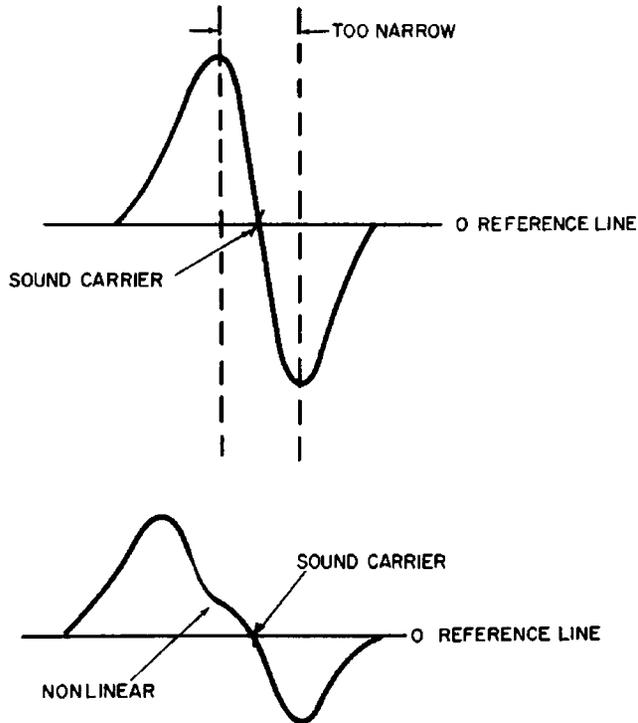
Fig. 5-10. These curves indicate a defective discriminator transformer.

If a scope is used, it is connected to the detector output at point *B*. In sweep alignment the response curve should have the same general appearance as the discriminator curve, except that the low- and high-frequency slopes are sometimes comparatively steeper. In any event, keep in mind that the primary adjustment of the detector transformer (discriminator or ratio detector) determines the curve linearity, and the secondary adjustment determines the center frequency.
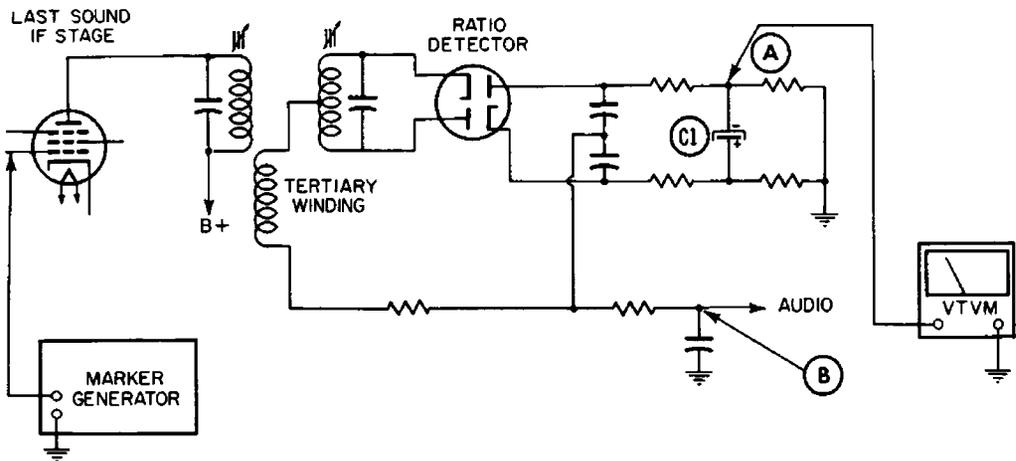


Fig. 5-11. Equipment connections for ratio-detector alignment.

To peak-align a ratio detector, (1) connect the VTVM lead to point *A*, (2) adjust the marker to the sound-IF carrier frequency, and (3) peak the primary. Disconnect the VTVM lead, zero-center the meter, and reconnect to point *B*. Then adjust the transformer secondary for zero output.

In some ratio-detector circuits, one end of the charging capacitor (C1) is grounded, and therefore a residual DC voltage will be present on the audio-output line (point *B*). Because of this DC voltage, the transformer secondary cannot be aligned
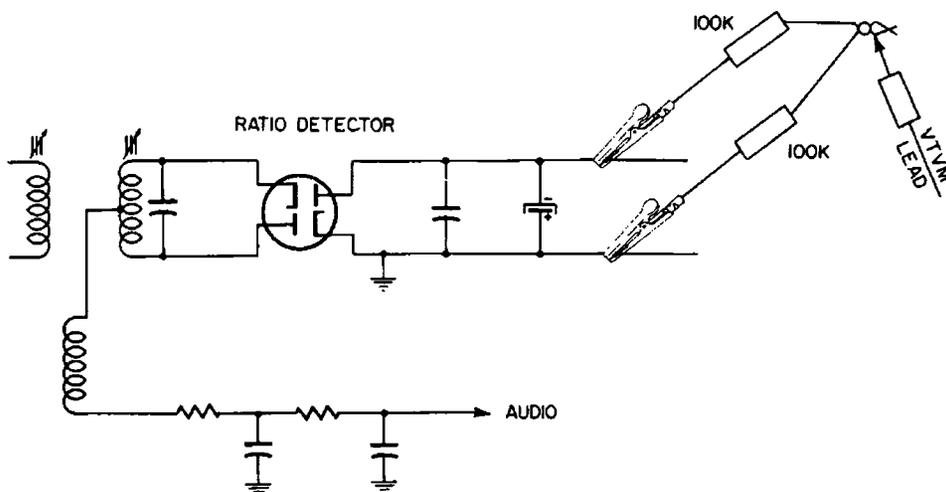


Fig. 5-12. Method of connecting a VTVM in a ratio-detector circuit where one side of charging capacitor is grounded.

with the VTVM when the lead is applied to this point. This problem is overcome by making the connection illustrated in Fig. 5-12. Here, two 100K resistors in series are temporarily jumped across the electrolytic capacitor, and the VTVM lead is connected to the center point. The ratio-detector secondary can then be adjusted for zero output.

## Sound-IF Alignment

Some of the symptoms which indicate misalignment of the sound IF strip are:
1. No sound on all channels.
2. Weak or distorted sound.
3. Excessive sync buzz.
4 Poor picture-sound tracking.

There are several methods of aligning the sound-IF section, but the following is probably the simplest and fastest:
1. Connect the marker generator to the grid of the stage preceding the sound take-off point.
2. Connect the VTVM to the grid or plate of the audio-output stage.

3. Adjust the generator to the sound-IF frequency, and turn on the internal 400-cycle modulation.
4. Peak all sound-IF slugs for maximum meter deflection. Repeat the adjustments at least twice, each time reducing the generator output as required.
5. Connect an antenna to the receiver, and tune in a local channel. Touch up the discriminator transformer, if necessary, for minimum sync buzz

Where misalignment is so serious that the modulated signal cannot pass through the IF strip, it will be necessary to align each stage separately by feeding the signal in at the grid of each stage, working back from the detector to the sound take-off point.

If the picture-sound tracking is poor and a generator is not readily available, such as on home service calls, the following procedure is generally quite effective.

1. Set the fine-tuning control for the best picture quality, and then turn it slightly until the sound is barely heard.
2. Peak all sound-IF slugs for maximum volume. Repeat the adjustments until the sound and picture quality coincide for one setting of the fine-tuning control. Check each local channel for proper picture and sound.
3. Carefully adjust the discriminator transformer to clear up any distortion or sync buzz in the sound output.

## FINAL CHECKS

After all tuned sections of a receiver have been properly aligned, it is important to check the over-all response curves and make any final touch-up adjustments necessary.

Interconnect the alignment equipment and check the over-all RF-IF response curve on each local channel. The curve shape normally varies from one channel to the next, but each curve must be within the limits specified earlier. If the response on one channel is poor, try touching up the video-IF adjustments slightly. Be careful, though, that the adjustments do not affect the response on other local channels. Under normal conditions, the video-IF carrier marker should fall in the 60% region of the curve slope. However, for fringe-area reception the IF strip may be aligned with the carrier nearer the 70% point on the curve; and in primary signal areas it can be down to the 30% point.

If the over-all response is poor on all channels, there may be a defect in the video-IF strip or the IF coils may be aligned to the wrong frequency or perhaps interchanged in frequency.

A hump in the IF response curve (Fig. 5-13A) may be noticeable in some receivers. The hump is caused by overcoupling in the coil-and-trap combinations of some receivers. The trap coils are usually wound on notched forms, as in Fig. 5-13B. To remedy the overcoupled condition, use solvent to soften the cement holding the turns in place, and unscrew the coil on the form. This reduces the coupling and should eliminate the hump as well. Once the best position for the coil is found, recement it to prevent microphonic feedback troubles.

Difficulty often arises in aligning tightly coupled coils and traps because of interaction between adjustments. There are two core positions for both the coil and the trap which will

(A) Response curve.
(B) Notched coil form.
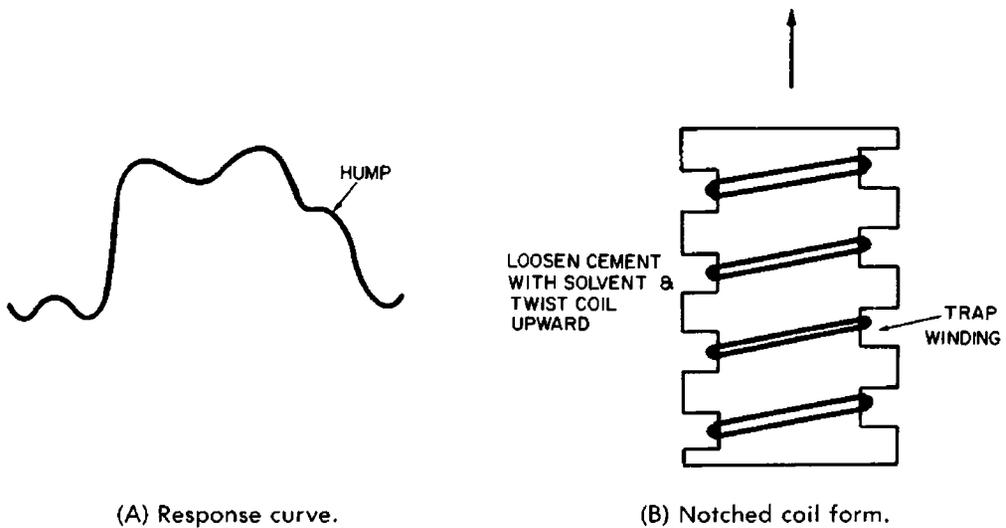
Fig. 5-13. A hump in the IF response curve may be caused by overcoupling in the coil-and-trap combinations of some receivers.

indicate a peak or null on the VTVM. The outer-core setting is always better since the inner setting puts the cores too close to each other, resulting in serious interaction. (There will still be a certain amount of interaction, but it is of little consequence.) Sometimes it is necessary to use the inner setting because the core cannot be moved upward far enough to reach the second point of resonance.

Time can often be saved by working on the over-all IF response curve, but the misalignment must be relatively minor. If you have a TV chassis to practice on, you can quickly learn what frequencies are associated with the response curve and what effects are produced as the various coils are adjusted.

To check the over-all response of the sound-IF channel, interconnect the equipment as described previously, except feed the sweep and marker generators to the grid circuit of the first

sound-IF amplifier. Touch up the sound-IF slugs, if necessary, to obtain a response as close to the ideal curve as possible. Move the scope lead to the discriminator output, and check the discriminator curve for linearity and center-zero at the sound-IF carrier frequency. This step completes the alignment job.

The principal considerations in the alignment of video- and sound-IF strips are:

1. The IF strip must be adjusted for maximum gain to obtain the best sensitivity at the required bandwidth. This refers to the amplitude of the response curve.

2. The bandwidth must be sufficient to amplify all sideband frequencies uniformly. This refers to the width of the response curve.

3. Traps must be accurately adjusted to the correct frequency to prevent serious interference from undesired signals.

4. The carriers must be properly placed on the response curve to obtain the proper phase and amplitude to compensate for vestigial-sideband transmission (sideband suppression at the transmitter).

# CHAPTER 6

# VHF Tuner

# Alignment

Because of the complicated-appearing circuitry, few technicians attempt TV tuner alignment, other than minor oscillator adjustments. Actually, tuner alignment is not really difficult; it is just lengthy. Some symptoms that indicate a need for tuner alignment are:

1. No picture, no sound, or both, on one or more local channels.
2. Weak, snowy picture on one or more local channels.
3. Distorted sound on one or more local channels.

NOTE: Always replace any weak tuner tubes before attempting alignment.

Most tuners have one or more RF-mixer adjustments. The local-oscillator section may have as many as three frequency controls (individual channel slugs accessible from the front panel, plus the fine-tuning control and a master oscillator adjustment). Although the oscillator adjustments all accomplish the same end, each has its own particular purpose. The master oscillator adjustment is made after the oscillator tube has been replaced, or to align the oscillator when one or more channels cannot be adjusted by the individual channel slugs. The fine-tuning control compensates for oscillator drift.

## OSCILLATOR CHECK

Oscillator alignment should be undertaken only if the fine-tuning control does not tune at all within its range, or if it produces good sound and picture only at the extremes of rotation. If some but not all channels cannot be tuned in, or they are not near the center of the fine-tuning control range, adjust the oscillator trimmer for the best compromise in tuning on all channels. For example, if all channels tune best to one side of the control, adjusting the master oscillator trimmer will bring them all toward the center. On the other hand, if just one or two channels tune best at one end of the control and others do so at the other end, adjusting the master trimmer will bring one group to the center and move the remaining ones beyond the range of the control. In such a case the oscillator coils must be aligned individually.

For over-all tuner alignment, the equipment is interconnected as described previously for visual IF alignment. If the tuner alignment is preceded by IF alignment, reinsert the oscillator tube and disconnect the sweep-generator lead. Connect the sweep leads, through a balanced network, to the receiver antenna terminals (Fig. 6-1). The scope is left connected across the video-detector load resistor. Refer to the manufacturer's data for biasing information. In addition to the bias on the AGC bus, separate bias is sometimes required on the RF AGC line.

Although the following alignment instructions and data describe the particular steps taken in one type, the basic principles apply to all tuners. You must be able to differentiate between tuners, and know which procedures are required for each. This information is correlated wherever possible to make it concise and comprehensive.

## OSCILLATOR ALIGNMENT

The following procedure is recommended for VHF oscillator alignment:
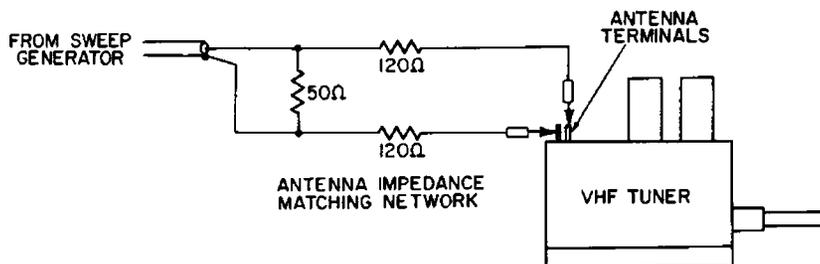


Fig. 6-1. One type of antenna impedance-matching network.

1. Connect the sweep generator, through a matching network, to the antenna terminals of the receiver. Adjust the channel selector and sweep generator both to Channel 13. Set the sweep width to 10 mc. Adjust the internal marker, if one is available, to the Channel-13 video-RF carrier frequency. See Table 6-1.
2. If the sweep generator has no internal marker source, couple a marker generator to a floating tube shield over the mixer stage and tune it to the RF video-carrier frequency (Channel 13).
3. Loosely couple a second marker generator to the first IF-amplifier grid circuit and tune it to the video-IF carrier frequency.

## Table 6-1. VHF Television Channel Frequencies.

| Channel | Bandwidth (mc) | Video Carrier | Sound Carrier |
|---------|----------------|---------------|---------------|
| 2 | 54-60 | 55.25 | 59.75 |
| 3 | 60-66 | 60-66 | 65.75 |
| 4 | 66-75 | 67.25 | 71.75 |
| 5 | 76-82 | 77.25 | 81.75 |
| 6 | 82-88 | 83.25 | 87.75 |
| 7 | 174-180 | 175.25 | 179.75 |
| 8 | 180-186 | 181.25 | 185.75 |
| 9 | 186-192 | 187.25 | 191.75 |
| 10 | 192-198 | 193.25 | 197.75 |
| 11 | 198-204 | 199.25 | 203.75 |
| 12 | 204-210 | 205.25 | 209.75 |
| 13 | 210-216 | 211.25 | 215.75 |

4. Connect the scope, through a decoupling network, across the video-detector load resistor.
5. Clamp the AGC bus as required.
6. Set the fine-tuning control to midrange. If there are two markers in the scope pattern, turn the fine-tuning control to determine which direction of rotation brings the markers closer together. If the control must be rotated clockwise, return it to midrange and squeeze the Channel-13 oscillator-coil turns together while watching the markers. Be extremely careful—only a slight movement is enough to adjust (or badly misadjust) these coils. When just a loop is used for the oscillator coil, bend it toward the wafer. If the fine-tuning control must be rotated counterclockwise to bring the markers together, the oscillator-coil

turns must be opened or a loop pulled up from the wafer. When the RF and IF video-carrier markers coincide, the oscillator is properly aligned for that channel.

7. Switch the selector to Channel 12, adjust the sweep likewise, and set the RF marker to the Channel-12 RF video-carrier frequency. Leave the IF video marker connected as is. Adjust the Channel-12 oscillator coil or loop for zero-beat of the markers.
8. Repeat the procedure for each channel from 11 through 2.
9. Recheck all channels, keeping in mind that the high-channel loops (7 through 13) are usually adjusted by moving them up or down, and that the low-channel coils are adjusted by pushing the turns together or spreading them apart.

## RF AND MIXER ALIGNMENT

Up to three adjustments can be made in order to produce the proper tuner response on any channel. These are in the antenna, RF, and mixer circuits. Practical design considerations dictate that tuner circuits follow a certain order of physical placement. From the front, the wafers contain these circuits:

1st Wafer—Oscillator coils
2nd Wafer—Mixer (converter) coils
3rd Wafer—RF coils
4th Wafer—Antenna coils

The RF wafer has B+ voltage on it, so be careful not to touch it with your hand or a metal tool while the receiver is operating. The oscillator coils, on the first wafer, should not be disturbed during the RF or mixer adjustments.

With the equipment still interconnected for the oscillator alignment, proceed as follows:

1. Disconnect the marker generator from the IF-amplifier grid circuit.
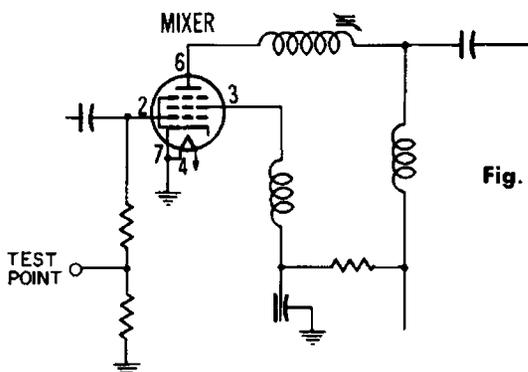


Fig. 6-2. Test point used during RF and mixer alignment.

2. Remove the first IF-amplifier tube and shunt the grid resistor with another resistor of 100 ohms or so. (In series-string receivers, disable the IF with a .05-mfd capacitor across the grid resistor.)
3. Move the scope lead to the test point at the center of the mixer grid load (Fig. 6-2). Use an isolating resistor of 10K or so in series with the scope lead. The vertical amplifier of the scope must have good sensitivity to adequately display a legible pattern of the RF response from this point.

## Rough-Alignment Procedure

After these preliminary steps have been taken, roughly align the high-band channels as follows:

1. Adjust the channel selector and sweep generator to Channel 13.
2. Tune the sweep-generator internal marker to the Channel-13 video-carrier frequency (or use an external marker generator).
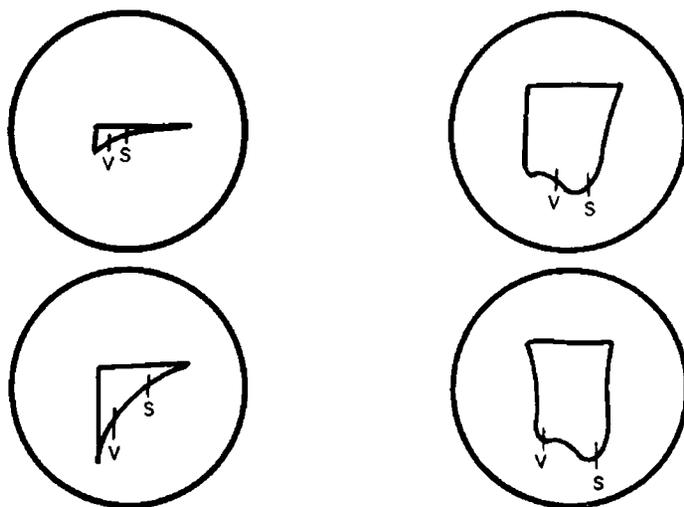


Fig. 6-3. Transition of a poor response curve into the desired shape (Fig. 6-4) as the coils are expanded or compressed.

3. Connect a marker generator (two, if the sweep generator is not equipped with an internal-marker source) to the receiver antenna terminals, and tune to the Channel-13 video- and sound-RF carrier frequencies.

If the coils are badly misaligned, their turns will have to be compressed or expanded slightly before the proper response can be obtained. Fig. 6-3 shows a very poor response curve and the transition seen on the scope as the turns of the various coils are expanded. When the coils are this far off, all three (if used) affect the curve height

mainly, so they should be adjusted initially for increased amplitude.

4. As the antenna, RF, or mixer-coil response is changed by the adjustment, the amplitude will rise on one side of the pattern and a hump will move across the curve. When the hump appears between the markers while you are adjusting a coil, this indicates the coil is almost properly adjusted. Leave it as is, and adjust another coil.

The lowest side of the curve indicates what steps to take next. If the left side is lower in amplitude, the next coil must be opened. If the right side is lower, the coil turns should be squeezed together. After the three coils have been roughly adjusted, the humps should be of nearly equal amplitude. The humps at the video- and sound-marker frequencies indicate that the RF and mixer coils are near the correct setting. Try adjusting the antenna coil slightly, to see if the curve amplitude can be improved. The correct setting is the point of maximum curve height.



Fig. 6-4. The desired response curve.

VIDEO CARRIER MARKER          SOUND CARRIER MARKER
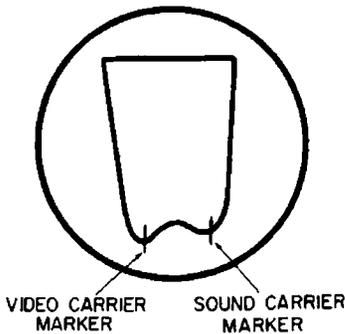
5. After Channel 13, rough-align Channel 6 for a curve similar to Fig. 6-4. Repeat the process for Channels 5, 4, 3, and 2 in that order.

### Final Alignment Procedure

1. Switch the channel selector and sweep generator back to Channel 13, and align this channel for the highest and narrowest curve possible consistent with good symmetry.

2. Align each channel in turn, from 12 through 2, for a similar curve. In addition to the curve characteristics mentioned earlier, a flat top with the markers on the slight peaks is desirable.

In the final touch-up, the curve can be moved to the left or right by adjusting the RF coil, and its tilt can be corrected with the antenna or mixer-coil adjustment (or both). The cor-

rect setting of each coil is the one giving the greatest curve amplitude. Although the antenna and mixer-coil settings both affect the curve tilt, they do so in an opposite manner:

1. Spreading a low-channel antenna coil results in the same curve effect as raising a high-channel mixer loop.
2. Opening a low-channel antenna coil results in the same curve effect as pushing down a high-channel mixer loop.

In any event, use the adjustment which produces the greatest curve amplitude.

## CURVE CORRECTION

There are certain adjustments to correct for curve faults. They are:

### Off-Frequency Curve

To correct for a curve like the one in Fig. 6-5A, raise a high-channel loop or close a low-channel coil on the RF wafer. Adjust so the curve is symemtrical around the markers.

To correct for a curve like the one in Fig. 6-5B, push down an RF loop or open an RF coil.
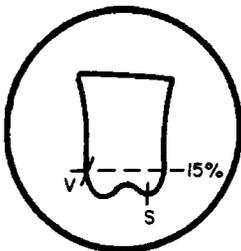


(A) Video carrier displaced.          (B) Sound carrier displaced.
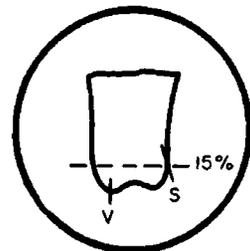
Fig. 6-5. Examples of off-frequency curves.

### Curve Tilt

To correct for the plus curve tilt in Fig. 6-6A, pull up a high-channel antenna loop or close a low-channel antenna coil.

To correct for the minus curve tilt in Fig. 6-6B, push down a high-channel antenna loop or spread open a low-channel antenna coil. Pulling up a high-channel mixer loop or closing a low-channel mixer coil will also correct the tilt.

### Combination Off-Frequency and Tilt

Fig. 6-7 illustrates various combinations of off-frequency and tilt. Your first step is to adjust the RF loop or coil to center the markers. Correct for the tilt as described before. Do not attempt to correct curve defects by adjusting a single coil.

(A) Plus tilt.                  (B) Minus tilt.

Fig. 6-6. Examples of curve tilt.

Generally, at least two coils on any channel must be adjusted before you can obtain the desired response curve.

## Single- or Double-Humped Curve

To correct for the single-humped curve in Fig. 6-8A, push down the high-channel antenna and mixer loops or spread
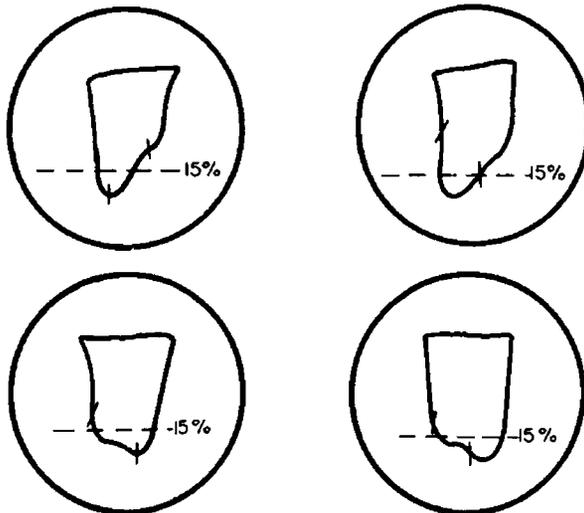


Fig. 6-7. Various combinations of off-frequency and tilt.

open the low-channel antenna coils. Then adjust the RF loop or coil to correct for an off-frequency curve. If this does not correct the condition, pull up the high-channel or close the low-channel antenna and mixer coils. Again adjust the RF section to correct for an off-frequency curve.



(A) Single hump.                (B) Double humps.

Fig. 6-8. Humped response curves.

To correct for a double hump (Fig. 6-8B), use the same procedure—i.e., adjust the antenna and mixer coils in one direction and the RF in the opposite. As before, if adjusting the coils in the first trial method does not correct the curve, proceed to the other as you would for a single hump.

## FINAL CHECKS

The alignment of all channels should then be checked. The top of the curve should be reasonably flat, and the tilt should be within 10% of the flat portion.

The time required to align a VHF tuner of this type depends primarily on your experience and equipment. Tuners requiring complete realignment should usually be sent to firms specializing in this sort of work. With their experienced personnel and specialized alignment equipment, they are in a better position to handle tuner alignment quickly and economically.

A common practice is to align only the local channels; for all practical purposes this is adequate if you do your own tuner alignment. The same procedures as those described are used, starting with the highest local channel and working down.

## TYPICAL TUNERS

The following is intended to aid you in aligning the more common VHF tuners.

### Standard Coil Tuner

*RF Alignment*
1. Connect marker and sweep generators to the antenna input terminals.
2. Disable or remove the first video-IF tube.
3. Clamp the tuner AGC terminal (white lead) with a −1.5-volt source.
4. Connect the scope, through an isolating resistor, to the tuner test point. See Fig. 6-9.
5. Align Channel 12, using the sequence shown in Fig. 6-9.
6. Check and compare the RF alignment of the other channels, and make compromise adjustments if necessary.

*Oscillator Alignment*
1. Restore the first IF stage to normal operation.
2. Move the scope lead to the discriminator.
3. Turn the fine-tuning control to its midposition.
4. Adjust the marker generator to the sound-RF carrier frequency.
5. Starting with Channel 13 and working down, adjust the oscillator slug to position the sound marker properly.

SWEEP IN

MARKER IN

4.7 MMF

TO SCOPE FOR RF CURVES

STEP 3 ADJUST FOR FREQUENCY

STEP 2 ADJUST FOR GAIN

10K

TEST POINT

STEP 4 ADJUST TO CORRECT FOR TILT

STEP I SWITCH TO CHANNEL 12

STEP 5 FINE TUNING AT MIDRANGE

STEP 9 ON SOME TUNERS AN IF COIL IS LOCATED HERE; ADJUST FOR PEAK

VIDEO IF OUT (GREEN LEAD)

(WHITE LEAD) -1.5V AGC

STEP 8 ADJUST TRAP

STEP 6 ADJUST FOR TRACKING 209.75 MC

Fig. 6-9. Adjustment sequence for a Standard Coil turret tuner.
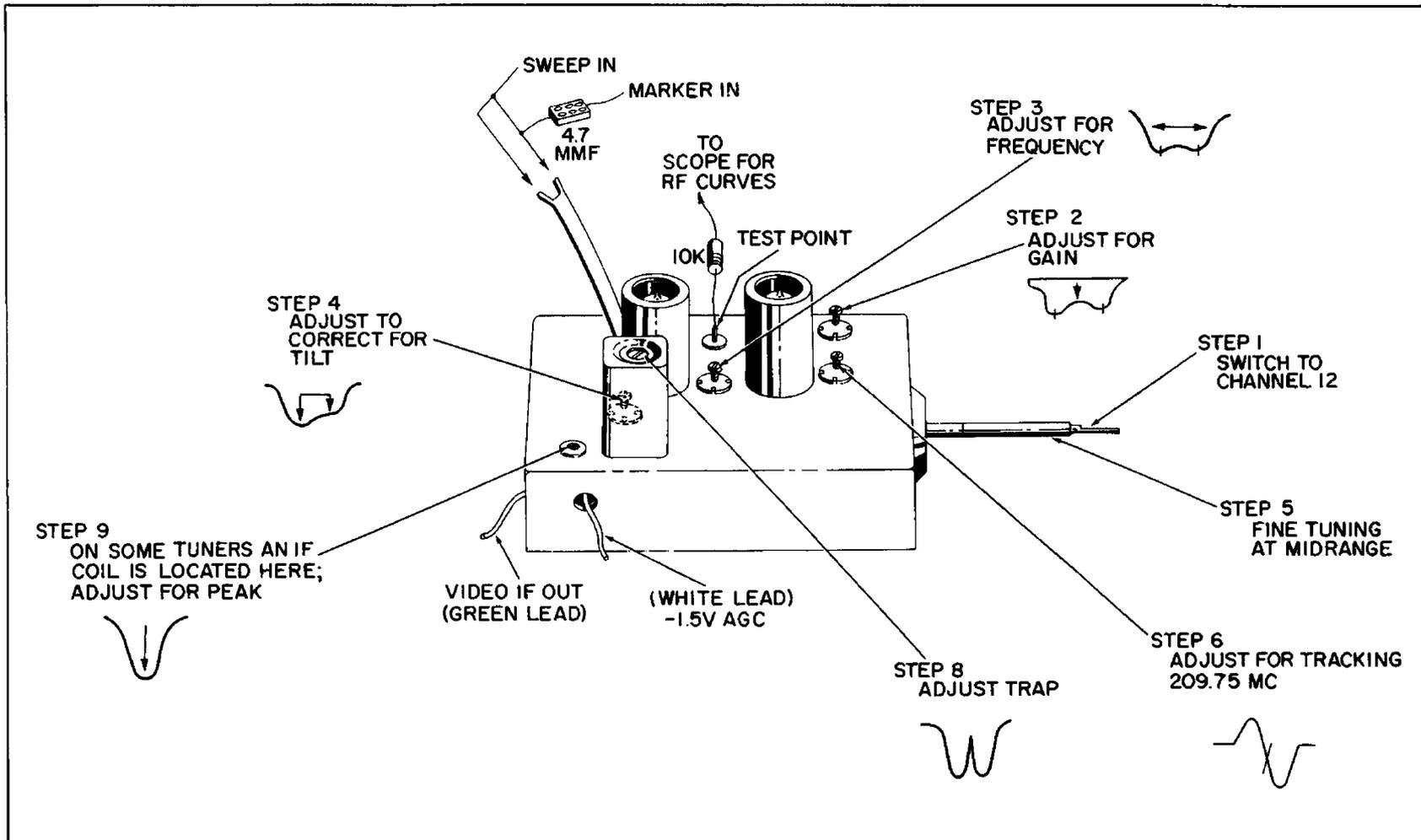
*IF Alignment*

1. Connect the marker generator, through a 4.7-mmf capacitor, to the mixer grid.
2. Remove the first IF tube, or otherwise disable the circuit, and connect the scope to the video-IF amplifier terminal through a demodulator probe.
3. Tune the marker generator to the sound-IF trap frequency, and adjust the trap for the dip shown.
4. Tune the marker generator to the first IF frequency, and peak the first IF coil to maximum.

## Sarkes Tarzian Tuner

*RF and Oscillator Alignment*

1. Connect the marker and sweep generators to the antenna input terminals (Fig. 6-10).
2. Disable the first video-IF stage.
3. Clamp the AGC terminal with a −1.5-volt source.
4. Connect the scope, through a 10K isolating resistor, to the RF test point.
5. Turn the fine-tuning control to its midposition.
6. Manipulate the coils, following the 1-2-3 sequence illustrated in Fig. 6-10, to obtain the desired curve.
7. Restore the first video-IF stage to normal operation.
8. Connect the scope across the discriminator output, and apply a Channel-13 sweep signal with a sound marker to the antenna input.
9. Center the sound marker on the discriminator curve by using the adjustment which precedes the one for Channel 13 (this adjustment is common to all channels).
10. Return the alignment equipment to the former connections (Steps 1 through 5), and perform Steps 5, 6, and 7 for the channels indicated.
11. Return the alignment equipment to the preceding connections (Steps 7 and 8).
12. Adjust each oscillator screw until the sound marker is at the center of the discriminator curve.
13. With the tube shields in place, make a final curve check on all channels.

## CURVE LIMITS

The amplitude between peaks and valleys may deviate as much as 30 per cent from the maximum, particularly on RF response curves having pronounced valleys. For other curves, particularly flat-topped ones, the tilt limit may be less. Usually,

Fig. 6-10. Adjustment sequence for a Sarkes Tarzian switch tuner.
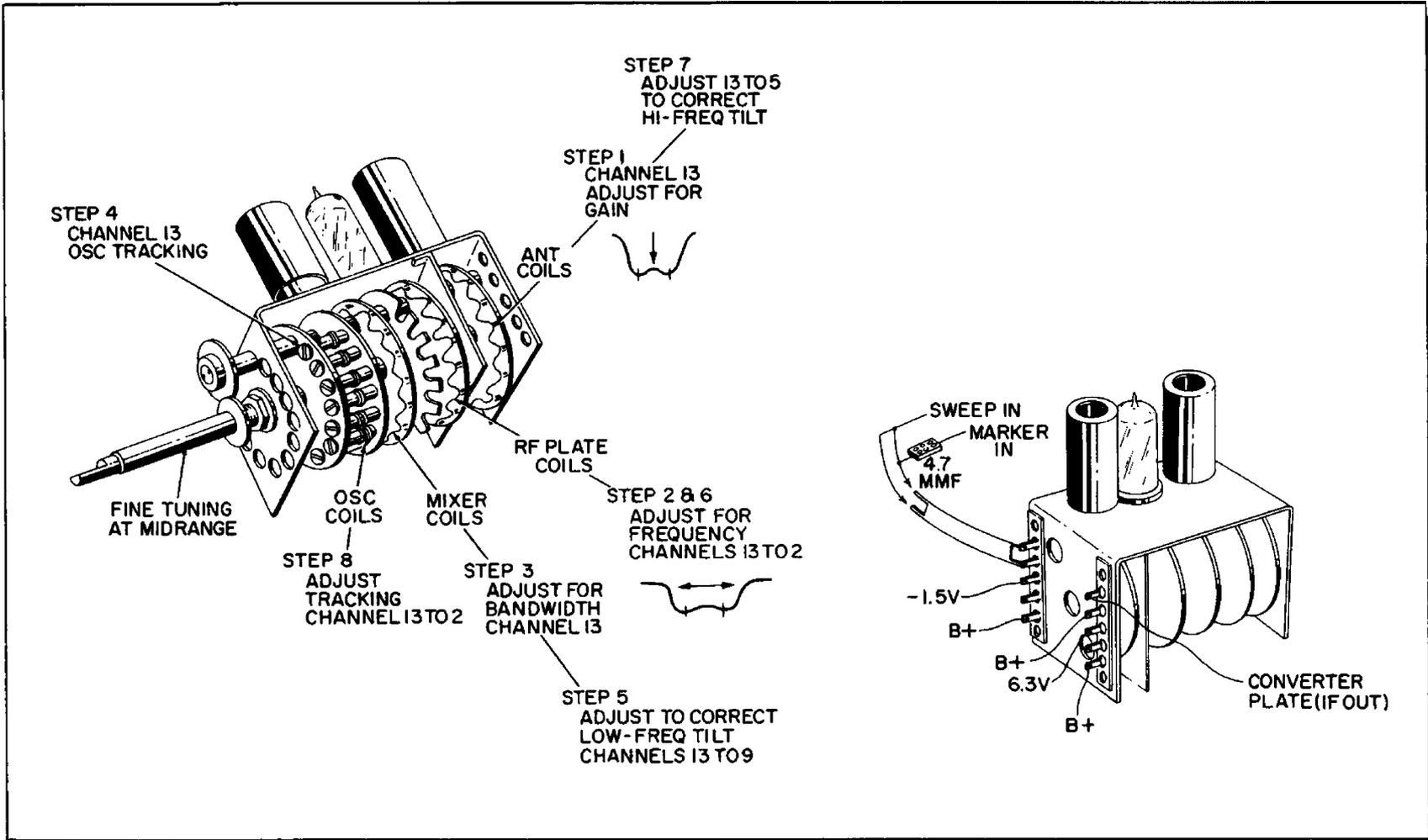
flat-topped curves have both carriers on the flat portion; but if the top is not broad enough, the sound carrier may be near the slope. Always refer to the manufacturer's specifications for the exact limits. Often the curves overlap into adjacent channels. However, if the curves extend beyond adjacent channels, this means that misalignment has produced broad RF tuning at the expense of gain.

In switch-type tuners, broader curves are found on the high-frequency channels; conversely, they occur on the low-frequency channels in variable-capacitor tuners. Because each tuner has its own peculiar response characteristics, do not attempt alignment without the necessary data.

When a tuner response curve is not up to par, look it over carefully, to determine if it is the low- or the high-frequency portion of the curve that is affected. At the same time make a comparison to determine if all other channels in the band (2 through 6 in the low band, and 7 through 13 in the high band) are similarly affected. If not, or if only a slight deficiency appears on the other channels, realignment is probably unnecessary. As a rule this condition is the result of a compromise alignment between several channel curves.

Just as in other lines of work, there are short cuts in tuner alignment. For primary-signal areas or where there is appreciable signal, here is a fast, simple, but dependable method of over-all tuner alignment:

1. Turn the fine-tuning control to its midposition.
2. Adjust the individual oscillator slugs, starting with the highest local channel and working down, for the best sound and picture on each channel.
3. Remove the antenna and connect the marker generator to the antenna terminals through a suitable matching network. Connect a VTVM across the video-detector load resistor.
4. Starting with the highest local channel, tune the marker generator to the video-RF carrier frequency and adjust the RF section for maximum VTVM deflection.
5. Adjust the generator to the sound-RF carrier frequency, and adjust the mixer section for maximum meter deflection. If the maximum reading differs by more than 25 per cent from that obtained at the video-RF carrier frequency, alternately adjust the mixer and RF sections until the readings are as equal as possible.
6. Check the reception on all local stations; and if necessary, make a compromise touch-up in favor of the weakest channel.

# CHAPTER 7

# UHF

# Alignment

The three principal UHF circuit arrangements in common use are the UHF strip, used in VHF turrent tuners; the combination UHF-VHF single-conversion tuner; and a UHF converter external to a VHF receiver.

The typical UHF strip in Fig. 7-1 utilizes both the fundamental frequency and a higher harmonic of the VHF local oscillator. No additional tuner circuitry is required. Its adjustment is critical because both the fundamental and harmonic (often up to the eighth) output from the local oscillator are used.

Fig. 7-2 illustrates the combination UHF-VHF tuner system, which resembles the familiar VHF tuner. However, an important difference occasionally encountered is the use of oscillator harmonics; these can complicate tuner alignment and possibly confuse you.

Fig. 7-3 illustrates the third method of UHF reception. Here is an external UHF converter that works into the tuner of a VHF receiver. Because a converter works through an unused VHF channel, the first requirement is to check the response on the VHF channel to be used. The possibility of misalignment on an unused channel is high, particularly in older receivers. Generally, UHF converters work into Channel 5 or 6.

Fig. 7-1. A typical UHF channel strip.
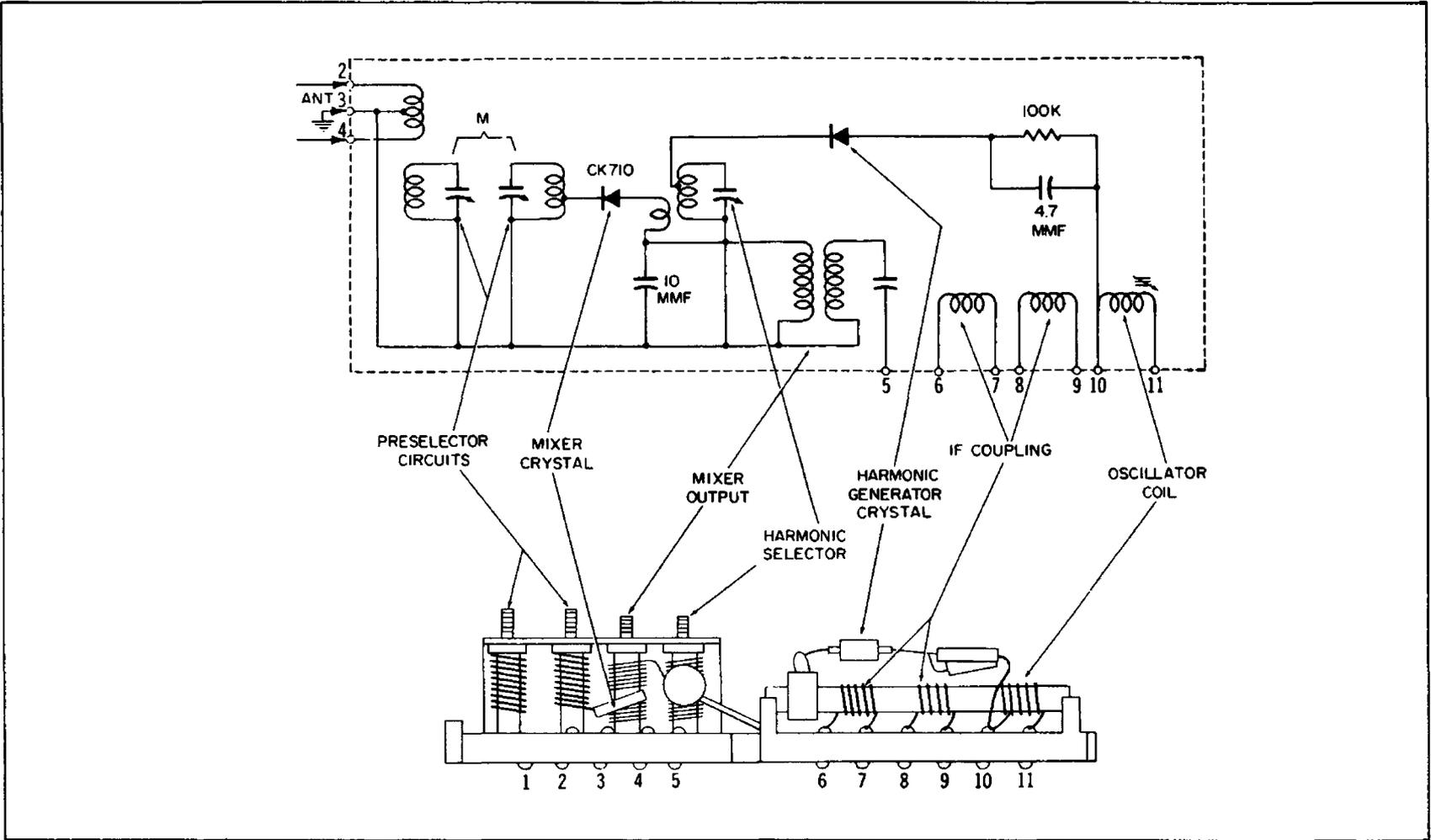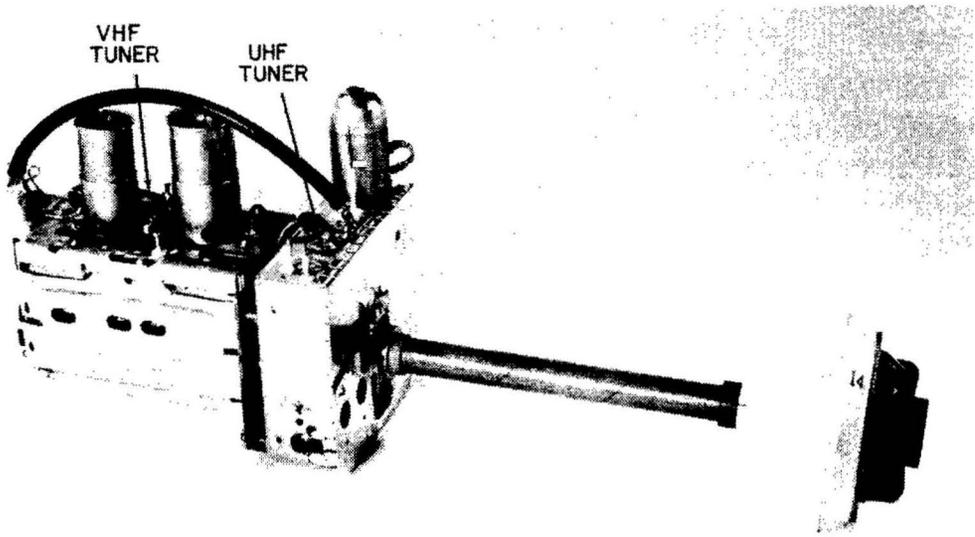
VHF TUNER    UHF TUNER

Fig. 7-2. A combination UHF-VHF tuner system.
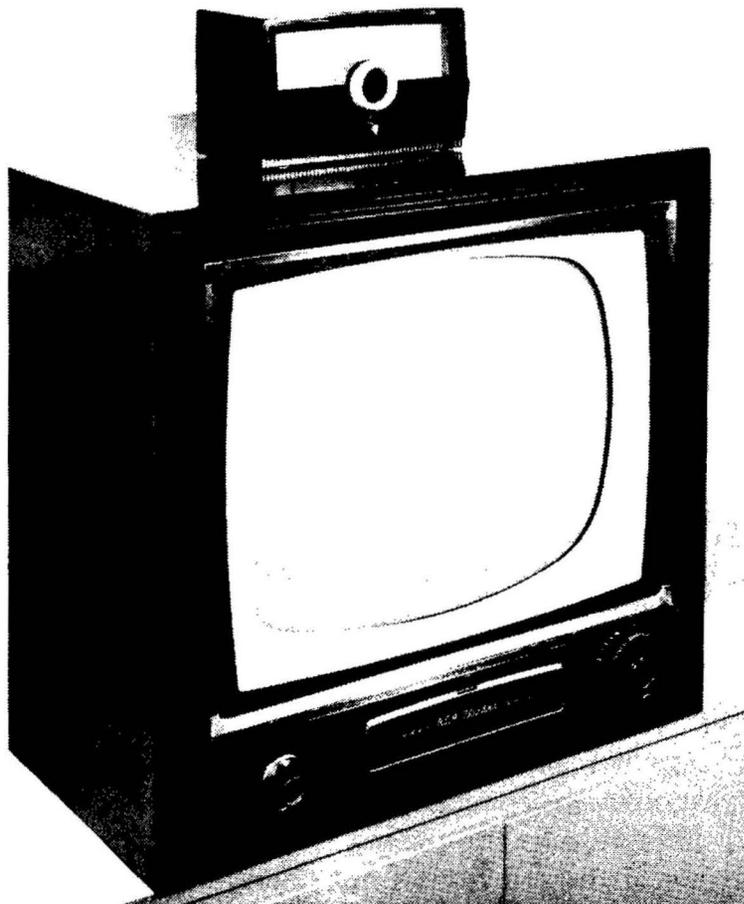


Fig. 7-3. A UHF converter used in conjunction with the VHF receiver.

# UHF CONVERTER TRACKING

The term tracking refers to the closeness with which the tuned circuits resonate to their respective frequencies as the converter is tuned. Fig. 7-4 shows the test setup used to check tracking. The output of the sweep generator (VHF or UHF) is coupled to the UHF antenna input terminals, and the scope is connected across the video-detector load resistor in the receiver. This test setup offers an advantage when harmonics of a VHF sweep generator are used. Since a harmonic has a lower voltage than its fundamental, it is necessary to utilize the gain of the IF amplifiers to obtain a legible curve on the scope screen.
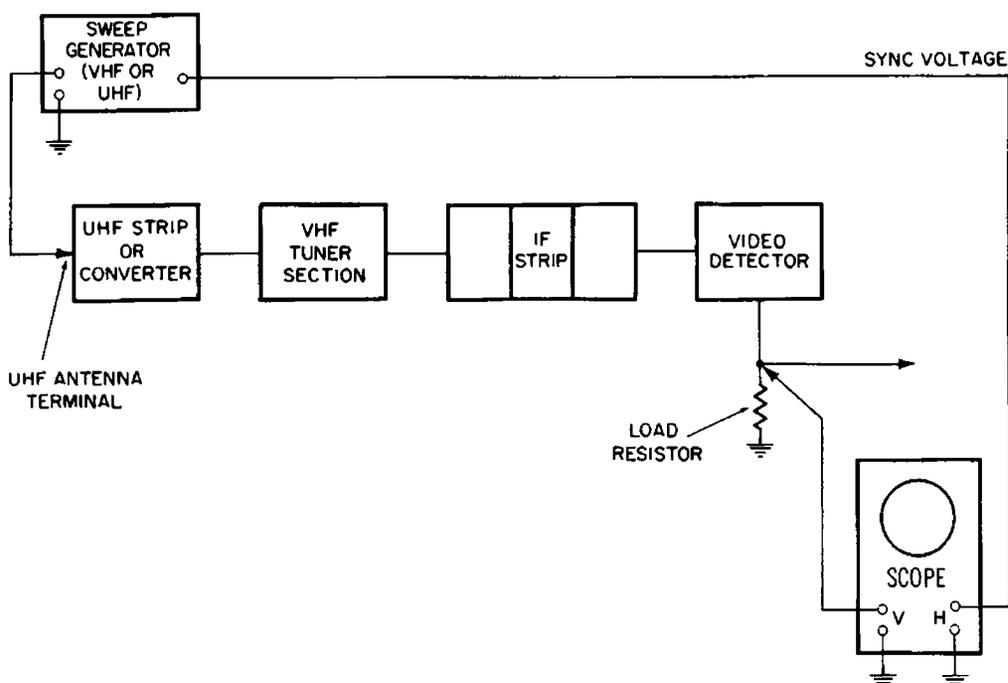


Fig. 7-4. Test setup used to check tracking.

To check the tracking, adjust the scope deflection for a fixed pattern of one to two inches of deflection while sweeping Channel 14. Vary the tuning of the UHF circuits and sweep generator upward simultaneously in frequency, in order to keep the response curve nearly centered on the scope. Note the amount of deflection as the tuning is varied; if tracking is good, the amplitude of the curve will not change appreciably. On the other hand, poor tracking reduces the curve amplitude at various points throughout the UHF range. Practice varies considerably when it comes to correcting tracking problems. Most

technicians either send the unit to a shop specializing in such work, or return it to the manufacturer for exchange. Poor tracking does not mean such steps must be taken; it all depends on whether the poor tracking occurs in the region of local UHF channels. For instance, if local reception can be had on only one or two local channels (say 18 and 49) and poor tracking occurs between Channels 22 and 30, the unit would be perfectly acceptable. But if tracking is poor on the local channels, it will be necessary to repair the UHF converter or replace it.

## USING VHF HARMONICS FOR UHF

When using a harmonic sweep for the first time, you may be baffled by the very narrow response curve on the scope screen. This is due to the sweep deviation being multiplied by the order of harmonic used. For instance, with the eighth harmonic, the sweep width at the harmonic frequency is eight times that of the fundamental—in other words, eight times the width indicated by the sweep-width control setting. Therefore, this setting must be reduced considerably for UHF applications.

Another difficulty often experienced with harmonics occurs in progressing from one generator band to another. For example, with a particular VHF sweep generator it may be possible to check the UHF channels from 14 through 25 on one band, but another band must be used to check from Channels 26 through 83. The order of harmonic has therefore changed, and the scope pattern is reduced in height and width. It is necessary then, when changing generator bands, to compensate for the curve changes by increasing the output-signal level of the generator (to increase the pattern height) and reducing the sweep-width control setting (to increase the pattern width).

The need for a sweep generator with a flat output over its entire range should be fairly obvious. If the sweep output varies too greatly from one frequency to another, UHF tracking checks will be meaningless; and if the generator characteristics are unknown, the UHF gear under test may be tagged as defective or in need of alignment when actually it is not. It is advisable for you to check your alignment gear, to make certain its performance characteristics are adequate for such work. Also check the flatness of harmonic output, since it is not unsuual for a sweep generator to be very flat on fundamentals and still have a poor flatness figure on harmonic oper-

ation. This information can usually be obtained from the instrument manufacturer. To prevent standing-wave problems, some VHF sweep generators require special test leads for UHF harmonic operation. This information can also be obtained from the manufacturer, or perhaps from the operating manual of the instrument.

Checking the over-all response characteristics of UHF equipment is just as important as for any other tuned signal circuit. The curve obtained indicates the bandwidth and response shape of the tuned circuits in their entirety. Since the quality of the picture depends mostly on these characteristics, it is good practice to check the over-all response when difficulty is encountered with UHF reception. The curve seen on the scope should have the same general characteristics as the IF response curve.

## UHF MARKERS

The harmonic output of most VHF marker generators is adequate for UHF work. It is simply a matter of multiplying the marker-dial frequency by the order of harmonic frequency being used. As an example, if the generator is set to 108.5 mc and the eighth harmonic is being used, the marker frequency of 868 mc (8 × 108.5) would be seen if the receiver were tuned to Channel 80.

In the service shop, the signal from a local UHF station often serves as a marker. The UHF antenna lead-in with an isolating resistor of approxiamtely 12K ohms inserted in series with each conductor is connected in parallel with the sweep-generator cable. A marker pip is produced at the video- and sound-carrier frequencies by heterodyning the UHF signal carriers with the sweep signal. The resistors may be almost any value in the 10K to 15K range to start; the value is varied to obtain normal marker amplitude on the response curve. A little difficulty may be encountered in determining whether the marker produced by a station signal is the video or sound marker. To check, tune the UHF section to move one marker to the top of the response curve; then examine it. Move the other marker to the top of the curve, and likewise examine it. When the sound carrier is at the top, the base line will be slightly wavy because the audio signal (slope detected) mixes with the scope signal. If the video carrier is at the top of the curve, a sync pulse will be present somewhere in the pattern.

UHF markers obtained from station signals are also useful for accurately calibrating the output frequency of a marker

generator at various dial settings. As the marker signal passes over the station carriers, the scope-pattern base line will become wavy. At zero-beat the waviness will disappear, meaning the generator frequency (fundamental or harmonic) is the same as the station's crystal-controlled carrier frequency. This dial setting will then serve as a guide to harmonic operation when you are checking response. Keep in mind that markers produced with higher harmonics will pass over the curve much faster than those produced with lower harmonics or the fundamental. The reason is that a change in the harmonic frequency is equal to the order of harmonic times the change in fundamental frequency. For instance, if the eighth harmonic of the generator is being used and the fundamental is 110 mc, the marker will fall at 8 × 110, or 880 mc. Shifting the fundamental dial reading one megacycle to 109 mc will change the marker to 8 × 109, or 872 mc. In other words, when the eighth harmonic is used a change of 1 in the fundamental produces a change of 8 in the harmonic frequency.

## SPURIOUS MARKERS

Usually, spurious markers are a nuisance at UHF frequencies; they must be identified and either ignored or sidestepped. Spurious markers often appear on the response curve, even when a generator is not used. The occurrence of cross-heterodyning increases, of course, when a marker generator is used, so you must be able to distinguish between true and spurious markers. If a UHF station is used as the markers, they should move over the response curve as the UHF unit is tuned through its range. Another indication of a true marker is the amplitude of the pip. Reduce the value of the UHF antenna isolating resistors to increase the station signal markers.

If markers are difficult to identify when a generator is used, try rocking the generator dial while watching the response curve. A decrease in frequency will cause the true marker to move toward the video-carrier end of the response curve, and an increase will move it toward the sound-carrier end. A marker pip that moves in the wrong direction, or does not move at all, is spurious.

Another method of distinguishing between markers is to vary the tuning of the UHF unit. The true marker will move with the response curve; all others are spurious. A variation of this check is to change the sweep-generator setting. Again, the true marker will move with the response curve, and the spurious pips will move across the curve.

# TYPICAL UHF TUNER ALIGNMENT

Because of the very wide variations in methods and equipment for UHF, it is impossible to describe a basic alignment procedure applicable to all. However, this typical example should give you an idea of how simple UHF alignment actually is.

A diagram of a typical UHF tuner is illustrated in Fig. 7-5. The normal response curve and the equipment setup for alignment are illustrated in Figs. 7-6 and 7-7, respectively. The procedure recommended by the manufacturer is as follows:

1. Remove the outer tuner cover. Make certain the inner shield cover is tightly in place.
2. Connect the UHF sweep generator to the antenna input terminals through a matching network, and set the sweep to 464 mc.
3. Loosely couple the UHF marker generator to the sweep-generator cable, and set to 464 mc.
4. Loosely couple the VHF marker generator to the UHF tuner output cable, and set to 44 mc.
5. Connect the vertical input of the scope, through the network illustrated in Fig. 7-7, to the UHF-tuner output cable.
6. Fully mesh the tuning capacitor of the UHF tuner.
7. Adjust the low-frequency oscillator trimmer (C2 in Fig. 7-5) to zero-beat between the UHF RF and the UHF IF markers.
8. Retune the UHF marker generator to 897 mc.
9. Turn the tuning-capacitor rotor shaft 180 degrees to stop.
10. Set the high-frequency oscillator adjustment (Fig. 7-5) to obtain a zero-beat between the UHF RF and the VHF IF markers.
11. Disconnect the generators.
12. Turn the capacitor rotor slowly through the UHF band while adjusting the injection shield. Adjust for a milli-ammeter reading of 0.5 to 5 ma in all positions of the capacitor.
13. Replace the outer tuner cover.
14. Reconnect the generators in their former positions.
15. Tune the UHF sweep generator to Channel 83.
16. Back the tuning capacitor approximately three degrees from the stop at the high-frequency end of the setting.
17. Set the UHF marker to first the video- and then the sound-carrier frequencies of Channel 83 while making the adjustment in the next step.

300Ω UHF ANT

IF OUTPUT

LOW FREQ OSC. ADJ

**2AF4A**

.5-3.0

C7 B+ FROM TUNER

R1 680K

L1

C1 33 MMF

L3

1N82A

L2

R2 5.6K

C2 .5-3 MMF

R3 100

C3 135 MMF

L4

1-7

2    6

5

3    4

R4

L5

L6

C9

C8

FIL.    FIL.

C4 1.5 MMF

C5 0.5

C6 0.5

HI FREQ. RF ADJ.

INJECTION SHIELD

HI FREQ. OSC. ADJ.

Fig. 7-5. A typical UHF tuner circuit.
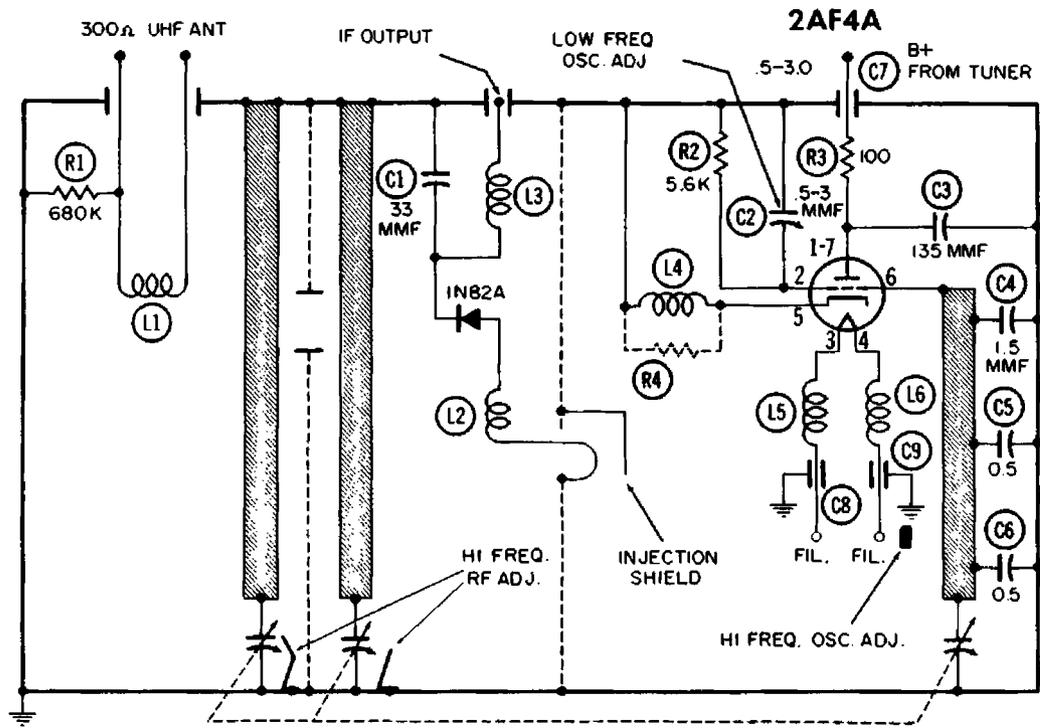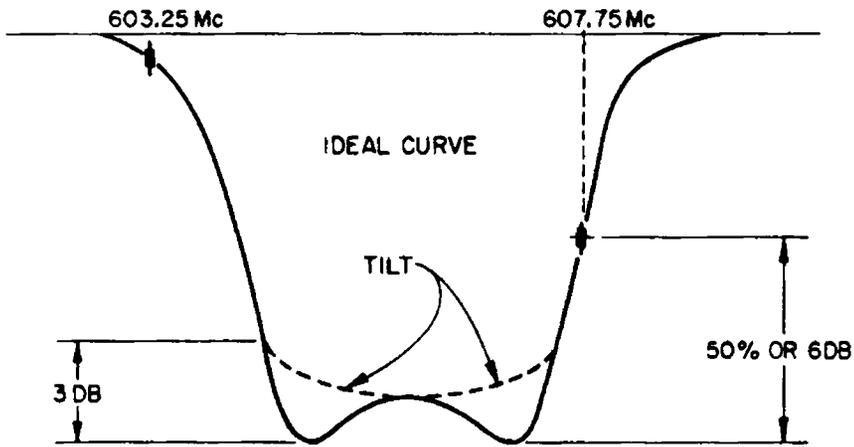
Fig. 7-6. A UHF tuner response curve.

18. Adjust the RF trimmers for the response curve in Fig. 7-6. The sound and video markers must be in the upper 50 per cent of the response.

Repeat Steps 16, 17, and 18 for each local channel. Make any necessary touch-up adjustments to the RF trimmers to produce the proper response.

19. Disconnect the network from the UHF tuner output, and insert the UHF output plug into the receptacle on the VHF tuner. Check the reception on local UHF channels.

If complete alignment is necessary or desirable, additional steps must be taken as follows:

20. Connect the UHF sweep and marker generators to the antenna input terminals. Set the sweep to Channel 36 and the marker to 603.25 mc.
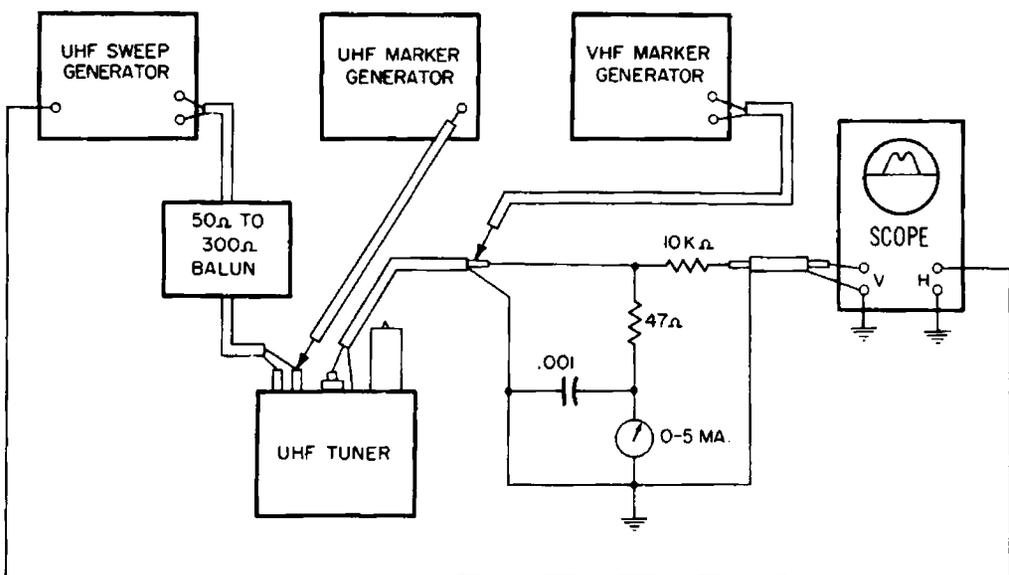


Fig. 7-7. Equipment setup for UHF alignment.

21. Connect the scope to the video-detector test point on the receiver chassis (across the video-detector load resistor).
22. Apply a −2.5-volt bias to the AGC tie point of the VHF tuner.
23. Set the UHF tuning dial to Channel 36.
24. Adjust the UHF input coil in the VHF tuner for the response shown in Fig. 7-6. Vary the UHF marker from the 603.25-mc video marker (Step 20) to the 607.75-mc sound marker while making the adjustment.
25. Repeat Steps 20 through 24 at both the high and the low ends of the band, and make any necessary compromise adjustments for good response.

You will note that two marker generators are required for UHF tuner alignment, just as for most VHF tuner alignment. Actually, this is the simplest method, and if your shop is equipped with two generators capable of producing a good output at VHF and UHF frequencies, alignment of VHF and UHF tuners should present no problem.

CHAPTER 8

# Color

# Alignment

A definite procedure for color alignment cannot be readily outlined for every receiver, since there is such a wide variation between early- and late-model color receivers. However, certain setup and alignment methods are applicable to almost all color receivers.

## BANDPASS AMPLIFIERS

The earlier color receivers used bandpass amplifiers with a realtively flat response (Fig. 8-1). In the mid-1950's the trend was toward moderate peaking of the high-frequency response. Fig. 8-2 illustrates a highly peaked bandpass-amplifier response

Fig. 8-1. IF response curve in an earlier color-television receiver.
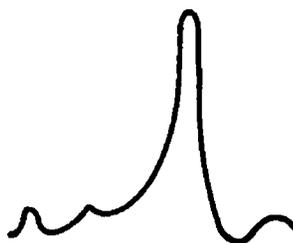
Fig. 8-2. A highly peaked bandpass-amplifier response curve.

(A) Ideal IF response curve.   (B) Color signal attenuated.
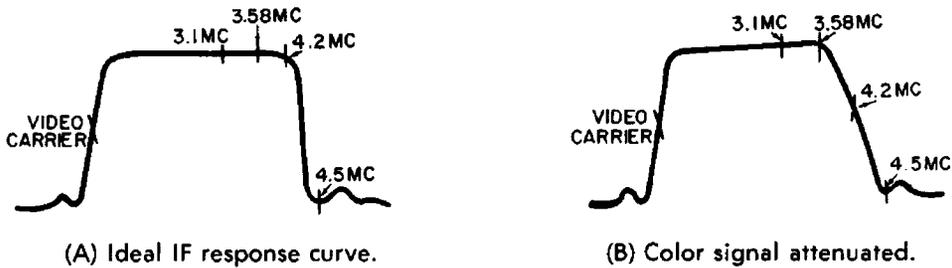
Fig. 8-3. High-frequency peaking is required to compensate for color-signal attenuation occurring in the IF amplifiers of many receivers.

curve. In later years most manufactures have returned to the flat-topped response. Fig. 8-3A shows how an ideal IF response curve in a color receiver should appear.

High-frequency peaking is required to compensate for the color-signal attenuation occurring in the IF amplifiers of many receivers. The bandpass amplifier can be aligned with a flat response, only when the IF-amplifier response is maintained flat over the 3.58- to 4.2-mc range. However, if the color signal is attenuated at these frequencies (Fig. 8-3B), the bandpass amplifier must be aligned with a rising response to compensate for it.

Observing the effects of excessive high-frequency peaking in a bandpass amplifier will bring home one important point: you must determine beforehand the exact amount of peaking, if any, required in the bandpass-amplifier response. A slight amount of overpeaking is generally tolerable, since it is scarcely discernible in the picture. A larger amount, however, will introduce ringing and overshoot in the color signal.

## CHECKING BANDPASS-AMPLIFIER RESPONSE

The equipment setup for checking the response of a chroma bandpass amplifier is illustrated in Fig. 8-4. Exact connection points are not indicated because they vary widely from one color receiver to the next. This information, however, will be
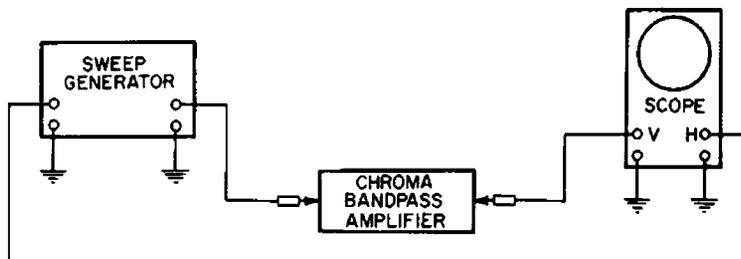


Fig. 8-4. Equipment setup for checking response of a chroma-bandpass amplifier.

Fig. 8-5. A curve like this will result in transient irregularities in the reproduction of a color-bar signal.
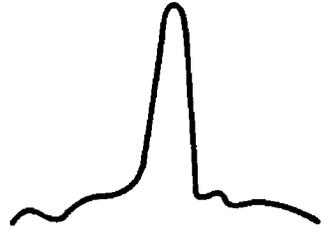
found in the manufacturer's service data, which you should consult prior to making any alignment adjustments. If a curve similar to the one in Fig. 8-5 is obtained with a response check, transient irregularities in the reproduction of a color-bar signal can be expected.

The output signal of a color-bar generator will appear similar to Fig. 8-6. This chroma signal has a good waveform and, assuming the receiver circuits do not introduce distortion, a color duplicate of it should be observed at the bandpass-amplifier output. A wide-band scope with flat response at the



Fig. 8-6. Output signal from a color-bar generator.
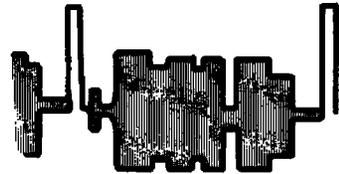
subcarrier frequency (3.58 mc) is required to observe this waveform; a narrow-band scope will distort the waveform badly enough to mislead you. Some technicians feel that a narrow-band scope is adequate if the operator is familiar with its characteristics. Quite to the contrary, it is not! The response curve of the bandpass is obtained through a demodulator probe, so the scope is required to reproduce only the envelope of the signal. On the other hand, when the bandpass signal itself is viewed, a demodulator probe is not used and the scope must reproduce frequencies which extend to over 4 mc.

The waveform in Fig. 8-6 might look like the one in Fig. 8-7 after passing through the RF, IF, and bandpass-amplifier circuits. By comparing the two signals, you can see that distortion, due primarily to the peaked response, has affected the chroma signal: the flat tops now show overshoot, curvature,



Fig. 8-7. A distorted color-bar signal.
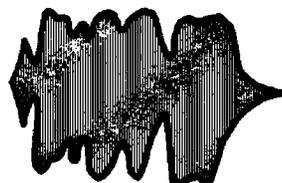
and tilt; the sharp corners are rounded; and the perpendicular rise and fall of the original chroma waveform is slowed to the point where the color-bar signals blend into each other. The black bar in particular has become badly contaminated by the slow decay of the chrominance signal.

The bandpass amplifier removes the horizontal-sync pulse from the chroma signal. Since the sylnc pulse is 15,750 cps and the bandpass amplifier is cut off below 2 mc, the pulse does not get through.

The excessively peaked bandpass response has a decided effect on the chroma signal applied to the grids of the picture tube. A square-wave response check, made by feeding in an R—Y signal, would show that the output of the R—Y demodu-

Fig. 8-8. A distorted chroma signal caused by an excessively peaked bandpass response.

lator has a distorted waveform with prominent ringing and overshoot of the leading edge. (See Fig. 8-8.) This produces vertical lines of spurious color in the color-bar presentation. A three-dimensional effect is apparent at the edges of the color bars, and being spurious, it does not correspond to the desired signal.

The preferred method of checking the frequency response of the bandpass amplifier is the undemodulated response check, made with the test setup of Fig. 8-4 but without the demodulator probe. This test is much more dependable because it eliminates distortion introduced by the probe itself. The scope used in viewing the response must be very flat over the 2- to 4-mc range; otherwise the display cannot be accepted as the true bandpass-amplifier response.

## TRAPS

Early black-and-white receivers had a full complement of interference traps in the IF-amplifier stages because the traps came very close to providing the ideal 4-mc IF bandpass when properly aligned. In later years the IF bandpass of most receivers has been reduced to a maximum of 3 to 3.5 mc, and so the number of traps has been kept to a minimum. Because of the narrow IF response, the IF strip is less susceptible to adjacent-channel interference. Hence, use of more than an occasional sound or 4.5-mc intercarrier trap is unnecessary.

In color receivers, however, the IF bandpass must be approximately 4.2 mc for good color reproduction. The wide bandpass means the color receiver must have at least as many traps as were used in the early monochrome receivers.

The traps used in either type of receiver have a fixed frequency related to the IF's. Current color receivers use an IF system with the following frequencies: 41.25 mc for the sound carrier, 45.75 mc for the video carrier, 39.75 mc for the upper adjacent-channel trap, and 47.25 mc for the lower adjacent-channel trap.

A 39.75-mc signal is close enough to the 41.25-mc sound carrier to cause interference, in the form of thin diagonal lines. When the upper adjacent trap is badly misaligned, the horizontal blanking bar (and possibly some of the video information) may appear in the picture. The interfering adjacent-channel signal will not be locked in; as a result, the shifting
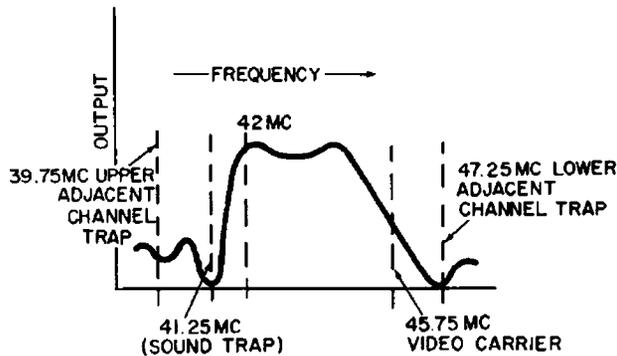


Fig. 8-9. An absorption trap tuned to the sound-carrier frequency causes a sharp dip in IF response curve at that point.

horizontal-blanking bars will produce interference resembling a windshield wiper moving back and forth across the screen. A misaligned lower adjacent trap may permit interference close to the video-IF carrier frequency to get through to the picture display, in the form of shifting diagonal lines.

In monochrome receivers the sound-IF carrier frequency must be attenuated to provide the amount of video and sound signals needed at the video detector to generate the 4.5-mc intercarrier sound IF, yet not cause sound-bar interference in the picture. In the color receiver the sound-IF carrier frequency is attenuated even more, to prevent (or at least mimimize) cross modulation between the color video subcarrier and the sound carrier. A 41.25-mc absorption sound trap is located in one of the IF stages, and another after the sound take-off. Therefore the sound-carrier frequency in the IF re-

sponse curve will dip sharply, as seen in Fig. 8-9. A 4.5-mc trap usually precedes the chroma bandpass amplifier to prevent heterodyne tweets that the 4.5-mc sound carrier sometimes produces in the color picture.

The adjacent-channel traps in the more popular color receivers are located after the first and last video-IF amplifiers (Fig. 8-10). These traps consist of a series-resonant shunt circuit tuned to the frequency of the interfering signal. Since a series-resonant circuit has minimum impedance at resonance, any undesired frequencies will be bypassed.

The first trap may be tuned to the upper adjacent-channel interference frequency of 39.75 mc, or to 40.75 mc to reduce interference from the color-sideband signal. The second trap is tuned to the lower adjacent-channel frequency of 47.25 mc.
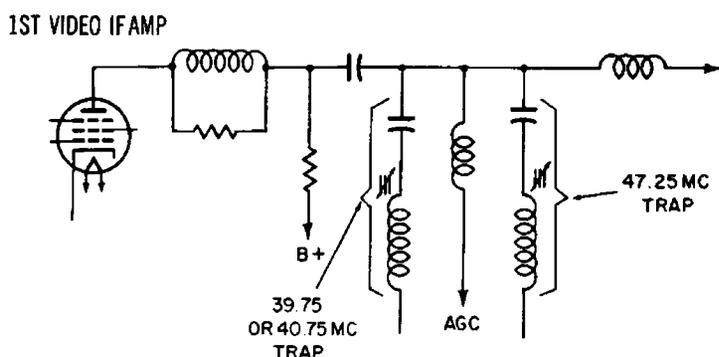


Fig. 8-10. Adjacent-channel traps follow the first and last video-IF amplifiers in the more popular color receivers.

Another 47.25-mc absorption trap may be located in the plate circuit of the last IF stage. Because of the sharp attenuation necessary at the sound-IF carrier frequency, the 4.5-mc sound IF is not taken from the video detector; it is taken off at the last IF, ahead of the video detector, and fed to a separate detector to produce the 4.5-mc sound-IF signal.

Fig. 8-11 shows the filter circuit often used to trap the 41.25-mc signal in the first video-IF amplifier grid circuit. The amount of attenuation is limited by the sound-level control. A similar filter circuit may follow the sound take-off point, the control being termed *sound rejection*. This control limits the attenuation level of any sound signals that manage to get past the earlier traps.

A 4.5-mc trap is usually located in the first video-amplifier cathode circuit, as shown in Fig. 8-12. This is a parallel-resonant circuit which offers maximum impedance at the frequency to which it is tuned. R2 completes the cathode circuit, and R1 is the contrast or chroma control.
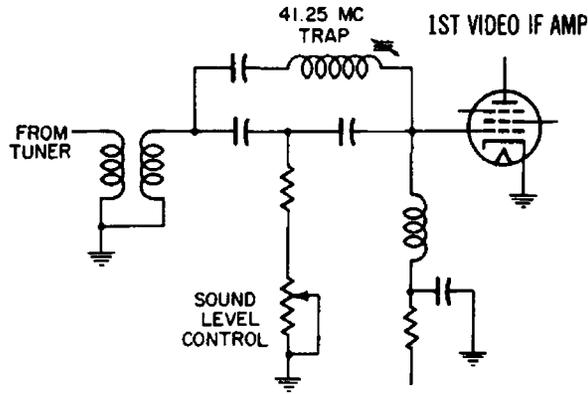
Fig. 8-11. Filter circuit used to trap the 41.25-mc signal in the first video-IF amplifier stage.

As in all other alignment work, the traps in color receivers must be adjusted with an accurate marker generator. The AGC line should be clamped with a fixed bias to prevent changes in the AGC voltage from affecting the stage gain and operating characteristics. Usually a bias of −3 volts is adequate. The usual method of adjusting one trap alone is to connect a VTVM across the video-detector load resistor, and then to couple the
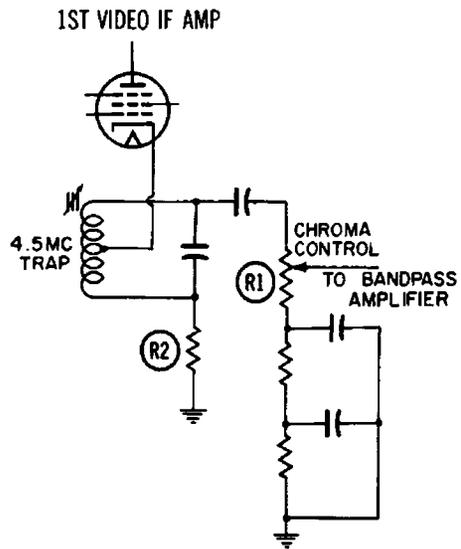


Fig. 8-12. Most color receivers have a 4.5-mc trap in the first video-amplifier cathode circuit.

marker generator to the mixer stage or in the grid circuit of a stage ahead of the trap to be aligned. The trap is then tuned for a minimum meter reading at the rejection frequency. When two traps are at the same frequency, tune the second one before adjusting the first. The marker signal must be injected between the first and second traps, because the loss in the first trap may reduce the signal to an unusable level before it reaches the second trap. As mentioned in previous chapters, it is possible to obtain a dip at two different settings of the trap core, and

best results are always obtained with the upper setting (core out).

Correct adjustment of the trap frequencies is important, even if no adjacent-channel signals are available in the area. Incorrect trap alignment can result in loss of picture quality, or even complete loss of color. This is due to a portion of the IF bandpass being removed by the mistuned trap. Where maximum efficiency in rejection of adjacent-channel interference is required, trap adjustments are on the critical side. Therefore, after the traps are adjusted, you should check the operating performance of the receiver.

To check the over-all color-IF response curve, you can use a sweep and marker generator as in ordinary monochrome response checks. However, don't forget that the response of a color receiver is wider, normally extending to 4.2 mc. It is important that the sweep-generator output be flat and the marker generator be very accurate.

If adjacent-channel interference problems are common to the area, check the receiver operation on each local station; even the most accurate alignment must sometimes be touched up to reduce or eliminate such interference. If it persists after these precautions have been taken, reorient the antenna or install traps.

## SIMPLE DEMODULATOR ALIGNMENT

A time-saving method of color-demodulator alignment is available to technicians trained in color servicing. The simplification of demodulator circuitry in the newer color sets makes this procedure possible. Only a standard NTSC color generator is required.

A standard NTSC signal produces one red, two green, and one blue bar on the screen of a correctly aligned color receiver. The bars are overlapped to produce the full range of color bars, as illustrated in Fig. 8-13. When the blue and green guns are cut off, only a red bar appears on the screen. Viewing only the red bar (R—Y plus Y) provides a quick check of the R—Y demodulator and the luminance (Y) channel. When the R—Y or Y signals appearing on the grid and cathode of the color picture tube are incorrect, the red bar will display uneven shading. Because the luminance channel is generally trouble-free, the R—Y channel is probably at fault here. Try varying the amplitude of the color signal by turning the color saturation or intensity control, or by changing the phase with the hue control.

G-Y PLUS Y = G ON GREEN GUN

R-Y PLUS Y = R ON RED GUN

B-Y PLUS Y = B ON BLUE GUN

GREEN  YELLOW  RED  MAGENTA  WHITE  CYAN  BLUE
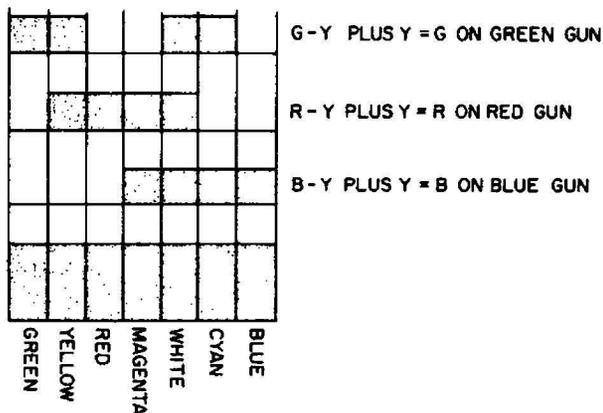
**Fig. 8-13. The standard NTSC color-bar pattern.**

The screen and background controls must first be adjusted for a neutral black-and-white picture free of tint. The approved method is as follows:

1. Tune in a local station transmitting monochrome program material.
2. Turn the brightness control to a high level.
3. Adjust the red, green, and blue screen controls for neutral whites and grays.
4. Reduce the brightness level to a dark picture.
5. Adjust the red, green, and blue background controls for low-level grays.
6. Repeat the process as often as necessary, until changing the brightness or contrast level does not produce a tinted black-and-white picture.

If the color sync circuits require alignment, follow the manufacturer's instructions before proceeding with the demodulator alignment.
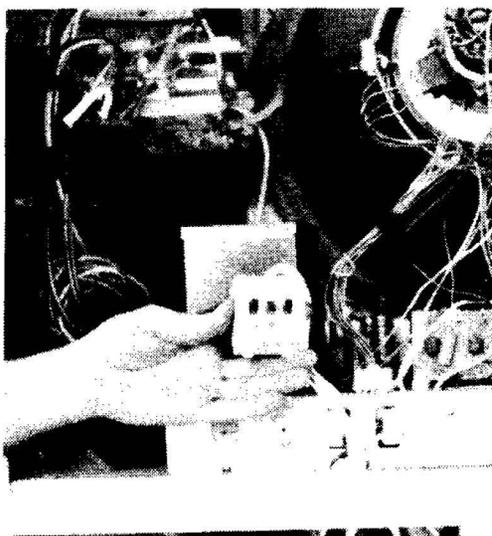


**Fig. 8-14. Color grid-bias box, used to cut off various guns during alignment.**

In the actual alignment process, the green and blue guns are first cut off with a color-grid bias box. (See Fig. 8-14.) The output of a standard NTSC color-bar generator is coupled into the receiver, either through the antenna input terminals (RF) or through the video detector (video output of the generator). A single red bar will appear on the screen, as shown in Fig. 8-15A; if the bar is unevenly shaded, try adjusting the controls as mentioned previously, in addition to advancing the contrast control to maximum. (Once the proper setting has been found,



(A) Green and blue guns cut off.
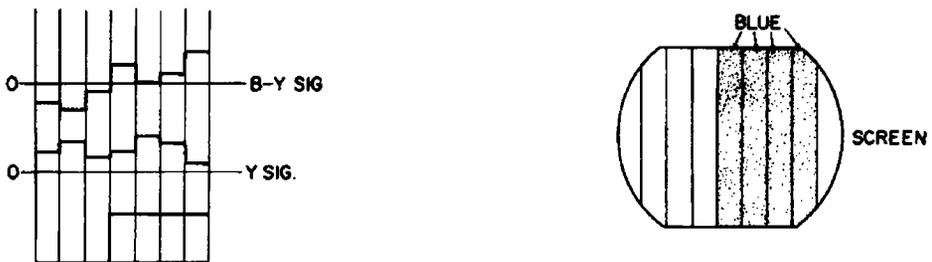


(B) Red and green guns cut off.



(C) Red and blue guns cut off.

Fig. 8-15. Color-bar pattern with two guns cut off.

these controls must not be disturbed during the remainder of the alignment.) Disconnect the bias-box lead from the blue gun, and cut off the red. Only a blue bar should appear (Fig. 8-15B). If it is unevenly shaded, adjust the quadrature transformer until the bar is a solid and even color. The quadrature-transformer

output drives the B—Y demodulator with the signal produced in the subcarrier oscillator, and may be quickly located by tracing the circuitry back from the B—Y demodulator grid.

In most color receivers this would complete the demodulator alignment, because portions of the R—Y and B—Y signals are mixed to form the G—Y signal and no adjustment of the G—Y channel is required. If the G—Y must be adjusted, however, cut off the red and blue guns and adjust for two green bars (Fig. 8-15C).

In some receivers the color signal may be demodulated along the R—Y and G—Y instead of R—Y and B—Y axes as indicated earlier. The same method of adjustment is used here, but the sequence is changed to suit. The service data will show what method and sequence to use.

# AM Radio

# Alignment

Basically there are two commonly accepted methods of aligning an AM radio receiver. The simpler one, termed peak alignment, is used where the bandpass characteristics of the receiver are not critical. The common AC-DC table-model radio of Fig. 9-1 falls into this category. Peak alignment may
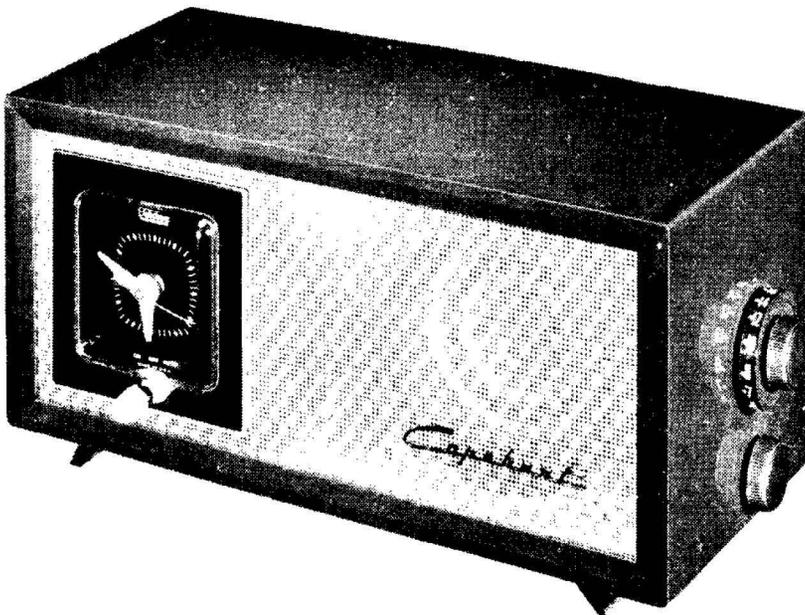
Fig. 9-1. A typical AC-DC table-model radio.

Fig. 9-2. Schematic of AM receiver in Fig. 9-1,
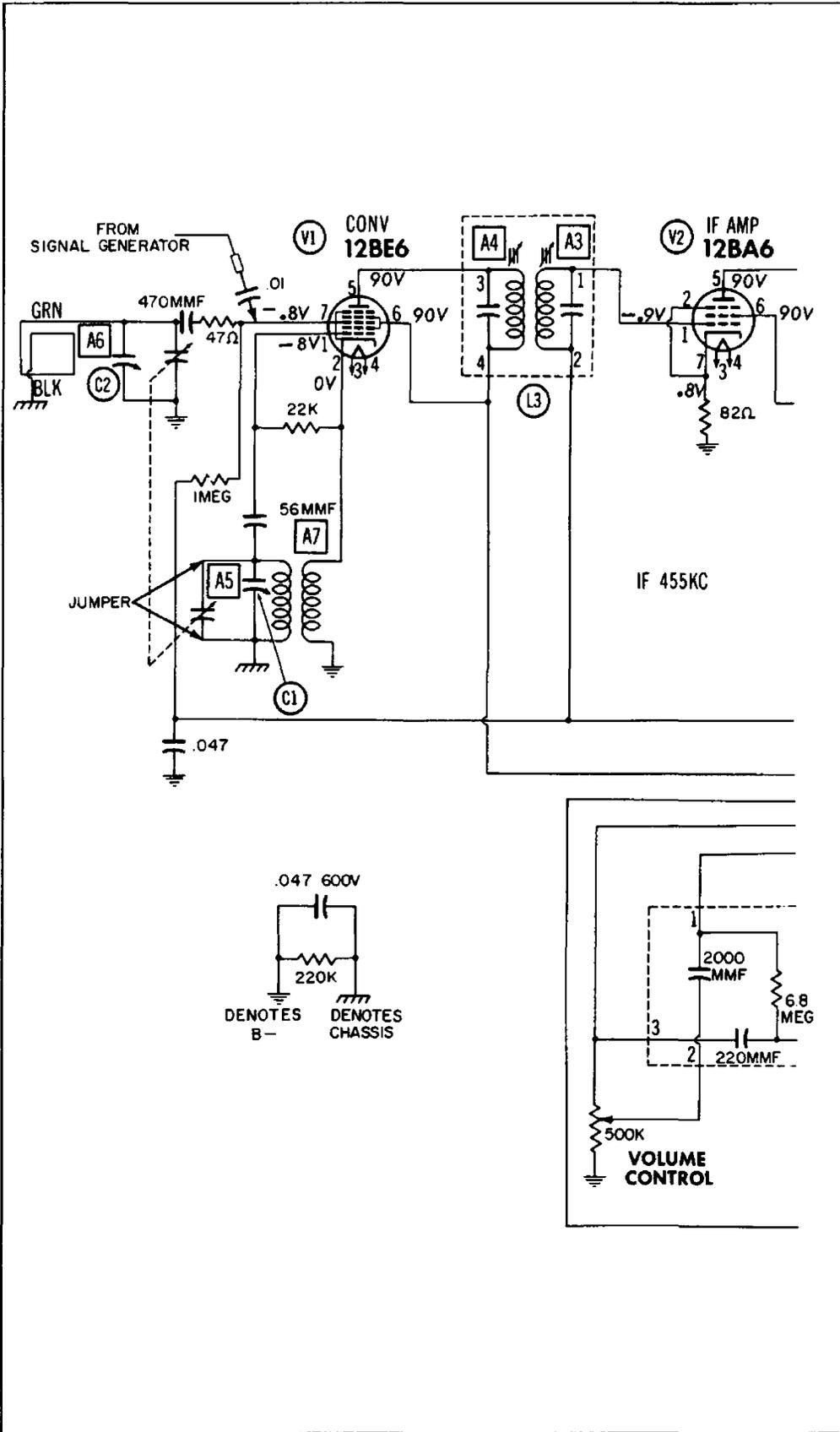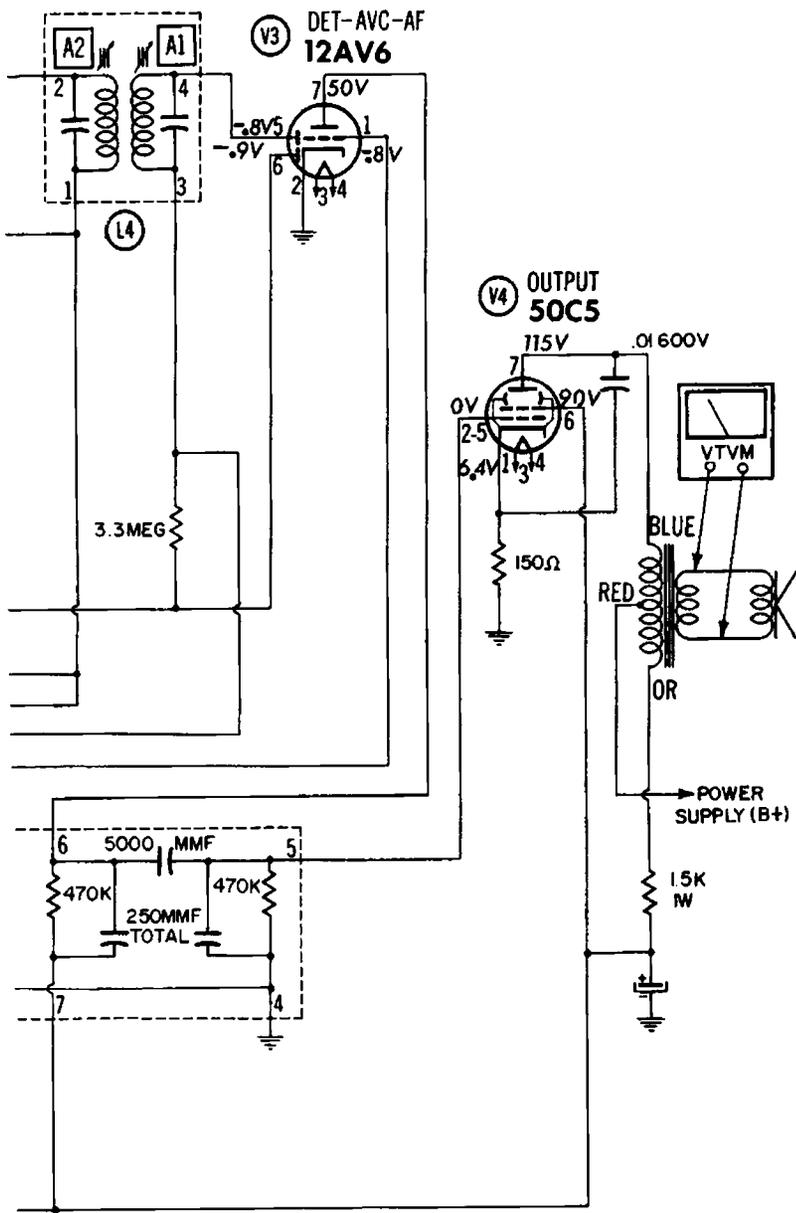
excluding the power supply.

be accomplished with an RF generator and voltmeter (VTVM preferred), or with a sweep generator and scope. The procedure used in both methods, along with their variations, will be described in detail; but you must remember that the different manufacturers may recommend other locations for the signal input and output indicators in their receivers. However, these differences are not too significant and the examples given here are applicable in the majority of cases.

## PEAK IF ALIGNMENT

### First Method

*Equipment Required:* RF signal generator and multimeter, output meter, or VTVM.

*Connections:*

1. Connect AC leads of meter (set to lowest range) across speaker voice-coil terminals (Fig. 9-2).
2. Connect "hot" lead of signal generator through a .01-mfd capacitor to the input (grid 3) of the converter (V1).
3. Connect the generator ground lead to the negative return circuit (not to chassis ground).
4. Adjust the generator output attenuator to minimum, and turn on the modulation.
5. Adjust the generator output frequency to the receiver IF (455 kc in this example).
6. Ground out the receiver local oscillator by jumpering from the stator terminal to the frame of the tuning gang as shown.
7. Turn all equipment on and allow to warm up (10 minutes or so is enough, since alignment of this type of receiver is not overly critical).

*Procedure:*

1. Turn the receiver volume control to maximum.
2. Adjust the generator output attenuator until you hear a faint modulation tone from the speakers and observe a reading on the output meter. Avoid using an excessively strong signal; use the minimum generator output capable of giving a legible meter deflection.
3. Adjust the slugs in IF transformers L3 and L4 for maximum output. Adjust the L4 secondary (top slug) first, and then the L4 primary (bottom slug). Repeat the adjustment in the same order for first IF transformer L3.

   As the tone output and meter reading increase, reduce the generator output to avoid overloading. Repeat the

entire IF alignment at least twice to assure maximum gain at the IF frequency.

The receiver illustrated in this example has a 455-kc intermediate frequency, which is the most common; but sometimes you may be in doubt about the IF value. The IF frequency can be determined in one of two ways. First, and most obvious, is to refer to the manufacturer's alignment data; even the receiver diagrams will usually have the IF frequency marked on them. Secondly, if such data are unavailable, set up the alignment equipment as outlined, and then slowly rotate the frequency dial through the 150- to 500-kc range. At some frequency near a common IF value, the meter will indicate maximum output. It is then a simple matter of aligning the IF's to the common frequency nearest the one at which a peak is observed. The most common IF frequencies are 175, 262, 455, and 456 kc.

To avoid misleading harmonic-output effects, start the check at 500 kc and work down. As an example, a detuned 456-kc IF strip might indicate a peak with a 230-kc signal at the input because the receiver passes the second harmonic, or 460 kc. Should you begin your check at the low-frequency end of the range, you could easily be misled and try to align the receiver to 262 kc, the nearest common IF frequency to the peak noted.

The component layout of a typical AM AC-DC receiver is shown in Fig. 9-3. Almost all receivers in this class follow a similar pattern. It is advisable, before beginning the alignment, to first study the layout in order to determine the location and function of each adjustment.

Here is a popular variation of the peak IF alignment: The VTVM is connected across the AVC line, as indicated in Fig. 9-4, rather than in the output circuit. Since the AVC voltage developed is proportional to the amount of signal reaching the second detector, this method provides an accurate indication of receiver response. In a shop where more than one person is working, this method has the invaluable advantage of being silent, since the volume control can be turned to minimum.

## Second Method

*Equipment Required:* RF sweep or signal generator with sweep adapter, and an oscilloscope.

*Connections:*
1. Connect the sweep generator, through an isolating capacitor, to grid 3 (mixer grid) of the 12BE6 (Fig. 9-2).
2. Connect the generator ground lead to the negative return circuit.
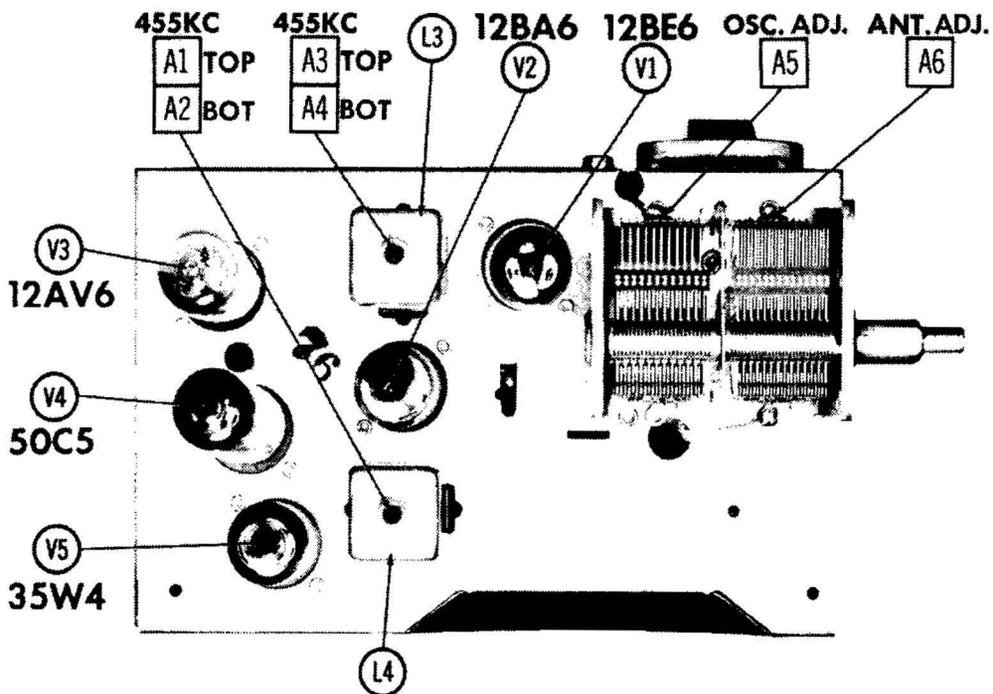
**Fig. 9-3. Top view of a typical AM AC-DC receiver chassis.**

3. Connect the vertical input of the scope across the receiver volume control (Fig. 9-4).

4. Ground out the local oscillator by connecting a jumper between the frame of the tuning gang and the stator of the oscillator section.

5. Ground out the AVC line with a jumper to the negative return.

*Procedure:*

1. Turn all equipment on and allow to warm up.

2. Adjust the sweep-generator center frequency to the receiver IF.
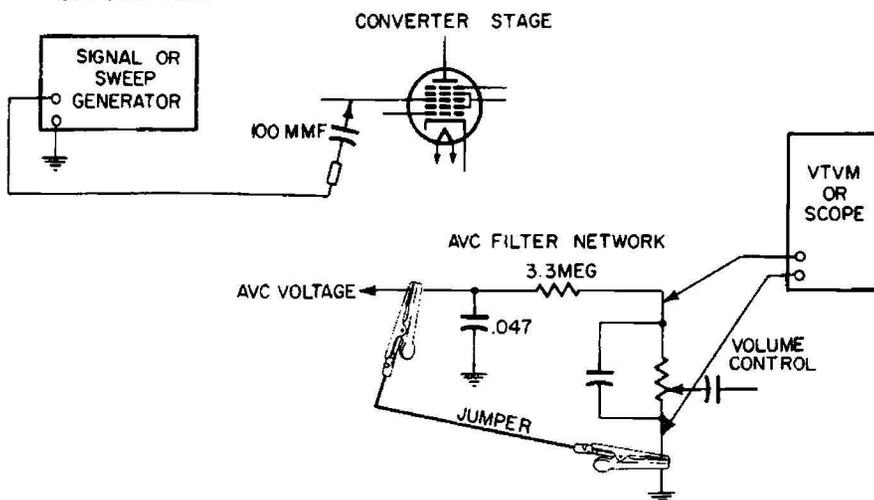


**Fig. 9-4. Connections for measuring the voltage across the AVC line.**

3. Adjust the sweep width to approximately 10 kc.
4. Adjust the scope operating controls for correct focus and beam intensity, and for adequate vertical and horizontal gain.
5. Adjust the coarse and fine scope frequency controls for a single trace.
6. Adjust the slugs in the IF transformers until the amplitude of the response curve cannot be improved. The



Fig. 9-5. A typical AC-DC receiver response curve.
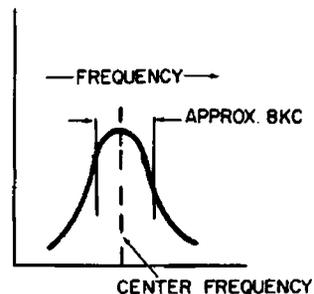
curve should be as high as possible, yet have smooth edges consistent with good symmetry (Fig. 9-5). Watch for jagged sides, which are usually an indication of oscillation in the IF strip.

## BROAD-BAND ALIGNMENT

A number of high-quality AM receivers require a more elaborate and exacting alignment than the foregoing. The sweep procedure is as follows:

1. Disable the external antenna input, local oscillator, and AVC circuits with shorting jumpers.
2. Connect the vertical leads of the scope across the volume control, and adjust the scope operating controls for normal initial operation.
3. Couple the sweep-generator output between the grid and ground of the last IF amplifier. Adjust the generator and scope for a normal pattern.
4. First align the secondary and then the primary of the last (output) IF transformer for the best response curve. It should look like Fig. 9-6.
5. Move the sweep-generator lead to the preceding IF-amplifier grid circuit. Readjust the sweep-generator output for the correct pattern amplitude.
6. Align this stage for the best superimposed curve. (Do not change the adjustment of the last stage.)
7. Move the sweep-generator lead to the grid of the con-

—FREQUENCY—

APPROX. 16KC

CENTER FREQUENCY
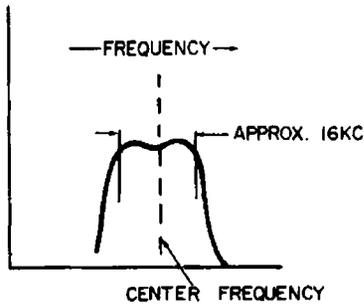
Fig. 9-6. A typical response curve obtained with a broad-band AM receiver.

verter or mixer stage. Adjust the input IF transformer in the same manner as in Step 4.

The response curve achieved in high-quality AM receivers and tuners should be similar to the one in Fig. 9-6. Fig. 9-7 shows two examples of incorrect response curves. Rarely do AM receivers have more than two IF stages; but if they do, follow the same procedure as before, repeating the steps outlined for each IF transformer in the same order.

## RF AND OSCILLATOR ALIGNMENT

After the IF section has been aligned using the applicable procedure, the RF and oscillator alignment can be performed. The AC-DC radio in Fig. 9-2 will be used as the example for the procedure; nevertheless, the same basic method applies to other types of radios as well.

### Procedure

1. Remove jumper from oscillator.
2. Remove the generator leads and connect the RF signal generator to a dummy loop placed 4 to 6 inches from, and in parallel with, the receiver antenna.
3. Tune the receiver to 1400 kc.
4. Adjust the generator to 1400 kc.
5. If the scope is being used as an indicator, adjust the operating controls for the correct pattern.



CENTER FREQUENCY

CENTER FREQUENCY
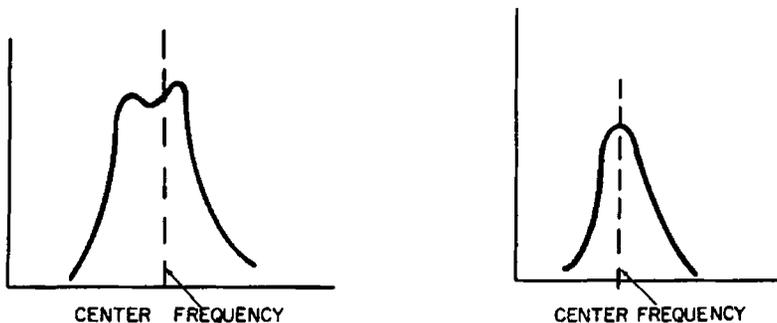
Fig. 9-7. Two examples of incorrect response curves.

134

6. Adjust the oscillator trimmer (C1 in Fig. 9-2) for maximum output indication.
7. Retune the receiver and signal generator to 600 kc.
8. Adjust RF trimmer C2 for maximum output.

With the alignment methods outlined, the front-end of the receiver is tied down at two points near the extremes of its tuning range. For this reason, the oscillator and RF sections should track satisfactorily over the entire dial. Keep in mind that oscillator alignment is the most critical of all, and oscillator adjustments should be made with the utmost care. Misalignment of the RF section results only in a loss of gain, but oscillator misalignment causes improper dial calibration and possibly distortion due to sideband cutting.

A standard replacement loop antenna makes an excellent dummy antenna for alignment applications. If a receiver does not employ a loop-antenna circuit, the signal-generator output can be coupled to the antenna input terminals through a 200- to 500-mmf series capacitor.

## TUNED SIGNAL-TRACER METHOD

Lately, another AM radio alignment method has been gaining popularity with service technicians because of its inherent simplicity, accuracy, and speed. This is the tuned signal-tracer method, which is faster because only one probe is used, and more accurate because the radio stations themselves serve as the signal source. Just about any signal tracer can be used, but commercially-built equipment (kits or ready-built) is ideal.

Most of the receivers in use do not have a low-frequency adjustment for the oscillator; nor do they employ a tuned RF stage. However, the procedure to be used when these circuit details are included will be outlined.

To prepare for the alignment, turn on the receiver and the tuned signal tracer. Turn the receiver volume control to minimum, and proceed as follows:

### Front-End Alignment
1. Set the signal-tracer function controls for the receiver IF frequency, and connect the probe to the converter plate (point 1 in Fig. 9-8).
2. Set the receiver tuning control to the frequency of a local station nearest 1400 kc. (Dial should be set to the correct station frequency even though the station cannot be heard at that point).
3. Adjust oscillator trimmer A5 to bring in the signal (heard
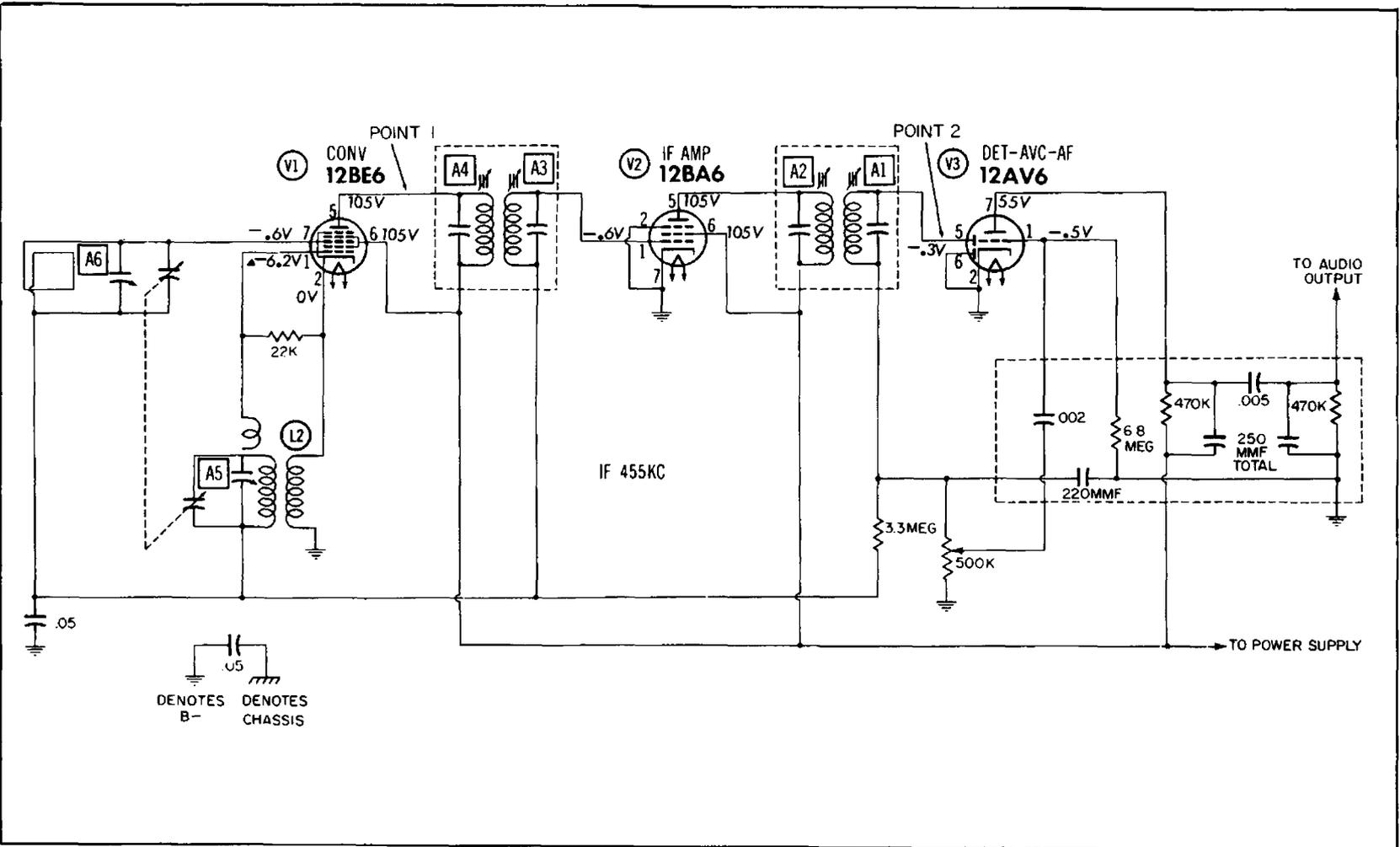
Fig. 9-8. Partial schematic of an AC-DC receiver, showing the check points and adjustments for tuned signal-tracer alignment.

136

from the signal tracer). Make certain you have the correct station at this frequency by comparing the program material with that on a correctly aligned receiver.

4. Adjust oscillator trimmer A5 further, if necessary, to obtain a peak indication on the signal tracer.

5. Adjust converter RF trimmer A6 and the RF trimmer if an RF stage is used for a peak indication on the signal tracer.

6. If the receiver does not have a low-frequency front-end adjustment, check the reception across the band, particularly at the low end. If the sensitivity seems good and the selectivity is adequate, continue on to the IF alignment. If not, correct the condition. Receivers using the popular ferrite rod antenna can be peaked at both ends of the tuning range, without affecting the dial accuracy, by using one of the following methods. First, be certain the receiver is already working at its best sensitivity, the tubes are good, and the front-end is properly aligned.

Only a very few ferrite rod antennas have provision for adjusting the core to peak the low-end response. However, if a receiver should have one, adjust the antenna trimmer for maximum response near 1400 kc, and adjust the ferrite antenna for maximum near 600 kc. Repeat this procedure at least twice.

Two other types of ferrite rod antennas are commonly used. One is about six inches long and one-half inch in diameter. The antenna coil is waxed or cemented onto the core in loosely separated turns on one end and tightly wound turns on the other. To peak this type, first free the tightly wound section of the coil with solvent. Tune the receiver to a weak station near 600 kc; then move the freed section of the antenna coil back and forth on the core, and leave it at the point of best signal. Adjust the antenna trimmer for maximum near 1400 kc. Repeat at least twice, and then cement the coil back in place.

Another type of ferrite rod antenna is about three inches long and is wound around a cardboard form to which the ferrite core is cemented. To peak this coil, free the core from the form by running solvent down between the form and core in the cemented areas. Tune the receiver to a weak station near 600 kc; then slide the core in and out of the coil, and leave it at the point of maximum signal strength. Tune the receiver to a station near 1400 kc, and peak the antenna trimmer. Repeat this process at least twice, and then cement the coil back in place.

In older receivers using a loop antenna, bending the outside rotor plate of the RF and oscillator sections of the tuning gang

will improve the tracking and low-end response. Usually the rotor plates are divided into three sections. Each section is adjusted for a weak signal near the low, middle, and high ends of the band, giving a good tracking figure over the entire tuning range.

Another problem often encountered is poor sensitivity due to IF transformers which have been deliberately misaligned to prevent oscillation. Reversing the IF primary or secondary leads or both, and then completely realigning the receiver, will usually clear up the trouble.

## IF Alignment

1. With the signal tracer still tuned to the IF frequency and the receiver tuned to the station nearest 1400 kc, connect the probe to the detector plate circuit (point 2). For most high-gain signal tracers, sufficient signal can be picked up by clipping the probe to the insulated plate lead. Avoiding a direct connection prevents the shunt capacitance of the probe from loading (detuning) the output IF transformer. However, where the IF transformers are badly misaligned, a direct connection is required initially in order to pick up enough signal to operate the signal tracer.

2. Make IF transformer adjustments A1, A2, A3, and A4 for maximum signal-tracer indication. Don't waste time on this initial adjustment; it is only a roughing-in step and any order may be followed.

3. After the IF transformers have been roughed-in, carefully repeat the process for exact maximum indication in this order:
   > Output IF secondary
   > Output IF primary
   > Input IF secondary
   > Input IF primary

If more than one stage of IF amplification is used, adjust the interstage transformer(s) after the output transformer, in the same order. Go over the procedure at least once more, because the setting of the primary and secondary slugs interact and affect each other.

If oscillation occurs during the alignment, switch the IF-transformer leads around, as described earlier. If this doesn't eliminate the squealing, the IF transformers cannot be aligned to the exact IF frequency, but must be slightly stagger-tuned. Of course, optimum audio quality and maximum gain must still be maintained at the highest level possible.

The final check on the alignment is an on-the-air test. Tune the receiver across the band, and note the number and strength of the stations received. If the sound quality is good and the over-all performance is on a par with, or better than, for comparable receivers, the alignment is complete.

# CHAPTER 10

# FM Radio

# Alignment

Visual alignment is the only method you should use for the final response-curve shaping in FM. Distortion, oscillation, and sideband cutting are sure to result if you attempt to align an FM radio (or tuner) by ear or with an output meter.

In FM broadcasting the signal swings over a range of ±75 kc, compared with the ±25 kc used for the FM sound channel in telecasting. The FM broadcast receiver must have a minimum flat bandpass 150 kc wide for good reproduction, compared with the 50-kc bandpass required in the FM sound section of a TV receiver. When aligning either type of circuit, however, you will use the same general procedure.

## DISCRIMINATOR ALIGNMENT

1. Disable the local oscillator.
2. Adjust the sweep generator to the receiver IF frequency (usually 10.7 mc), and adjust the sweep width to approximately 200 kc. (The manufacturer's service manual gives the exact sweep width recommended.) Couple the sweep-generator output to the grid circuit of the limiter preceding the discriminator as shown in Fig. 10-1. If a limiter
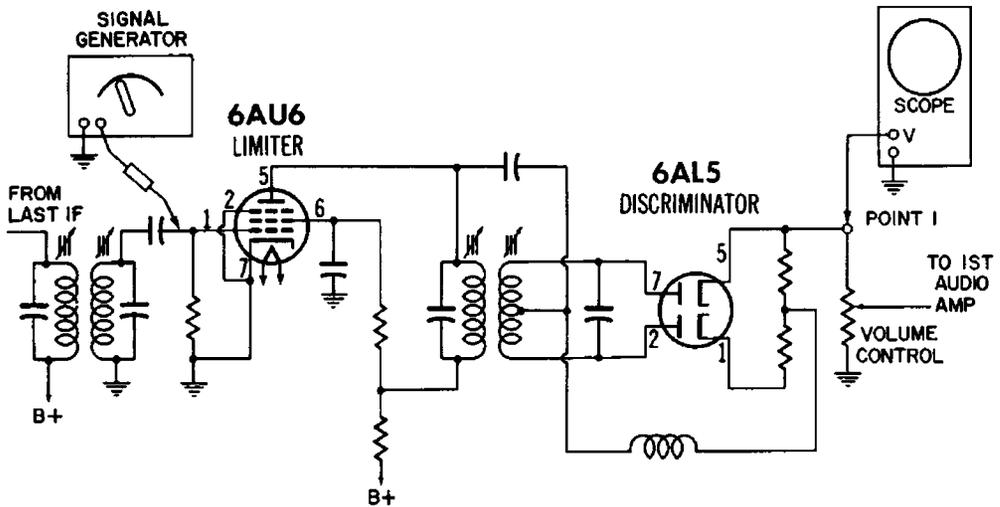
Fig. 10-1. Equipment connections for discriminator alignment.

is not used, couple the sweep signal in at the grid of the last IF amplifier.

3. Connect the scope leads across the input to the first audio amplifier (Point 1 in Fig. 10-1). Adjust the scope operating controls for the proper trace.

4. Align the discriminator-transformer primary and secondary for a pattern similar to Fig. 10-2. The symmetry and
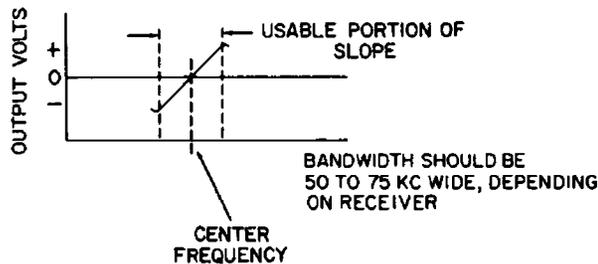


Fig. 10-2. Ideal discriminator curve.

linearity of the curve depend primarily on the primary-slug setting, and the secondary determines the center-frequency or zero-output position. A more common discriminator curve is illustrated in Fig. 10-3. This is the familiar double response curve obtained by using the
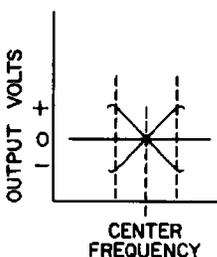


Fig. 10-3. A more common discriminator curve.

scope internal horizontal sweep and adjusting it to 120 rather than 60 cps. Using this curve in discriminator alignment makes it easier to see dissymmetry and an improperly located center frequency. In aligning with this double curve, the symmetry of both curves is determined with the primary adjustment of the discriminator transformer, and the secondary setting determines the center frequency (intersection of the two curves).

Most FM detectors employ a center-tapped secondary type of transformer. The input to the detector is aligned for maximum IF signal to produce the highest possible audio output, and a minimum output (zero perferred) is required at the center frequency which corresponds to an unmodulated carrier. Because the FM detector is a type of bandpass stage (the bandpass extending above and below the center IF frequency), alignment must produce a symmetrical bandpass on both sides of the midpoint. In addition, since the midpoint is the center frequency, there should be no appreciable output at this point. Therefore, the secondary is aligned for proper phase and equal voltage across each half of the winding, and the result is a net output of zero.

Occasionally FM receivers and tuners built from kits are brought to the service shop after the owner has made an attempt at alignment. Needless to say, the tuned circuits are generally away off. In cases like this, some rather special pro-



Fig. 10-4. Basic discriminator circuit.
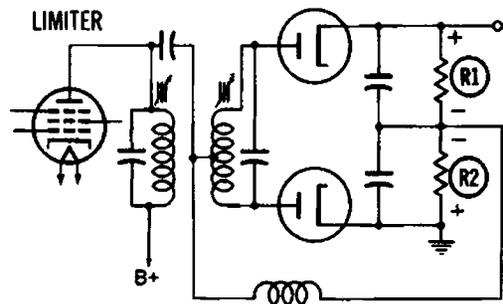
cedures must be used to rough-in the adjustments before sweep alignment can be used effectively. For the discriminator alignment, refer to the basic circuit shown in Fig. 10-4 and follow this procedure:

1. Connect a VTVM across load resistor R1.
2. Couple the marker generator to the grid of the limiter or IF amplifier preceding the discriminator, and adjust it to the IF center frequency (10.7 mc in most cases).
3. Adjust the discriminator-transformer primary for a peak indication on the VTVM.

4. Disconnect the VTVM and center-zero the meter. Reconnect the VTVM leads across the load combination of R1 and R2.

5. While maintaining the input signal at a usable level, adjust the secondary for a zero-output indication on the meter. If the secondary is tuned too far in one direction, the DC output voltage will rise negatively, and vice versa.

An alternate method of adjusting the secondary is to amplitude-modulate the input signal and tune the secondary for minimum audio output at the speaker. This works well because the sine-wave amplitude variations of the signal cancel out across detector load R1 and R2 in series. The AM signal will pass through the limiter if the carrier level is maintained below the threshold of limiting action; otherwise the AM signal must be coupled in at the plate circuit of the limiter.

## IF AND LIMITER ALIGNMENT

FM receivers and tuners require a much wider bandpass for high-fidelity performance. In AM receivers, for example, the IF bandpass may be anywhere from 3 to 16 kc wide, compared with 50 to 250 kc for FM.
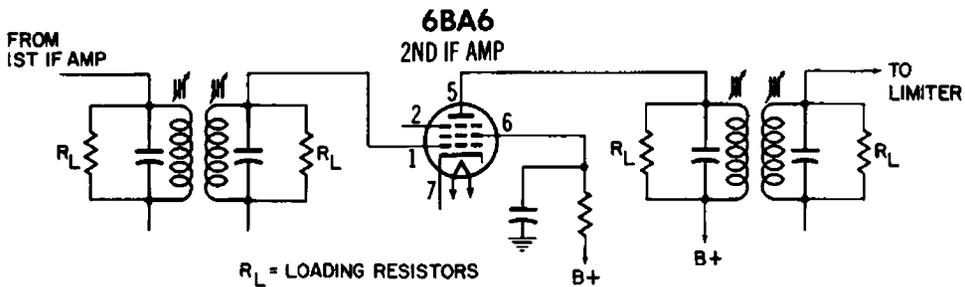


Fig. 10-5. Resistors are often placed across the IF transformer windings to reduce the circuit "Q" and thereby broaden the response curve.

There are several ways of achieving the wide bandwidth required. One method is illustrated in Fig. 10-5. The IF strip uses ordinary transformers with load resistors added across the windings. These shunt resistors decrease the $Q$ of the circuit and flatten the response, resulting in a wider and flatter response curve.

Another type of wide-band FM IF design, not too common, is illustrated in Fig. 10-6. Here the IF transformers have a tuned tertiary winding which determines the bandwidth by absorbing energy from the circuit. The amount of signal bled off by the winding depends mostly on the frequency to which it is tuned.

144

A third type of FM IF uses the stagger-tuned system. The circuit is identical to that in Fig. 10-5, except the loading resistors are omitted. In this type of circuit the wide bandwidth is accomplished by tuning each IF transformer to a slightly different frequency within the bandpass of the IF strip. This system is identical to that commonly used in TV video-IF strip design, and the alignment procedures are basically the same.
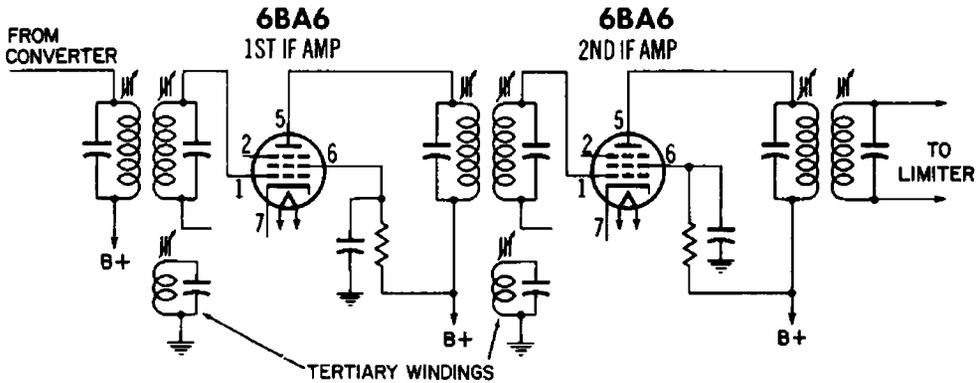


Fig. 10-6. Tuned tertiary windings on the IF transformers can also broaden receiver response by absorbing energy from the circuit.

Alignment of the tertiary-type IF transformer is a little more difficult. The simplest procedure is as follows:

1. Disable the local oscillator.
2. Couple the sweep generator to the grid circuit of the first IF amplifier. Adjust the generator output to the IF frequency, and set the sweep width at ±50 to ±300 kc (see manufacturer's data for exact value).
3. Connect the scope from the grid of the limiter stage to ground.
4. Adjust the primary and secondary of the last IF transformer for a maximum peak.
5. Adjust the tertiary winding for maximum bandwidth (flat top) on the response curve. Do not adjust the tertiary beyond the point where the curve amplitude begins to decrease rapidly.
6. Move the sweep-generator lead to the grid circuit of the converter or mixer. Reduce the generator output to the correct level and repeat the alignment for each IF transformer, working backward toward the converter.

## LIMITER ALIGNMENT

With the exception of its low gain and limiting effect, the limiter operates like an IF amplifier. The tuned input and out-

145

put circuits are adjusted for resonance at the center intermediate frequency.

A basic grid-circuit limiter stage is shown in Fig. 10-7A. A unique feature of the limiter is its ability to provide an indicator voltage for alignment of all stages preceding the limiter itself. This is the bias voltage developed across grid load resistor R1. The greater the signal reaching the limiter grid, the greater the DC voltage across the grid resistor. It is therefore possible to rough-in IF alignment by using this voltage to op-



(A) Grid-circuit limiter.    (B) Plate-circuit limiter.
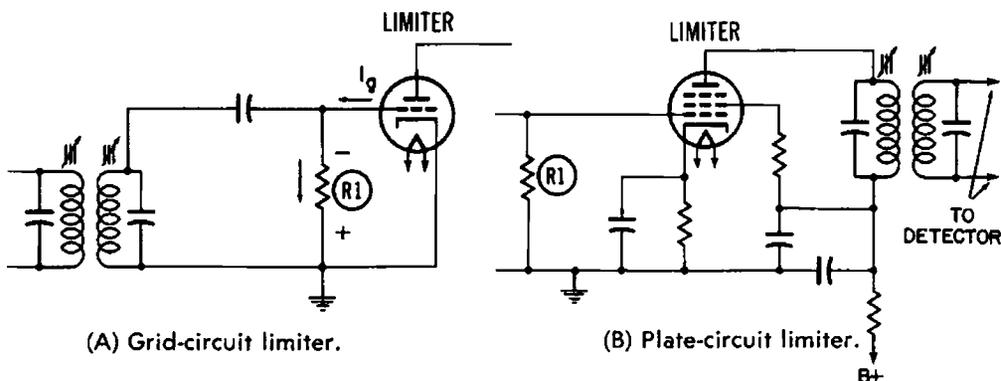
Fig. 10-7. Typical limiter circuits.

erate a peak indicator. Another type, the plate-circuit limiter, is shown in Fig. 10-7B.

## RF ALIGNMENT

RF alignment of FM receivers is similar to that of AM receivers except for the following:

1. The sweep-signal width is greater, being up to ±300 kc, as opposed to the few kilocycles used in sweep-aligning AM receivers.
2. The exact alignment frequencies must be determined from the manufacturer's data because of the widely differing design factors which dictate the oscillator tie-down points.
3. The scope is connected across the limiter grid load or ungrounded discriminator cathode resistor.

## RATIO-DETECTOR ALIGNMENT

The specific alignment procedure for the basic ratio-detector circuit in Fig. 10-8 is as follows:

1. Adjust the sweep generator to the center frequency of the IF, and adjust the sweep to a little more than the specified IF bandwidth. (Consult the manufacturer's specifications

for the precise figure.) Connect the generator output across the grid of the last IF stage.

2. Connect the vertical leads of the scope across the audio load resistor as shown.

3. Adjust the scope operating controls for a pattern similar to that shown previously in Fig. 10-3.

4. Detune the secondary slug of the ratio-detector transformer as far as slug travel will permit in an outward direction.
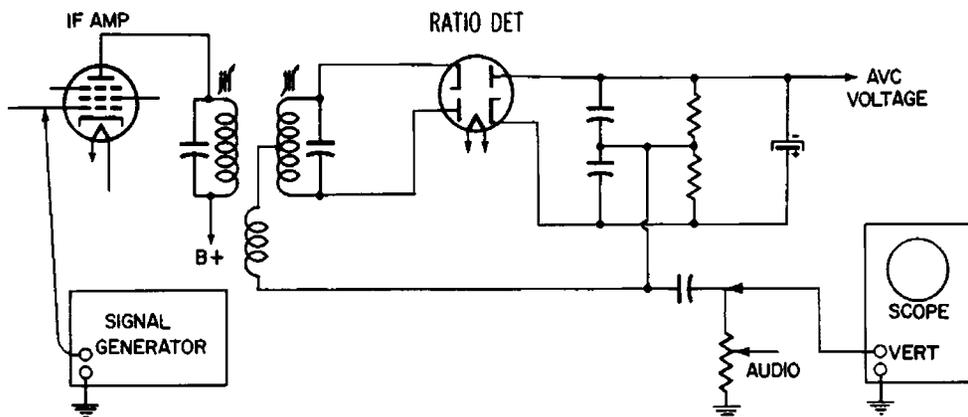


Fig. 10-8. Basic ratio-detector circuit.

5. Align the primary slug for maximum linear slope on the response curve.

6. Adjust the secondary slug to obtain a crossover of the S curves at the center frequency. A marker generator may be used and the slugs adjusted for equal response on both sides of the marker pip.

There are numerous variations in the alignment methods outlined here—such as modified methods of feeding in the signal, and various connections of the output indicator—but these are always specified in the service data. The basic method and purpose, however, remain the same.

# INDEX

## W

Waveform aspect on scope, effect of input voltage polarity on, 44

Waves, standing, effect of on alignment, 46

Weak-signal reception, effects of on picture, 12

Wide-band scope, use of in color alignment, 117-118

## Z

Zero voltage adjustment, discriminator, 68-69